FINAL
MUNITIONS RESPONSE –
QUALITY ASSURANCE PROJECT PLAN

FORMER FORT DEVENS ARMY INSTALLATION

DEVENS, MASSACHUSETTS

Contract No.: W912DR-21-D-0002 **Delivery Order** W912DR22F0121

Prepared for:

US Army Corps
of Engineers®

U.S. Army Corps of Engineers, Baltimore District

November 2022

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Final
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Former Fort Devens Army Installation
Devens, Massachusetts

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Prepared by:

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4801 University Square
Suite 24
Huntsville, AL 35816

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LIST OF ACRONYMS AND ABBREVIATIONS

°F	degrees Fahrenheit
AGC	Advanced Geophysical Classification
AHA	activity hazard analysis
AOPI	area of potential interest
BRAC	Base Realignment and Closure
CA	corrective action
CIH	Certified Industrial Hygienist
CORS	continually operating reference station
CPR	cardiopulmonary resuscitation
CQA	Certified Quality Auditor
CQM	Corporate Quality Manager
CSP	Certified Safety Professional
DDESB	Department of Defense Explosives Safety Board
DESR	Defense Explosive Safety Regulation
DFW	definable features of work
DMM	discarded military munitions
DoD	Department of Defense
DoDI	DoD Instruction
DQO	data quality objective
DS	Dive Supervisor
DUA	Data Usability Assessment
EM	Electromagnetic
EOD	Explosive Ordnance Disposal
ESP	Explosives Siting Plan
EZ	exclusion zone
FCA	functional check area
FCR	field change request
FFA	Federal Facilities Agreement
GIS	geographical information system
GPS	global positioning system
HARN	high-accuracy reference network
HAZWOPER	Hazardous Waste Operations and Emergency Response
IAW	in accordance with
ISO	industry standard object
MassDEP	Massachusetts Department of Environmental Protection
MDoT	Massachusetts Department of Transportation
MD	munitions debris
MDAS	material documented as safe
MEC	munitions and explosives of concern
MPPEH	munitions potentially presenting an explosive hazard
mm	millimeter
MPC	measurement performance criteria
MQO	measurement quality objective
MR-QAPP	Munitions Response–Quality Assurance Project Plan
mV	milli Volt

NCP	National Contingency Plan
NCR	non-conformance report
NMRD	non-munitions-related debris
NRL	Naval Research Laboratory
NRWA	Nashua River Watershed Association
OESS	Ordnance & Explosive Safety Specialist
OSHA	Occupational Safety and Health Administration
PDT	Project Delivery Team
PG	Professional Geologist
PLS	Professional Land Surveyor
PM	Project Manager
PMP	Project Management Professional
QA	quality assurance
QC	quality control
RCA	root cause analysis
RMS	root mean square
RSE	Removal Site Evaluation
RTK	Real Time Kinematic
SNR	signal-to-noise ratio
SOP	Standard Operating Procedure
SPP	Systematic Project Planning
SRA	saturated response area
SSS	side scan sonar
SUXOS	Senior UXO Supervisor
UDGM	Underwater Digital Geophysical Mapping
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
UUTA-LT	UXO Underwater Towed Array Light
UIVS	underwater instrument verification strip
UXO	Unexploded Ordnance
UXOSO	Unexploded Ordnance Safety Officer
UXOQCS	Unexploded Ordnance Quality Control Specialist
VRS	Virtual Reference Station

INTRODUCTION

This Munitions Response – Quality Assurance Project Plan (MR-QAPP) has been written to provide the project team guidance for the Military Munitions Investigation Nashua River Former Fort Devens project (Figure A-1 provided in Appendix A). The military munitions investigation will be performed within an approximate 3-mile stretch of the Nashua River, which includes five areas of potential interest (AOPIs) near Former Fort Devens (Figure A-3 provided in Appendix A). The five AOPIs are associated the following four bridges from south to north: State Route 2, Jackson Road, Hospital Road, and West Main Street, and a portion of the Bill Ashe Trail as shown on Figures A-3.

The Former Fort Devens was active from 1917 to 1996 and was placed on the National Priorities List in 1991. In May 2021, the Army and United States Environmental Protection Agency (USEPA) signed a Federal Facilities Agreement (FFA). The river is primarily used by recreational users (i.e., canoeing, kayaking, fishing), with trails along some of its banks used for hiking. Massachusetts Department of Transportation (MDoT) divers perform bridge inspections and associated maintenance along the Nashua River. The Nashua River is also known to have an infestation of water chestnut, a non-native, invasive aquatic plant. Active management of this invasive species has been performed by volunteers with the Nashua River Watershed Association (NRWA) since 2014.

Recently, military munitions have been recovered within the study area (Figure A-2 provided in Appendix A). Recovered military munitions include the following:

- Summer 2020: During magnetic fishing, two MK-II hand grenades and an un-fuzed 60-millimeter (mm) mortar were found.
- March 2021: During a MDoT bridge inspection, three practice 2.36-inch M6A1 rockets, a practice 60mm mortar, and an expended M18 smoke grenade were discovered.

The two hand grenades were disposed of by the Massachusetts State Police Bomb Squad. While trained and capable in the disposal of the items, they are not qualified to classify the munitions as UXO in accordance with DESR 6055.09. Per DESR 6055.09 and other DoD, only military EOD personnel or qualified UXO Technicians are qualified to make that determination. While the State Police are not qualified to make the determination, it is assumed they were live based on their findings post blast.

Based on the recovered military munitions findings, under the FFA in place for Fort Devens, USEPA Region 1 initiated an Informal Dispute with the Army, and a Removal Site Evaluation (RSE) was conducted (USACE, 2021). The 2021 RSE concluded there is no evidence the Army used the Nashua River or its banks for munitions-related operations. The most likely source of potential munitions in the study area is discarded military munitions (DMM).

The United States Army Corps of Engineers (USACE) and the USEPA require that environmental monitoring and measurement efforts mandated or supported by these organizations participate in a centrally managed quality assurance (QA) program. QA/Quality Control (QC) procedures have been developed using applicable professional technical standards, USEPA and USACE requirements, government regulations and guidelines, and specific project goals and requirements. This project is managed by the USACE, Baltimore District in coordination with the USACE, New England District.

This MR-QAPP (optimized worksheet format) has been prepared in accordance with (IAW) the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) (USEPA, 2005); Optimized UFP-QAPP Worksheets (USEPA, 2012); and EM 200-1-15, Technical Guidance for Military Munitions Response Actions (USACE, 2018). Table 1-1 provides an MR-QAPP component crosswalk table that shows the Optimized UFP-QAPP Worksheets, their applicability to the MR-QAPP, and an indication of the applicability of the worksheet to this investigation.

Table 1-1. Crosswalk: Optimized UFP-QAPP Worksheets to MR-QAPP

Optimized UFP-QAPP Worksheets		MR-QAPP
1 & 2	Title and Approval Page	Included
3 & 5	Project Organization and QAPP Distribution	Included
4, 7, & 8	Personnel Qualifications and Sign-off Sheet	Included
6	Communication Pathways and Procedures	Included
9	Project Planning Session Summary	Included
10	Conceptual Site Model	Included
11	Project/Data Quality Objectives	Included
12	Measurement Performance Criteria	Included
13	Secondary Data Uses and Limitations	Included
14 & 16	Project Tasks & Schedule	Included
15	Project Action Limits and Laboratory-Specific Detection/Quantitation Limits	Not applicable – No chemical testing being performed
17	Sampling Design and Rationale	Included – Title changed to “Survey Design and Project Work Flow”
18	Sampling Locations and Methods	Not applicable – No environmental samples being collected
19 & 30	Sample Containers, Preservation, and Hold Times	Not applicable – No environmental samples being collected
20	Field Quality Control (QC)	Worksheet not included – Field QC procedures are included on Worksheet #22
21	Field Standard Operating Procedures (SOPs)	Included
22	Field Equipment Calibration, Maintenance, Testing, and Inspection	Included – Title changed to “Equipment Testing, Inspection, and Quality Control”
23	Analytical SOPs	Not applicable – No laboratory analysis being performed
24	Analytical Instrument Calibration	Not applicable – No laboratory analysis being performed
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection	Not applicable – No laboratory analysis being performed
26 & 27	Sample Handling, Custody, and Disposal	Not applicable – No samples being collected
28	Analytical QC and Corrective Action (CA)	Not applicable – No laboratory analysis being performed
29	Project Documents and Records	Included – Title changed to “Data Management, Project Documents and Records”
31, 32, & 33	Assessments and CA	Included
34	Data Verification and Validation Inputs	Included – Title changed to “Data Verification, Validation, and Usability Inputs”
35	Data Verification Procedures	Included – Title changed to “Data Verification and Validation Procedures”
36	Data Validation Procedures	Worksheet not included – Data validation is addressed in Worksheet #35
37	Data Usability Assessment	Included

QAPP WORKSHEET #1 & #2 – TITLE AND APPROVAL PAGE

1. **Project Identifying Information**
   a. **Location Name:** Former Fort Devens Army Installation

   Project Name: Military Munitions Investigation Nashua River Former Fort Devens

   a. Location/Number: Devens, Massachusetts

   b. Lead Organization: USACE, Baltimore District

   c. Contractor: Tetra Tech

   d. Contract Number: W912DR-21-D-0002 **Delivery Order:** W912DR-21-D-0002

2. **Lead Organization**
   a. USACE Project Manager (PM): Pete Phillips

   ____

   Signature Date

3. **Prime Contractor: Tetra Tech**
   a. Jennifer Harlan, Project Management Professional (PMP), Program Manager/PM

   ____ 29 November 2022

   Signature Date

   b. Eugene Mikell, Certified Quality Auditor (CQA), Corporate Quality Manager (CQM):

   ____ 29 November 2022

   Signature Date

QAPP WORKSHEET #3 & #5 – PROJECT ORGANIZATION AND QAPP DISTRIBUTION

Figure 3-1. Geophysical Investigation Organization Chart

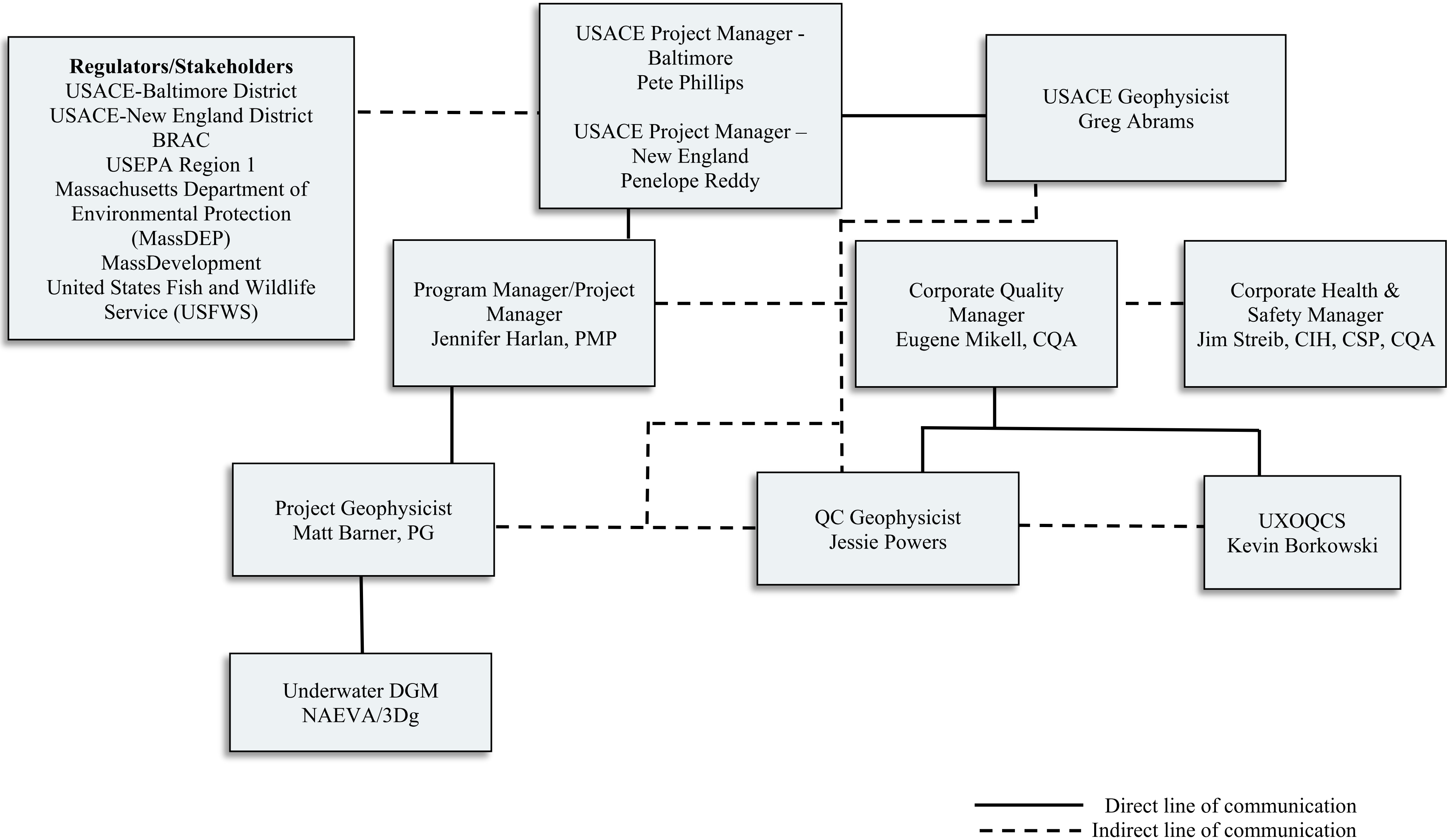
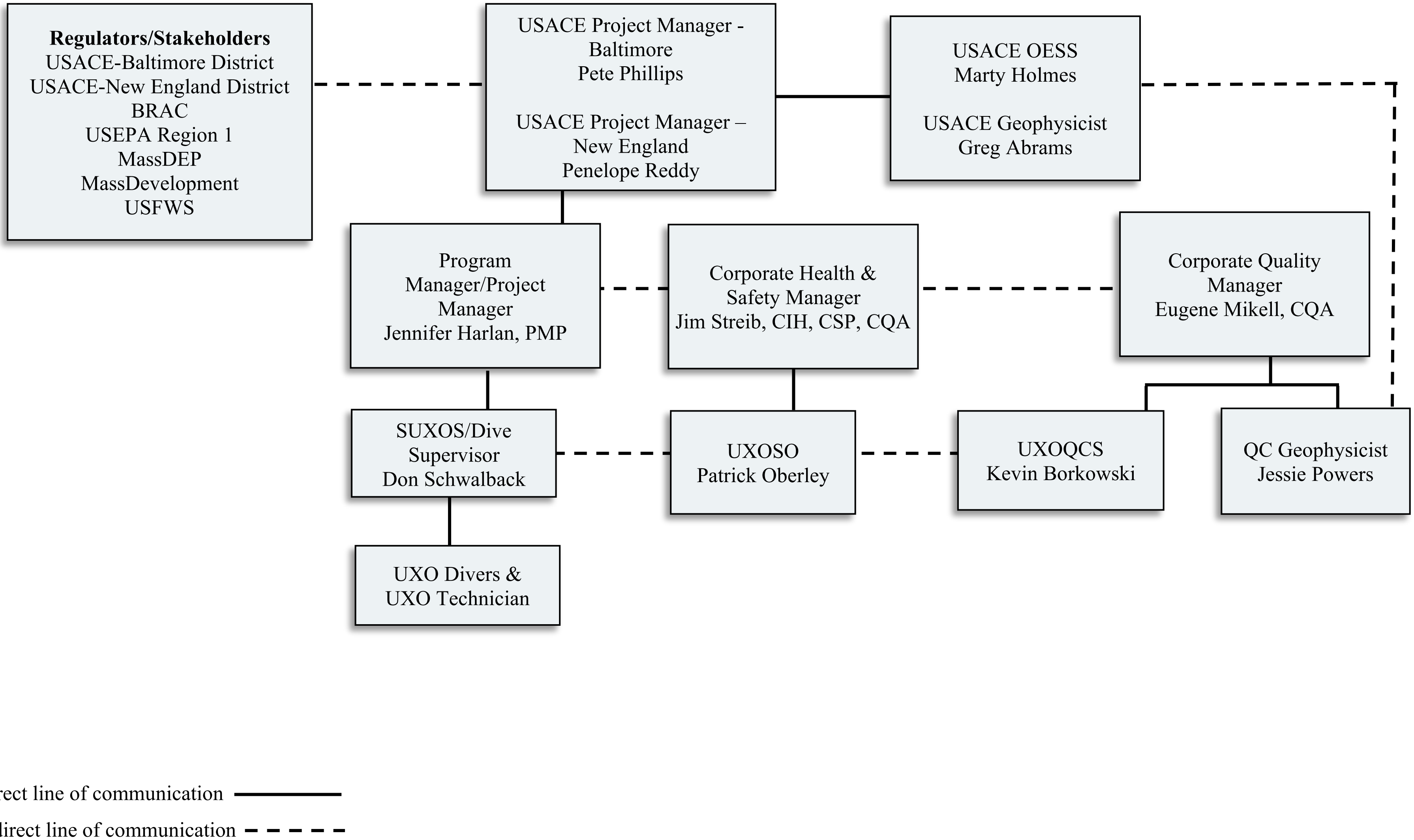


Figure 3-2. Military Munitions Investigation Organization Chart



QAPP WORKSHEET #4, #7, & #8 – PERSONNEL QUALIFICATIONS AND SIGN-OFF SHEET

Table 4-1. Prime Contractor and Subcontractors

Name	Title/Role	Education/Experience Qualifications	Specialized Training	Required Licenses/Certifications/ Authorizations	Signature*/ Date
Jennifer Harlan, PMP jennifer.harlan@tetratech.com (406) 940-5040	Program Manager/Project Manager	• BS, Biology/Ecology • 12 years managing Military Munitions Response Program and hazardous, toxic, and radioactive waste (HTRW) projects	• Occupational Safety and Health Administration (OSHA) 40-Hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training • Tetra Tech Project Management Training, Level 01 & 02	• PMP #1484360	
Eugene Mikell, CQA eugene.mikell@tetratech.com (865) 816-0388	Corporate Quality Manager	• Naval Explosive Ordnance Disposal (EOD) School • 12 years of combined corporate QC and regulatory QA oversight experience • 35 years EOD/unexploded ordnance (UXO) experience	• HAZWOPER 40-hour • Current 8-hour refresher OSHA Supervisor • Construction Quality Management	• ASQ CQA # 47375	
Jim Streib, CIH, CSP, CQA jim.streib@tetratech.com (240) 727-9240	Corporate Health & Safety Manager	• MS, Occupational Safety and Health / Environmental Management • BS, Occupational Safety & Health • AS, Public Health • Over 15 years of environmental construction safety/explosive ordnance experience	• 40-Hour EM 385-1-1 USACE Safety & Health • OSHA 30 Hour Construction Safety • Safety Management Specialist No. SMS-209 • Construction Health and Safety Technician No. CHST-10023 • UXO Level 1 Training • Construction Quality Management for Contractors	• Certified Industrial Hygienist (CIH) # 12059 CP • Certified Safety Professional (CSP) # CSP-34027 • CQA # 68792	

Name	Title/Role	Education/Experience Qualifications	Specialized Training	Required Licenses/Certifications/ Authorizations	Signature*/ Date
Jessie Powers jessie.powers@tetratech.com (434) 989-4879	QC Geophysicist	• BS, Environmental Science • 9 years of geophysics for environmental remediation and munitions response experience	• Tetra Tech Project Management Training, Level 01& 02 • 40-Hour OSHA HAZWOPER • 30-Hour OSHA Construction • 8-Hour OSHA HAZWOPER Refresher, Current • First-Aid/ cardiopulmonary resuscitation (CPR) • Geosoft Oasis montaj (Geosoft) Training		
Matthew Barner, PG matt.barner@tetratech.com (980) 257-6800	Project Geophysicist	• BS, Geology • MS, Geology with a geophysics concentration • 20 years of geophysics for environmental remediation and munitions response experience	• Tetra Tech Project Management Training, Level 01& 02 • 40-Hour OSHA HAZWOPER • 8-Hour OSHA HAZWOPER Refresher, Current • Geosoft Training	• Professional Geologist (PG) #2171 (NC) and #2801-001635 (VA)	
Karen Lemley klemley@naevageophysics.com (434) 218-1075	NAEVA Project Manager/Senior Geophysicist	• BS, Marine Science, Geophysics • 22 years of geophysics experience for environmental remediation and munitions response	• 40-Hour OSHA HAZWOPER • 8-Hour OSHA HAZWOPER Refresher, Current • 8-Hour OSHA Supervisor, Current • Oasis Montaj Training		

Name	Title/Role	Education/Experience Qualifications	Specialized Training	Required Licenses/Certifications/ Authorizations	Signature*/ Date
Erik Kitt erik@3dgeophysics.com (952) 556-1118	3Dgeophysics Site Geophysicist, Data Collection	• BS, Geophysics • 28 years of geophysics experience for environmental remediation, geotechnical analysis, and munitions response	• 40-Hour OSHA HAZWOPER • 8-Hour OSHA HAZWOPER Refresher, Current • 30-Hour OSHA Construction Safety • Oasis Montaj Training		
Jon Guillard jguillard@naevageophysics.com (434) 218-1058	NAEVA QC Geophysicist	• B.S. Geology, • 30+ years of geophysics experience for environmental remediation, geotechnical analysis, and munitions response	• 40-Hour OSHA HAZWOPER and current 8-Hour Refresher • Oasis Montaj Training • UX-Analyze Workshop - 2018		
Don Schwalback don.schwalback@tetratech.com (360) 941-0912	Senior UXO Supervisor (SUXOS)/Dive Supervisor	• Graduate, Naval EOD School • 37 years of munitions and explosives of concern (MEC)-related experience	• HAZWOPER • 8-Hour OSHA Supervisor training • 30-hour OSHA Construction Safety and Health training • ADCI Air Diver/Supervisor • DAN Diving First Aid for Professional Divers • OSHA 80-hour Contaminated Water Diving	• Qualified SUXOS IAW Department of Defense (DoD) Explosives Safety Board (DDESB) TP-18 • US Navy Diver Second Class	

Name	Title/Role	Education/Experience Qualifications	Specialized Training	Required Licenses/Certifications/ Authorizations	Signature*/ Date
Patrick Oberley patrick.oberley@tetratech.com (850) 890-2381	UXO Safety Officer (UXOSO)	• Graduate, EOD School • Second Class Dive School, NDSTC Panama City • 30 years of MEC-related experience	• HAZWOPER • 8-Hour OSHA Supervisor training • 30-hour OSHA Construction Safety and Health training • DCBC Unrestricted Surface Supplied Diving Supervisor • ADCI Unrestricted Surface Supplied Diving Supervisor • IED Division Instructor • CPR/First Aid/AED Qualified	• Qualified Unexploded Ordnance Safety Officer (UXOSO) IAW DDESB TP-18 • Certified UXO Diver	
Kevin Borkowski kevin.borkowski@tetratech.com (360) 672-4023	UXO Quality Control Specialist (UXOQCS)	• Graduate, EOD School • 30 years of MEC-related experience	• HAZWOPER • 8-Hour OSHA Supervisor training • 10-hours & 30-hour OSHA Construction Safety and Health training • CQCM • ISO 9001:2015 Internal Auditor	• Qualified UXOQCS IAW DDESB TP-18 • Certified UXO Diver	

QAPP WORKSHEET #6 – COMMUNICATION PATHWAYS AND PROCEDURES

Table 6-1. Communication Pathways

Communication Driver	Initiator (name, project title)	Recipient (name, project title)	Procedure (timing, pathway, documentation)
Regulatory agency interface	Tom Lineer, BRAC	USEPA Region 1	Base Realignment and Closure (BRAC) lead will provide regular project updates to the Regulator via e-mail.
Daily field progress reports	Don Schwalback, SUXOS/DS	Jennifer Harlan, PM Tetra Tech Project Team	The Senior UXO Supervisor (SUXOS)/Dive Supervisor (DS) will provide daily progress report by e-mail to the PM and Tetra Tech project team. During digital geophysical mapping (DGM) operations, the SUXOS/DS will obtain input from the NAEVA/3Dg site personnel, as needed, to document these daily activities. Deviations from the MR-QAPP or governing procedures and the reasons for them, will be documented in these reports. PM provides daily progress reports to the Army Project Delivery Team (PDT) via e-mail.
Daily DGM field reports	Erik Kitt, NAEVA/ 3Dg Site Geophysicist	Jennifer Harlan, PM Tetra Tech Project Team	The NAEVA/3Dg Site Geophysicist will provide daily field reports to the listed recipients, documenting completion of requisite equipment function checks, field QC tests and completed inspections. This documentation will include pass/fail status of these tests, as possible based on field testing. Deviations from the MR-QAPP or governing procedures and the reasons for them will be documented in these reports. Daily field logs provided with raw data packages may be used in lieu of a separate daily DGM field report, provided the field logs specifically include the aforementioned details. PM provides daily DGM reports to the Army PDT.
Daily UXO QC report (intrusive/dive operations)	Kevin Borkowski, UXOQCS	Jennifer Harlan, PM Tetra Tech Project Team	The UXOQCS will be notified (email) of any data processing or other quality checks conducted by home office activities. Daily field QC reports are provided to the Tetra Tech PM, Project and QC Geophysicists, and CQM. Daily QC reports will include as one file all additional quality documents and checklists. PM provides daily UXO QC reports to the Army PDT.

Communication Driver	Initiator (name, project title)	Recipient (name, project title)	Procedure (timing, pathway, documentation)
Weekly DGM QC reports	Jessie Powers, QC Geophysicist	Jennifer Harlan, PM Matthew Barner, Project Geophysicist Eugene Mikell, CQM	The QC Geophysicist will provide a weekly report of completed DGM QC activities, including inspections and data reviews, as applicable, to the listed recipients. Inspection reports, as applicable, will be appended to the weekly QC report. During Underwater Digital Geophysical Mapping (UDGM) operations, the QC Geophysicist will obtain input from the NAEVA/3Dg QC Geophysicist, as necessary, to complete these weekly reports. During intrusive operations, the QC Geophysicist will obtain input from the UXOQCS, as necessary, to complete these reports as they relate to anomaly resolution. This report will also provide the status of open non-conformance reports (NCRs) and field change requests (FCRs). The PM provides copies of the weekly DGM QC reports to the Army PDT.
Safety-related mishap notification	Patrick Oberley, UXOSO	Jennifer Harlan, PM Don Schwalback, SUXOS/DS Jim Streib, Corporate Health & Safety Manager	UXOSO will notify AGC PM by phone immediately. PM will notify the USACE, Baltimore District PM by phone and e-mail within 24 hours.
Stop work due to safety issues	Patrick Oberley, UXOSO Don Schwalback, SUXOS/DS	Jennifer Harlan, PM Jim Streib, Corporate Health & Safety Manager	As soon as possible following discovery, the UXOSO or SUXOS/DS will inform PM and Corporate Health & Safety Manager by phone of critical safety issues and will generate a follow-up Stop Work Memorandum. PM will notify the USACE PM by phone as soon as possible. NOTE: All team members have the authority to Stop Work for safety concerns.
Military munitions find	Don Schwalback, SUXOS/DS	Jennifer Harlan, PM Local Fire Department Local Sheriff's Office	If a military munition is found, the SUXOS/DS will immediately notify the PM, who will provide notification to the USACE PMs and BRAC Lead. The SUXOS/DS or the UXOSO will provide verbal notification via phone to the local fire department, local Sheriff's office, and any other interested entities.

Communication Driver	Initiator (name, project title)	Recipient (name, project title)	Procedure (timing, pathway, documentation)
QA stand-down	Pete Phillips, USACE PM	Jennifer Harlan, PM	USACE PM will notify PM by e-mail of need and reason for QA stand down. PM notifies CQM and appropriate project and subcontractor personnel based on the phase of work. The appropriate failure response in this MR-QAPP will be undertaken by the appropriate Tetra Tech or subcontractor personnel upon notification of the stand down.
Resume work following a stop work or QA stand-down	Pete Phillips, USACE PM	Jennifer Harlan, PM	The USACE PM will provide the PM with written notice to resume after appropriate safety corrective measures have been accepted and implemented or after failure response to QA stand down is accepted by USACE before work may resume.
Minor MR-QAPP changes during project execution	Matthew Barner, Project Geophysicist Don Schwalback, SUXOS/DS	Jennifer Harlan, PM	Minor MR-QAPP changes will be noted on daily progress reports and provided to the listed recipients. Additionally, the USACE PM will be verbally notified of any changes, and a follow-up e-mail will be sent by PM. All changes to the final plans will be recorded in a change log established for the project. Minor QAPP changes comprise replacement of non-key project and field personnel, field workday/work week schedule adjustments and regular schedule updates provided there is no impact to delivery of critical path data packages, reports, and memoranda.
Major QAPP changes during project execution	Jennifer Harlan, PM	Pete Phillips, USACE PM Eugene Mikell, CQM	Within one working day of identification of a need for a change, PM initiates a field change request (FCR) and submits to the listed recipients for approval. The USACE PM will coordinate review/approval of the FCR with the appropriate Army PDT members and provide approval to the PM. Following approval, the BRAC Lead will inform the Regulator via e-mail. Major QAPP changes are those which necessitate updates to key personnel, data quality objective (DQO) decision logic, measurement performance criteria (MPC), technical approach and/or definable features of work (DFWs) and measurement quality objectives (MQOs). Note: Advanced Geophysical Classification (AGC) SOPs are subject to updates as required by changes in technology, software, and mandatory annual reviews. Changes to the AGC SOPs will not require an FCR. All changes to the final plans will be recorded in a change log established for the project.

Communication Driver	Initiator (name, project title)	Recipient (name, project title)	Procedure (timing, pathway, documentation)
Technical nonconformance	Jessie Powers, QC Geophysicist Kevin Borkowski, UXOQCS	Jennifer Harlan, PM Tetra Tech Project Team	The UXOQCS or QC Geophysicist will initiate an NCR within one working day of observed nonconforming condition or notification by the project team of a nonconformance. NAEVA/3Dg will notify the Tetra Tech QC Geophysicist of nonconformances within one working day of discovery (e.g., if the problem is identified during data processing or home office tasks). A non-conformance is defined as a performance standard that is not achieved as shown in WS #22 or a process that is not implemented as documented in QAPP/SOPs. The UXOQCS or QC Geophysicist will notify the listed recipients of the technical nonconformance via e-mail at the time the NCR is initiated. The appropriate failure response in this MR-QAPP will be undertaken by the appropriate Tetra Tech or NAEVA/3Dg personnel upon initiation of the NCR. The PM notifies the Army PDT about the technical nonconformance via e-mail. Tetra Tech personnel are permitted to communicate with subcontractor personnel and USACE counterparts, as needed, during development of the root cause analysis (RCA), development of potential CAs or other failure response measures included in this MR-QAPP.
Communication of firewalled information	Kevin Borkowski, UXOQCS Jessie Powers, QC Geophysicist	Eugene Mikell, CQM Greg Abrams, USACE QA Geophysicist	The UXOQCS and QC Geophysicist are responsible for implementing firewall measures during the execution of the project. The NAEVA/3Dg QC Geophysicist will be permitted to communicate with the Tetra Tech QC Geophysicist regarding firewalled information. The QC Geophysicist is solely responsible for the communication of firewalled blind seed information to the USACE QA Geophysicist. Firewalled information may be released by the QC Geophysicist to the appropriate Tetra Tech project team members to specifically support the RCA/CA process in response to a technical nonconformance.

QAPP WORKSHEET #9 – PROJECT PLANNING SESSION SUMMARY

No formal project planning meetings have been held as of the date of this MR-QAPP. Coordination is ongoing with USEPA and stakeholders as needed.

QAPP WORKSHEET #10 – CONCEPTUAL SITE MODEL

Facility Profile:

Location, size, and ownership:

The Former Fort Devens is located in portions of the towns of Ayer, Shirley, and Harvard Massachusetts and the Devens Regional Enterprise Zone comprises portions of those three towns. The area of investigation for this project as defined by USACE, includes 5 AOPIs within an approximate 3 mile stretch of the Nashua River next to the Former Fort Devens (Figures A-2 and A-3 provided in Appendix A). The river flows east of South Post and mainly west of what was known as Main and North Post now known as Devens. The river is slow moving, with a river bottom composed of heavy layers of silt and sand. This investigation will only be conducted within the river and will not extend to any terrestrial areas.

History:

The Former Fort Devens was active from 1917 to 1996 and was placed on the National Priorities List in 1991. In May 2021, the Army and USEPA signed an FFA. The river is primarily used by recreational users (i.e., canoeing, kayaking, fishing), with trails along some of its banks used for hiking. MDoT divers perform bridge inspections and associated maintenance along the Nashua River. The Nashua River is also known to have an infestation of water chestnut, a non-native, invasive aquatic plant. Active management of this invasive species has been performed by volunteers with the NRWA since 2014.

Recently, military munitions have been recovered within the study area. Recovered military munitions include:

- Summer 2020: During magnetic fishing, two MK-II hand grenades (July and August) and an un-fuzed 60- mm mortar (August) were found.
- March 2021: During a MDoT inspection, three practice 2.36-inch M6A1 rockets, a practice 60mm mortar, and an expended M18 smoke grenade were discovered.

The two hand grenades were disposed of by the Massachusetts State Police Bomb Squad. While trained and capable in the disposal of the items, they are not qualified to classify the munitions as UXO in accordance with DESR 6055.09. Per DESR 6055.09 and other DoD, only military EOD personnel or qualified UXO Technicians are qualified to make that determination. While the State Police are not qualified to make the determination, it is assumed they were live based on their findings post blast.

On August 19, 2020, the USEPA requested that the Army perform an RSE, pursuant to Paragraph 12.3(c) of the Devens FFA and § 300.410 of the National Contingency Plan (NCP), after the discovery of military munitions (presumed MEC) in 2020 at two different locations during magnet fishing activities. These discoveries were located within the Nashua River, adjacent to the former Fort Devens. The USEPA requested that the Army evaluate the likely presence of additional military munitions (potential MEC) at other locations along the Nashua River and determine whether a removal or other remedial action was necessary to address the imminent threat and substantial endangerment to human health and the environment posed by these military munitions (potential MEC).

After the USEPA initiated informal dispute to ensure the development of an RSE, the two parties participated in several calls and exchanges of correspondence. Ultimately, upon receiving the Army's commitment to perform the RSE and an amended, final schedule to complete the RSE, informal dispute was concluded on September 16, 2020.

After the Army's submission of a Draft RSE on November 18, 2020, the USEPA provided comments identifying the actions and revisions necessary to satisfy paragraph 12.3(c) of the FFA and NCP § 300.410. After receiving responses to those comments, the USEPA provided follow-up comments on March 4, 2021, again identifying the actions necessary to adequately complete the RSE. The Army's submission of a Draft Final RSE in May 2021 and a Draft RSE Addendum in August 2021 did not include the actions and revisions identified by the USEPA as necessary to adequately evaluate areas of prior military munitions (potential MEC) discoveries and to confirm potential presumed MEC exposure pathways along the Nashua River. As a result, the USEPA again initiated an informal dispute on September 16, 2021, and later invoked formal dispute resolution on December 16, 2021. In accordance with the Dispute Resolution Committee's January 20, 2022 Agreement, which resolved and ended the formal dispute, the Army agreed to perform the activities proposed in this MR-QAPP.

Previous Investigations

Removal Site Evaluation

Due to the DMM finds in the Nashua River in summer 2020 and March 2021, the USEPA initiated an informal dispute over the response to those incidents. In accordance with the FFA, the Army determined an RSE should be conducted. The objective of the RSE was to determine the probability of encountering military munitions in the Nashua River from military munitions use and evaluate the magnitude of the threat of release.

For the RSE, USACE conducted an in-depth review of available historical documents followed by analog survey of the riverbanks and accessible shallow water areas. Based on the historical records search, no other munitions encounters have been documented for the Nashua River beside the recent incidents discussed above. In October 2020, USACE's Baltimore District mobilized a two-person Ordnance & Explosive Safety Specialist (OESS) team to conduct an analog survey industry standard magnetometer (Schonstedt 52cx) and an all-metals detector (White XLT) of the Nashua River's banks and accessible shallow water areas (not more than 2 feet in depth). The OESS team conducted this two-day survey along Nashua River from Hospital Road Bridge south for approximately 0.75 miles on both the east and west sides of the river for a total of approximately 1.5 miles. The OESS team used a mag and dig approach during this survey. Using this approach, the team investigated each detected anomaly as they conducted the survey, including in shallow water. The OESS team encountered only cultural debris (e.g., barb wire, cans, rebar, and pipe); no military munitions or munitions debris (MD) was found.

USACE also completed an extensive document review of available information about Former Fort Devens including the 1995 Archives Search Report, the 1995 HFA Sampling Action Report, 2003 Closed Transferring and Transferred report, a 2005 Preliminary Assessment Site Inspection, a 2008 Historical Records Review, and a 2011 Site Inspection Report. As a result, USACE determined that Former Fort Devens never used the Nashua River or its riverbanks for munition-related purposes. While operational ranges existed on Main and North Post prior to the 1960s, none of the operational ranges encumbered the Nashua River.

During construction of Hospital Road Bridge in the 1960s which involved excavation within the Nashua River for new bridge abutments, there were no reported discoveries of munitions. In addition, the Army performed munitions surveys within the Nashua River in 1995 based on the Former Fort Devens Archive Search Report. Survey areas included (1) the area near the Hospital Road Bridge where the hand grenade was found in the summer of 2020; and (2) an area along and within the Nashua River that borders the Former North Post. During these surveys, the Army did not encounter UXO or DMM.

Prior to this survey and based on both historical information, including previous investigations, and use, the Army had determined there was a low probability for munitions to be present in the areas that made up the cantonment (i.e., the main and north post administrative support areas). In compliance with the Defense Explosive Safety Regulation (DESR) 6055.9 Edition 1 and in consideration of the RSE results, USACE determined that the Nashua River has a "Low Probability" for encountering munitions. This Low Probability Assessment is consistent with areas on Former Fort Devens given the type of historical military use.

The RSE concluded that based on scenarios where munitions have been recovered in areas where munitions would not reasonably be expected to be encountered, the Army believes an individual (e.g., a veteran, a Soldier) most likely discarded the munitions recovered to dispose of them to avoid turning them over to the police or military for disposal. There is no evidence the Army used the banks of the Nashua River or the river itself for munitions-related operations. The most likely source of potential munitions in the Nashua River is due to DMM. Please note magnetic fishing has been prohibited along this portion of the Nashua River and advisory signs are in place.

Physical Profile:

River Characteristics:

The Nashua River is a slow-moving river with a bottom that contains a heavy layer of silt that significantly limits the opportunity for munitions to migrate down river. The river flows northward from its impoundment at Wachusett Reservoir to the Merrimack River in Nashua, New Hampshire. In contrast, all of the river's major tributaries flow in a southeasterly direction (nashuariverwatershed.org).

In the river, variety of emergent plant-life like pickerel weed (*Pontederia cordata* L.), cattails (*Typha latiflia*) and many different sedges and rushes exists. Floating on the surface of the river, in calm areas, wolfia (*Wolffia columbiana* Karst) and duck weed (*Lemns minor*) can be seen (nashuariverwatershed.org). The NRWA periodically conducts removal of invasive water chestnut plants from the area.

Geologic Setting:

The bedrock underpinning of the Nashua River watershed is made up of two types of rock: granite and some other igneous types of rock, and metamorphic rock, primarily schist and gneiss. The central part of the Nashua River watershed is dominated by sand and gravel deposits created by the valley's history of glaciations. These deposits are the groundwater source for many of the watershed's municipal water supplies (nashuariverwatershed.org).

Geology/Aquifers:

The geology of Fort Devens was chiseled by the continental glaciers of the Pleistocene epoch. The glaciers deepened existing river valleys by eroding the bedrock and depositing till poorly sorted clay, silt, and sand, glacial outwash well sorted, sandy deposits from rivers and melting glaciers, drumlins hills of till, kames hills of sand, kettles depressions caused by buried blocks of ice that melt, and other landforms characteristic of glacial terrain. The bedrock beneath the unconsolidated glacial sediments consists primarily of metamorphic rocks old crystalline rocks.

Groundwater exists at Fort Devens in two geologic formations. The primary aquifer is the glacial drift that overlies the bedrock. This aquifer consists of well sorted sands and gravels, fine sands, silt, and clay and is known as the glacial outwash aquifer. It is capable of supplying large quantities of water. The aquifer is used by Fort Devens and nearby municipalities for water supply. Groundwater is also present in the fractured bedrock beneath the glacial outwash aquifer. The bedrock has a low permeability because groundwater only moves in fractures in the rock. It is not capable of supplying large amounts of water. It is used for single family domestic water supply in the area of Fort Devens (Engineering Technologies Associates, 1993).

<u>Climate:</u>

The average high in Devens, MA is 59.7 degrees Fahrenheit (°F) and average low is 37.1°F. The hottest month is July, and the coldest month is January. Annual rainfall is 47 inches. The rainiest month is October with an average of 4.46 inches. Annual snowfall is 51.9 inches. The snowiest month is January with an average of 16.3 inches (ww.milbases.com).

<u>Release Profile:</u>

Potential for DMM to be found in the study area. Based on the findings of the RSE, DMM was thrown by hand into the river, falling through the water column to the surface of the riverbed with no penetration depth. Current models of munitions mobility in underwater environments have demonstrated that munitions-like items mainly have upward mobility due to the currents scouring of sediments around and under the item. Items have very limited downward mobility in some cases due either liquefaction or sediment deposits covering the item. In those cases, the downward mobility is limited to moving the object just below the sediment surface where the downward forces are no longer driving movement. In order for a DMM to be deposited significantly below the sediment surface in this area, a significant event (i.e., dam construction, mudslide, meandering riverbed) would have taken place.

<u>Land Use and Exposure Profile:</u>

<u>Current/Future Land Use:</u> The river is currently used for recreational purposes. This use is not expected to change.

<u>Receptors:</u> Area workers (MDoT divers), recreational users

<u>Exposure Pathways:</u> Potential for area workers and recreational users to find DMM within the top foot of sediment in the AOPIs based on the release profile.

QAPP WORKSHEET #11 – PROJECT/DATA QUALITY OBJECTIVES

<table>
<tr><th>DQO Steps and Description</th><th>DQO Step Activity</th></tr>
<tr><td>1) State the Problem</td><td>Based on recent military munitions discoveries in 2020 and 2021, an approximate 3-mile stretch of the Nashua River has been delineated that includes five AOPIs within the study area. It is not known whether unacceptable explosive hazards to area workers and recreational users remain within the study area.</td></tr>
<tr><td>2) Identify the Goal of the Project</td><td>The goal for this military munitions investigation is to assess whether an explosive safety hazard remains within the Nashua River study area.

<u>Principal study questions:</u>
• Is there an explosive safety hazard to area workers and recreational users in the AOPIs and/or the approximate 3-mile area of the Nashua River defined as the study area?

<u>Alternative outcomes:</u>
• Geophysical survey results in detection of no geophysical anomalies (other than blind seeds)
• Resulting saturated response areas (SRAs) in the geophysical mapping data prevent reliable identification of discrete target locations
• The nature of geophysical anomaly sources cannot be confirmed and/or extracted by hand due to size and/or depth below river bottom
• Lateral extent of high geophysical anomaly density areas appears to extend beyond an AOPI footprint

<u>How the data will be used in solving the problem:</u>
Geophysical survey and follow-up intrusive investigation results will inform the project team’s decisions with regards to remaining explosive hazards and potential next steps for the study area.</td></tr>
<tr><td>3) Identify Information Inputs</td><td>The information identified below is needed to answer the principal study question
• Locations of obstructions and underwater navigation hazards
• Water depths within the study area
• Geophysical system validation results
• Geophysical target threshold
• Geophysical target locations and distribution within the study area
• Geophysical sensor survey paths within the study area
• Geophysical system QC and function test results
• Blind seed performance results
• Dig list
• UXO diving and target reacquisition QC and function test results
• Types and quantity of recovered military munitions
• Description of nature and disposition of geophysical anomaly sources</td></tr>
<tr><td>4) Define the Boundaries of the Project</td><td><u>Target population:</u> The target population includes DMM potentially present in the river. This population includes military munitions equivalent to and larger than the size of a MKII hand grenade.</td></tr>
</table>

DQO Steps and Description	DQO Step Activity

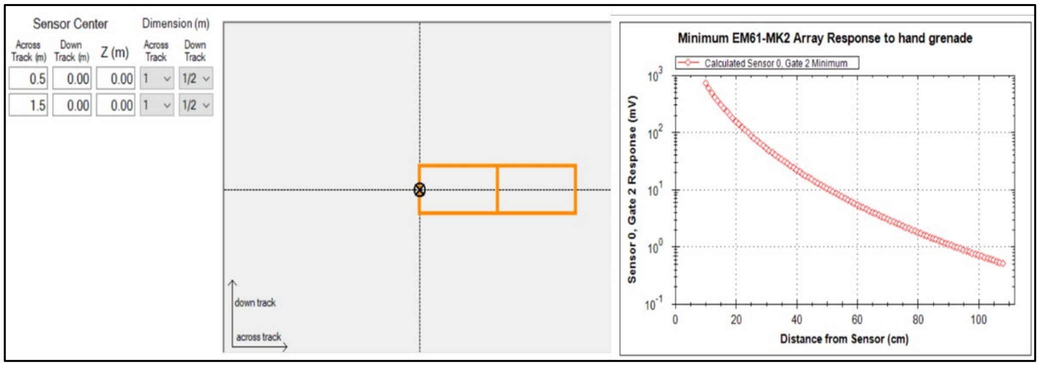
	<u>Spatial and temporal boundaries:</u>
	• The lateral extent of the investigation is the footprint of the study area shown in Figure A-3 in Appendix A.
	• The vertical boundary is represented by the project performance objective of detection of MKII hand grenades to 1 foot below the river bottom. The target selection threshold to ensure a detection depth of a hand grenade at 1-foot bgs was selected based on detection capabilities of industry standard equipment when considering the smallest items of concern at their least favorable orientation. There is a low probability that items would be present below that depth and based on the CSM and location conditions. This target selection threshold has the ability to detect hand grenades deeper than 1-foot bgs but will ensure detection of potential DMM at their anticipated depth at this location.
	
	<u>Temporal boundaries:</u>
	• Seasonal conditions (e.g., fall/low water levels, winter/ice) that could limit site access, equipment performance, or schedule.
	    • Late fall issues that could impact a UDGM survey include overhead tree foliage impeding global positioning system (GPS) reception if leaves are still on trees, low water levels that could reduce boat accessibility, underwater foliage impacting underwater survey equipment, and a shortened workday due to reduced day light hours).
	    • In winter, the boats will not be able to access the river if it is covered with ice. Additionally, there are safety concerns with operating boats in potential icy conditions. Divers cannot safely dive if the water is below 34°F, and the optimal temperature for diving starts at 45°F.
	
	<u>Access constraints:</u>
	• There is limited access to the study area for boats. Access to the study area from the north is blocked by an upstream low dam. Access from the south is possible, via the only known boat ramp approximately 3 miles south of the study area at the Oxbow National Wildlife Refuge.
	• The DGM survey vessel planned for use on this project can operate in water depths between approximately 2 and 15 feet deep.
	• Diving operations will not be conducted when there is ice on the river, or the water temperature is below 34°F.

5) Develop the Project Data Collection and Analysis Approach	Data collection includes side scan sonar (SSS)/bathymetry surveys, followed by a UDGM survey and intrusive investigation of the dig list by UXO divers. Additional investigation details are provided in Worksheet #17. Prior to the start of data collection, temporary control points will be established by Tetra Tech's subcontracted Massachusetts-registered professional land surveyor (PLS). **SSS/Bathymetry Survey** The SSS and bathymetry survey will be conducted simultaneously along survey lines spaced nominally 25 feet apart providing effective 100% coverage of the study area (including the AOPIs). The results of this survey are intended to inform the UDGM

DQO Steps and Description	DQO Step Activity
	mission planning by documenting underwater obstructions and navigation hazards, including water depths too shallow to operate the survey vessel. <u>Parameters of interest:</u> Positions of underwater hazards and navigation hazards, water depths within the study area. <u>Assumptions:</u> The study area is accessible with the planned survey vessel to obtain effective 100% coverage with the SSS/bathymetry surveys. <u>Type of inference:</u> Locations of underwater obstructions and navigation hazards will be digitized in the processed SSS/bathymetry data and incorporated into the survey planning for the UDGM survey. <u>Decision rules:</u> • If an obstruction or underwater navigation hazard within an AOPI is identified in the SSS/bathymetry data, then its location will be digitally incorporated into the survey mission plan for the UDGM survey. • If the obstruction/navigation hazard necessitates deviation around the feature, then the feature will be identified as an explained UDGM data gap and will be appropriately displayed in the DGM results maps and project geographical information system (GIS). **UDGM** UDGM surveys will be conducted using NAEVA/3Dg's shallow water survey vessel and the underwater UXO Towed Array Light (UUTA-LT), which uses two side-by-side Geonics, Ltd. (Geonics) EM61-Flex3 sensors. Within the AOPIs, data collection will be performed along a nominal survey line spacing of 5 feet; this spacing intends to provide an estimated 1.6 feet of array overlap between successive passes covering the entire AOPI, less obstructions. An additional 3 miles of single-pass UDGM data will be collected along the Nashua River outside the footprint of the AOPIs, spanning the length of the study area from south to north. These line paths will track as close as possible to the water edge while still being able to safely navigate the survey vessel in enough water and avoid underwater hazards as determined during the bathymetry survey. <u>Parameters of interest:</u> Root mean square (RMS) noise, target picking threshold, derived geophysical target locations with response amplitude exceeding the picking threshold, target count and target distribution within each AOPI, and the areas outside of the AOPIs. <u>Assumptions:</u> Using the EM61-MK2 Response calculator tool developed by Naval Research Laboratory (NRL), a hand grenade buried 12 inches below the river bottom in its least favorable orientation (i.e., horizontal) has a predicted 3 milliVolt (mV) response amplitude on Channel 2 and 1.3 mV on Channel 3 with a standard EM61-MK2 sensor. This is also the predicted response with the grenade located at the outer edge of the coil array (Figure 11-1) and at a 16-inch flight height. This flight height translates to a 28-inch total distance of the hand grenade from the sensors (i.e., height of the sensor array plus burial depth). This survey design accounts for the minimum detection threshold at the outer edge of the array given the outermost passes along the edges of the AOPIs will have no overlapping survey passes. An additional underlying assumption for this project is that RMS noise levels are adequate for meeting the performance objective.

DQO Steps and Description	DQO Step Activity

Figure 11-1. EM61-MK2 Array Minimum Channel 2 Response for Hand Grenade



The NRL response calculator tool assumes use of a standard 12-Volt EM61-MK2 transmitter, whereas the UUTA-LT will include a high-power transmitter at 24 volts. This high-power transmitter facilitates a greater signal-to-noise ratio (SNR) as the sensor is flown above the river bottom. According to Geonics, the high-power transmitter provides an eightfold increase in the amount of signal received and typically yields 45 to 60% greater depth of detection than a standard power transmitter. The project-specific target picking threshold will be established based on data collected at the project location. The discussion of predicted response using the NRL response surveys is provided to demonstrate the assumptions for the 16-inch planned array flight height as part of the survey design.

<u>Type of inference:</u> Discrete target locations derived from the UDGM data, and which meet the established picking criteria will be evaluated by the project team for inclusion on the dig list.

<u>Decision rules:</u>

- If a geophysical anomaly exceeds the established detection criteria, then it will be added to the target list.
- If the target is considered invalid (e.g., noise pick), then it will be appropriately commented in the target list by the UDGM data processor but will still be included in the resulting target list.
- If ≤500 discrete targets are identified, then 100% of the targets will be added to the dig list, reacquired, and intrusively investigated.
- If >500 discrete targets are identified, then the project team will discuss a prioritization scheme to determine which 500 targets will be reacquired and intrusively investigated.
- If an SRA (i.e., defined area where discrete target locations cannot be reliably derived) is identified within an AOPI, then the project team will discuss a path forward with how to address the SRA during the intrusive investigation.
- If the study area coverage goal of 100% cannot be achieved using UDGM methods for each AOPI due to challenging navigation conditions or underwater

<table>
<tr><th>DQO Steps and Description</th><th>DQO Step Activity</th></tr>
<tr><td></td><td>obstructions or hazards, then the project team will discuss a path forward for obtaining usable data to meet the investigation objective.

Underwater Intrusive Investigation
Tetra Tech's certified UXO divers will perform all dive work. The Dive team boat and safety/chase boat will be deployed from the Oxbow National Wildlife Refuge boat ramp. The team will intrusively investigate up to 500 targets and conduct military munitions/ munitions potentially presenting an explosive hazard (MPPEH) management and disposition, including demolition of five military munitions targets.

After completion of the geophysical survey and compilation of the target list, the project team will meet to discuss an appropriate search radius to be used by UXO divers around each UDGM target location. Because of the inherent challenges in positioning during UDGM data collection, this discussion will be informed by the documented blind seed positioning accuracy results and daily UIVS survey results tracked during the UDGM survey.

<u>Parameters of interest:</u> The nature, quantity, position, and depth of each recovered source.

<u>Decision rules:</u>
If the project team convenes in accordance with the decision rules from the preceding UDGM section, then that meeting will also include a discussion of a search radius. Otherwise, a meeting on the intrusive investigation search radius will be its own stand-alone meeting.
If the blind seed positioning accuracy varies from one AOPI to the next, resulting from localized conditions (e.g., stronger localized water currents around structures), then the project team will discuss whether the size of the search radius by UXO divers could vary between AOPIs during intrusive investigation.
If the UXO diver is not able to reach a target because it's too deep in the sediment for manual excavation to safely investigate the target, then it will be recorded as such.
If no geophysical anomaly is detected within the agreed-upon UDGM target search radius by UXO divers using underwater analog instruments, including during step-out searches, then the dig result will be recorded as a "No Contact".
If "No Contact" results are identified in the dig results, then the UXOQCS will inspect 100% of these locations in the field.</td></tr>
<tr><td>6) Specify Project-Specific MPC</td><td>Project-specific MPCs are presented in Worksheet #22.</td></tr>
<tr><td>7) Develop the Detailed Plan for Obtaining Data</td><td>The RSE design is summarized below and detailed in Worksheet #17 and accompanying SOPs. Worksheet #17 presents the project DFWs.
Temporary control points will be established by Tetra Tech's subcontracted land surveyor.
SSS and bathymetry surveys will be conducted prior to UDGM surveys to support mission planning for the UDGM transect survey.</td></tr>
</table>

DQO Steps and Description	DQO Step Activity
	• NAEVA/3Dg will process the SSS and bathymetry data and a GIS shapefile will be produced from the list of obstructions and uploaded into the navigation system of the UDGM vessel prior to data acquisition. • Blind seeding of the UDGM transects will occur between the SSS/bathymetry survey and start of the UDGM survey. • A UDGM survey will be completed across the 5 AOPIs using a planned line spacing of 5 feet within each AOPI. • An additional 3 miles of single pass transect collection will be collected outside the AOPI footprints by the UDGM survey team. • The sensor array will be flown at a nominal height of 16 inches above the river bottom. Exceptions will include localized areas where the UUTA-LT array must be raised to avoid an underwater obstruction or hazard. • ≤500 discrete target locations will be intrusively investigated. • UXO divers will reacquire target locations using integrated GPS and underwater navigation technology and will pinpoint anomaly sources using underwater analog geophysical instruments. • Military munitions/MPPEH will be managed in accordance with the approved Explosives Siting Plan (ESP) (Appendix F). • The anomaly resolution process will qualitatively evaluate recovered sources by the UXO divers to assess whether the recovered object(s) are consistent with the geophysical anomaly characteristics. • QC reviews during each phase of data collection will assess usability of the data and results to meet the project objectives.

QAPP WORKSHEET #12 – PROJECT MPC

Table 12-1. Measurement Performance Criteria

Measurement	Data Quality Indicator	Specification	Activity Used to Assess Performance
Survey Area Preparation			
1. Accessibility	Completeness	Inaccessible portions of AOPIs (e.g., land portions) and known navigation hazards are identified in master GIS.	• Initial SSS and bathymetry survey results will inform the assessment of accessibility for follow-up UDGM survey. Documented obstructions or inaccessible conditions will be incorporated into the GIS. • Lead organization will visually inspect the location and/or review the GIS.
2. Survey Control	Accuracy/Completeness	Initial temporary control points at the beginning of the project are independently established by professional land surveyor (PLS) and conform to third order accuracy (1:10,000).	• Land surveyor report
Sampling Design			
3. Study area coverage design	Representativeness/ Completeness	Survey design includes 100% coverage of accessible portions of each AOPI. Exception: Known inaccessible conditions (e.g., bridge abutments, shallow water) or underwater obstructions from SSS/bathymetry survey.	• Project team reviews GIS, areas identified as inaccessible prior to start of UDGM survey and the reasons for this designation. • Review SSS/bathymetry survey results and assesses potential gaps in survey coverage within AOPIs prior to start of UDGM survey.
4. Detection threshold	Sensitivity	Survey design, system performance and SNR facilitate detection of a hand grenade to a depth of 12 inches below the river bottom. Exception: locations where sensor array altitude must increase to avoid an underwater navigation hazard.	• Reviews daily field logs and checklists to confirm survey specifications are as planned and conditions requiring deviations are noted. • Review initial and ongoing sensor response and RMS noise at Underwater Instrument Verification Strip (UIVS). • Review RMS noise from within AOPI and assess relative to UIVS location. • Review running QC summaries.

Measurement	Data Quality Indicator	Specification	Activity Used to Assess Performance
			• QC Geophysicist reviews blind seed performance.
SSS/Bathymetry Survey			
5. Achieved survey coverage	Completeness	Data coverage (i.e., quantity) and quality are appropriate for intended purpose of supporting UDGM planning and meeting the project objectives.	• Review survey line paths and achieved digital data coverage. • Review daily field reports for explanation of excepting conditions. • Review survey performance relative to Worksheet #22 requirements and excepting conditions.
UDGM Data Acquisition			
6. Achieved survey coverage	Accuracy/ Completeness	Data coverage (i.e., quantity) and quality are appropriate for intended purpose of informing planned intrusive investigation of targets and meeting the project objectives.	• Review daily and weekly field reports for explanation of unexpected conditions and known survey line path deviations. • Review survey performance relative to Worksheet #22 requirements and excepting conditions. •
7. Blind seeding	Accuracy/ Completeness	Blind seed rate facilitates UDGM survey team encountering at least one seed per day of initial data collection. Additionally, 100% of blind seeds (QA and QC seeds) detected within tolerance. Exceptions: Onset of inclement weather or hardware problems prematurely shut down daily operations; seed location is found by on-site personnel to have been physically moved from its emplaced location prior to surveying; and workdays where gap-fill collection is performed to meet data density and data coverage requirements are excluded to avoid need for additional underwater QC seeding.	• QC Geophysicist reviews blind seed performance. • USACE Geophysicist reviews blind seed plan and evaluates QA seed performance. • USACE Geophysicist reviews applicable RCAs and concurs with CAs. • DGM report summarizes blind seed performance and relevancy to data usability.

Measurement	Data Quality Indicator	Specification	Activity Used to Assess Performance
Intrusive Investigation			
8. Target reacquisition during intrusive investigation	Accuracy	Derived UDGM target location accuracy facilitates reacquisition and recovery of anomaly source by UXO dive team within maximum search radius of ±6.6 feet.	• Review target positions relative to UDGM array line paths • Geodetic function test with topside positioning system and positioning system used during reacquisition • UIVS results • Review running QC summaries. • QC Geophysicist reviews blind seed performance and offset of derived target relative to ground truth.
9. Anomaly resolution	Accuracy/ Completeness	100% of discrete target locations on dig list are intrusively investigated. Excavation proceeds until anomaly source is identified, the excavation reaches a depth of 24 inches below the river bottom, or depth of refusal, whichever comes first. Targets below 24 inches will be recorded as too deep. Exception: Unsafe underwater dive conditions prevent access or completion of target location. Additionally, if >500 discrete targets are identified, locations not prioritized for digging will not be investigated.	• UXOQCS inspection of dig location • Review running QC summaries • QC Geophysicist reviews dig results and evaluates recovered source relative to UDGM anomaly characteristics.
10. Blind Seed Recovery	Completeness	100% of blind seeds are recovered by the UXO divers during intrusive operations. Exception: seed location is found by on-site personnel to have been physically moved from its emplaced location prior to target reacquisition.	• UXOQCS tracks seed recovery during intrusive operation. • QC Geophysicist reviews dig results and verifies seeds in blind seed registry are recovered at expected locations.

QAPP WORKSHEET #13 – SECONDARY DATA USES AND LIMITATIONS

Table 13-1. Secondary Data Uses and Limitations

Data type	Source	Data uses relative to current project	Factors affecting the reliability of data and limitations on data use
Historical data review and background information	• RSE	• Identifies prior munitions recovered in study area • Determined that Former Fort Devens never used the Nashua River or its riverbanks for munition-related purposes.	• None noted.

QAPP WORKSHEET #14 & #16 – PROJECT TASKS AND SCHEDULE

Task Name	Duration	Start	Finish
CLIN 0002 - Approved MR-QAPP and APP/SSHP			
MR-QAPP - Current review durations are based on the FFA. The Army is committed to expediated review times associated with their tasks. If the USEPA/DEP takes step to reduce the review timeframes, surveys/UDGM fieldwork may be able to start sooner (i.e., Fall 2022) as long as field conditions are safe and will provide valid data results.			
Submit Draft MR-QAPP to USACE & USEPA for concurrent review	1 day	7/18/2022	7/18/2022
Army Review of Draft MR-QAPP	13 days	7/19/2022	8/1/2022
USEPA/DEP review of Draft MR-QAPP	43 days	7/19/2022	8/31/2022
Army Submits Draft Final MR-QAPP to USEPA/DEP	30 days	8/31/2022	9/30/2022
USEPA/DEP Review of Draft Final MR-QAPP	41 days	9/30/2022	11/10/2022
Army Submits Final MR-QAPP to USEPA/DEP	20 days	11/11/2022	11/30/2022
APP/SSHP			
Tetra Tech Prepare and Submit APP/SSHP to USACE for review	69 days	5/11/2022	7/18/2022
USACE Review of APP/SSHP	8 days	7/19/2022	7/26/2022
Comment Resolution Period	72 days	7/27/2022	10/7/2022
Tetra Tech Submits Final APP/SSHP	1 day	10/7/2022	10/7/2022
CLIN 0003 - Underwater DGM Survey			
Mobilization of Tetra Tech Field Management Team (final date of mobilization will be based on field conditions to ensure safety of field personnel; work cannot be conducted in icy water)	1 day	2/27/2023	2/27/2023
Install Temporary Control Points	1 day	2/28/2023	2/28/2023
Side Scan Sonar (SSS)/Bathymetry Surveys			
Mobilization of Subcontractor Field Survey Team	1 day	2/27/2023	2/27/2023
Conduct SSS/Bathymetry Survey	2 days	2/28/2023	3/1/2023
Demobilize Subcontractor Field Personnel (survey vessel and equipment hardware remain local)	1 day	3/2/2023	3/2/2023
Process Survey Data; Prepare and Submit Data Packages to USACE	15 days	3/3/2023	3/17/2023
Civil Survey and QC Seeding			
QC Seeding Team Mobilization	1 day	3/22/2023	3/22/2023
Conduct QC Seeding	1 day	3/23/2023	3/23/2023
Administratively Support Government QA Seeding	1 day	3/24/2023	3/24/2023
UDGM Survey			
Re-mobilization of Subcontractor Field Personnel	1 day	3/27/2023	3/27/2023
Install UIVS and Conduct UIVS Surveys	1 day	3/28/2023	3/28/2023
Prepare and Submit UIVS Technical Memorandum for USACE Review	7 days	3/29/2023	4/5/2023
Conduct UDGM Survey	7 days	3/29/2023	4/5/2023
Demobilization of Subcontractor Personnel and Equipment and Tetra Tech Field Management Team	3 days	4/6/2023	4/8/2023
Process UGM Data and Submit Data Packages for USACE Review	14 days	4/7/2023	4/20/2023

Task Name	Duration	Start	Finish
<u>DGM Report</u> - Current review durations are based on the FFA. The Army is committed to expediated review times associated with their tasks. If the USEPA/DEP takes step to reduce the review timeframes, intrusive fieldwork may be able to start sooner as long as field conditions are safe and will provide valid data results. Additionally, with Army and USEPA agreement, review and acceptance of the Target Dig List may be separated from DGM Report, to accelerate the schedule, with the understanding that no additional targets can be added to the Dig List once dive work commences.			
Prepare and Submit USACE Draft DGM Report and Target Dig List	48 days	4/12/2023	5/30/2023
USACE Review Draft DGM Report and Target Dig List	30 days	5/31/2022	6/30/2023
Comment Resolution Period and Submit Stakeholder Draft DGM Report and Target Dig List	22 days	7/1/2023	7/23/2022
USEPA/DEP review of Draft DGM Report and Target Dig List	45 days	7/24/2022	9/7/2023
Army Issues Response Letter to USEPA/DEP Comments on Draft DGM Report and Target Dig List	45 days	9/8/2023	10/23/2023
USEPA/DEP Review of Response Letter	15 days	10/24/2023	11/8/2023
Army Submits Draft Final DGM Report and Target Dig List to USEPA/DEP	30 days	11/9/2023	12/8/2023
USEPA/DEP Review of Draft Final DGM Report and Target Dig List	45 days	12/9/2023	1/23/2024
Army Submits Final DGM Report and Target Dig List to USEPA/DEP	1 day	1/24/2024	1/24/2024
Army and USEPA/DEP Acceptance of Data Packages and Target List	1 day	1/25/2024	1/25/2024
CLIN 0004 - Underwater Intrusive Investigation			
<u>Intrusive Investigation</u> - Dive work must be conducted in water > 34 degrees and preferably >45 degrees, which will drive final scheduling of this task. Current schedule assumes March for mobilization.			
Team Mobilization	1 day	3/11/2024	3/11/2024
Project Specific Training and Equipment Set-up & Testing	2 days	3/12/2024	3/13/2024
USACE Dive Inspection	1 day	3/14/2024	3/14/2024
Intrusive Investigation/Demolition Operations of UDGM Targets	30 days	3/15/2024	4/15/2024
MDAS Inspection and Disposal of MDAS and non-munitions related debris	1 day	4/16/2024	4/16/2024
Cleanup and Shipping out of Equipment	1 day	4/17/2024	4/17/2024
Demobilization	3 days	4/18/2024	4/20/2024
<u>RSE Addendum</u>			
Prepare and Submit USACE Draft RSE Addendum	45 days	4/23/2024	6/7/2024
USACE Review Draft RSE Addendum	30 days	6/8/2024	7/8/2024
Comment Resolution Period and Submit USEPA/DEP Draft RSE Addendum	22 days	7/9/2024	7/31/2024
USEPA/DEP review of Stakeholder Draft RSE Addendum	45 days	8/1/2024	9/16/2024
Army Issues Response Letter to USEPA/DEP Comments on Draft RSE Addendum	45 days	9/17/2024	11/1/2024
USEPA/DEP Review of Response Letter	15 days	11/2/2024	11/18/2024
Army Submits Draft Final RSE Addendum to USEPA/DEP	30 days	11/19/2024	12/19/2024
USEPA/DEP Review of Draft Final RSE Addendum	45 days	1/27/2025	2/3/2025
Army Submits Final DGM Report to USEPA/DEP	1 day	2/4/2025	2/4/2025

*When the Finish date falls on a weekend based on duration, the date has been changed to the next business day.

QAPP WORKSHEET #17 – SURVEY DESIGN AND PROJECT WORK FLOW

This investigation includes collection of initial SSS/bathymetry data, UDGM surveying using NAEVA/3Dg's UUTA-LT and intrusive investigation of anomaly sources by Tetra Tech UXO divers. The UUTA-LT has a swath width of 6.6 feet. Positioning during data collection and target reacquisition will be maintained using a real-time kinematic (RTK) GPS.

Table 17-1 summarizes the project workflow and presents the project DFWs. The DFWs are presented in sequential order of execution, with applicable critical questions and decision points identified within the process. This table also lists the outputs associated with each DFW and applicable Tetra Tech and subcontractor SOPs.

Tetra Tech's quality system includes SOPs which are also used to govern projects that include advanced geophysical classification (AGC) and AGC-related support tasks. AGC will not be implemented on this project. However, relevant SOPs for this project may include "AGC" in the procedure title. A complete listing of SOPs applicable to this project is in Worksheet #21.

Table 17-1. Project Workflow and Documentation

DFW	Title	Documentation	Applicable SOPs
1	Site Setup and Temporary Control Points	• Preparatory and initial inspection records • Daily field production reports • Functional check area (FCA) construction details • Control point data • Weekly DGM QC report • SOP checklist • Land surveyor report • Updated master project database	• AGC SOP 11
2	SSS/Bathymetry Survey	• Preparatory and initial inspection records • Daily field production and QC reports • Weekly DGM QC report • Updated project GIS • Running QC summary • Updated master project database	• NAEVA/3Dg SOP 1
3	QC Seeding	• Daily field production and QC reports • Weekly DGM QC report • Running QC summary • Updated master project database • Blind seed registry	• AGC SOP 11
4	UIVS	• Processed UIVS data package • UIVS ground truth locations • Running QC Summary • Updated master project database • UIVS Technical Memorandum	• NAEVA/3Dg SOP 2
Critical Question: Were IVS MQOs achieved? If yes, proceed to DFW 5. If no, initiate failure response measures in Worksheet #22.			
Critical Decision Point: USACE review of UIVS Technical Memorandum and concurrence with target picking threshold.			
5	UDGM Survey	• Daily field production and QC reports	• NAEVA/3Dg SOP 2

DFW	Title	Documentation	Applicable SOPs
		• Weekly DGM QC report • Processed UDGM data packages • Running QC summary • Updated master project database • Dig List • UDGM Report	• AGC SOP 13
Critical Question: Were UDGM survey MQOs achieved? If yes, proceed to DFW 6. If no, initiate failure response measures in Worksheet #22.			
Critical Decision Point: USACE QA acceptance of UDGM data packages and concurrence with dig list.			
6	Target Reacquisition, Underwater Intrusive Investigation, Identification of Sources, and Military Munitions and MPPEH Inspection, Verification, and Certification	• Daily field production and QC reports • Weekly DGM QC report • Running QC summary • Updated master project database • Military Munitions Log and photos • Explosives receipt and expenditures records • Material documented as safe (MDAS) disposal form (1348-1) • MDAS final destruction letter	• Dive SOP 1 • Dive SOP 2 • Dive SOP 3 • UXO SOP 1 • UXO SOP 2
Critical Question: Were intrusive investigation MQOs achieved? If yes, proceed to DFW 7. If no, initiate failure response measures in Worksheet #22.			
Critical Decision Point: USACE QA acceptance of dig packages and demolition records.			
7	Prepare and Submit RSE Addendum	• Final project GIS • Final master project database • Revised CSM (as applicable) • RSE Addendum	• AGC SOP 13
Critical Decision Point: USACE and stakeholder acceptance of final deliverables and RSE addendum.			

Training in support of this project will be conducted both prior to mobilization to the project location and after personnel arrive for the start of field tasks. Prior to mobilization, a field readiness review will be conducted.

The UXOSO will provide a project-specific safety briefing for project personnel new to the project location as well as project visitors. This safety briefing will cover explosive hazards, emergency evacuation routes, directions to the nearest hospital as well as general project-specific hazards and personal protective equipment requirements. The SUXOS will provide an orientation to the project and review project objectives. Subcontractor personnel will review their applicable activity hazard analysis (AHA) prior to starting field work. Documentation of training sessions and briefings will be on applicable signature forms in the governing MR-QAPP and Accident Prevention Plan (Appendix E).

17.1 DFW 1: Survey Area Setup and Temporary Control Points

Survey Area Setup: Tetra Tech UXO personnel will prepare the survey area for the start of field work and initiate contact with local project stakeholders and emergency response personnel (as necessary).

Temporary Control Points: Our land surveying subcontractor will establish project-specific control near the study area IAW Tetra Tech's AGC SOP 11. Control will be established to a minimum of third-order accuracy (1:10,000) and will be referenced to a high-accuracy reference network (HARN), continually operating reference station (CORS), Virtual Reference Station (VRS), or equivalent available network. Temporary control points will be established to facilitate performing topside positioning system function checks during UDGM surveying and target reacquisition during intrusive operations. The land surveying subcontractor will issue a survey report documenting field and correction methods used, relevant field observations, temporary control point measurement details and verification of conformance to the required accuracy. The work will be conducted under the supervision of a Massachusetts-registered PLS. The PLS will also sign the surveyor report.

17.2 DFW 2: SSS/Bathymetry Survey

SSS/Bathymetry Surveys: NAEVA/3Dg will collect SSS and bathymetry data IAW NAEVA/3Dg SOP 1 prior to the UDGM survey. Survey lines will be nominally spaced 25 feet apart to gather bathymetry data over 100% of the entire study area. The systems will be set up in the field to maximize the resolution of the imagery relative to environmental conditions.

The SSS survey will be completed using an Edgetech 4125 system, a fully digital, simultaneous dual frequency sonar system designed to identify subsea contacts and analyze seabed conditions in real time. The sonar system will be deployed with a hull mount on the survey vessel.

SSS/Bathymetry Field QC: Field QC includes a “rub test” on the SSS transducers to verify the sensor is operational. A geodetic function check of the topside GPS is performed using established temporary control points. Additionally, a SSS test line (similar to an IVS) is collected across a known, visible target location. Examples may include a fixed point, feature on the boat ramp, or along the shoreline. This point is recorded using RTK GPS and subsequently targeted in the SSS data. The test line facilitates an assessment of repeatability in targeting the feature in data each day SSS surveying is performed.

SSS/Bathymetry Data Processing: NAEVA/3Dg will process the SSS and bathymetry data IAW NAEVA/3Dg SOP 1. Identified bottom obstructions will be catalogued in a spreadsheet with coordinates for each potential obstruction. A GIS shapefile will be produced from the list of obstructions and uploaded into the navigation system of the UDGM vessel prior to data acquisition. Additional deliverables will include a color-shaded contour map of the bottom depth data, target map showing interpreted bottom obstructions and survey exclusion zones, and SSS bottom obstruction target table including geo-referenced locations, target dimensions, and target image snippets.

17.3 DFW 3: QC Seeding

Prior to the UDGM survey, the QC Geophysicist and UXOQCS will emplace blind QC seeds within the AOPIs. The AOPI transects will be seeded at an average rate of two seeds per AOPI, for a total of ten QC seeds. Seven seeds will comprise small industry standard object (ISO) (McMaster Carr Part No. 44615K466), and three will comprise medium ISOs (McMaster Carr Part No. 44615K529).

Seed emplacement will be performed from a topside vessel using sections of polyvinyl chloride pipe outfitted with a level bubble and RTK GPS to facilitate accurate seed measurements in the river environment. The seeds will be considered surface seeds and will be placed in a horizontal orientation on the river bottom. The measured response from the UUTA-LT array will be evaluated against the predicted response relative to the calculated array position and the derived target location. The seed ground truth information will be compiled in a seed registry by the Tetra Tech QC Geophysicist and provided to the USACE Geophysicist in advance of the UDGM survey.

The seed registry will be maintained in accordance with the Blind Seed Firewall Plan (Appendix B). The seeds will physically remain in place throughout the duration of field work. This process will allow for verification of the following: 1) seeds are picked as targets and added to the dig list; 2) target reacquisition by UXO divers is accurate; and 3) the seeds are recovered at each expected location to demonstrate the search radius was appropriate.

17.4 DFW 4: UIVS

Prior to the start of data collection, the NAEVA/3Dg field crew will assemble the UUTA-LT and perform initial topside function checks on the sensor and positioning system. The assembled sensor array will be photographed to document assembly of the geophysical sensors as well as other sensors mounted to the survey vessel.

NAEVA/3Dg will establish a UIVS to use for initial validation of the UUTA-LT system and as part of ongoing QC tests during survey execution. The IVS will be established in an easily accessible portion of the project location that is relatively free of anomalies. NAEVA/3Dg will use a marine electromagnetic (EM) sensor to select a final IVS location that is sufficiently free of background anomalies, including a line for seed items and a line for dynamic background noise measurements. The IVS will be constructed in an area with water depths less than approximately 10 feet. Once a suitable location is identified, the NAEVA/3Dg team will emplace seeds on the river bottom from the UDGM vessel and record RTK GPS positions of the seeds. The seeds will be placed in the IVS, without diver assistance using the DGM survey vessel, and distributed approximately 50 feet apart to prevent overlapping signals. The items will be placed horizontally to prevent subsequent accidental movement due to currents, wave action, or tidal forces. With the survey vessel held in a fixed position (anchored from both the bow and stern) the seeds will be placed by sliding the barbell weights down a leveled survey pole to the sediment floor where they will sit proud the bottom. An RTK DGPS attached to the survey pole will be used to record the position of the seeds. The IVS seeds will not be placed near anomalies identified during the background survey.

The seed parameters (i.e., the surveyed location, size, water depth, and orientation) will be recorded and entered into the master project database.

A series of plate weights (i.e., barbell weights) will be used in lieu of ISOs as UIVS seeds. Because the project objective includes detection of hand grenades, the IVS will be seeded using 5-lb plate weights (Figure 17.1). NAEVA/3Dg has extensive prior UUTA-LT data for these weights and thus, the response from these weights is well characterized for assessing system performance. Use of these weights overcomes the challenges inherent with constructing an IVS in the underwater environment compared to terrestrial applications where the motion of the geophysical sensors can be more rigidly controlled.

Figure 17-1. UIVS Seeds Used by NAEVA/3Dg

The layout and configuration of the UIVS and spacing between seeds will be established in the field and based on observed conditions (e.g., water depth, current, location in the river) and the pre-seeded mapping results. The spacing between the plate weights will be sufficient to minimize ambiguity in the response from each one. Depending on the UIVS layout, dynamic noise levels will be evaluated during ongoing UIVS surveys using data along the seeded strip and from between the seed locations, or a separate background line (i.e., noise strip) will be established near the seeded transect.

Topside static response sessions using an ISO will be used to assist with establishing the target picking threshold in conjunction with the measured UIVS background response and RMS noise. The goal is to use a target picking threshold corresponding to 5x the RMS noise measured at the UIVS. A more aggressive threshold may be used, as supported by the data, which would potentially provide detection of potential munitions at greater depths but also increase the risk for noise-related target picks in the production data. Ultimately, the target picking threshold will be evaluated and established with regard to expected system performance and meeting the project detection objective.

The UIVS Technical Memorandum will document the UIVS construction process, system validation, initial system function tests, RMS noise and proposed target picking threshold. The production data will be considered at risk prior to USACE acceptance of this memorandum and the UIVS data.

17.5 DFW 5: UDGM Survey

NAEVA/3Dg will collect UDGM data using the UUTA-LT at the five individual AOPIs using the planned survey line spacing of five feet. Data collection will be performed IAW NAEVA/3Dg SOP 2. The survey vessel will be operated at average speeds between 1.8 and 3.5 knots (i.e., 0.9 and 1.8 meters/second) along the transects. Data will be recorded automatically using a sample rate of 15 readings/second. In addition to the geophysical sensor data, data from a pressure transducer, inclinometers, and a bottom finder transducer will be digitally recorded on a rugged, waterproof field computer.

Navigation during the UDGM survey will be aided by HYPACK hydrographic navigation software. The UUTA-LT uses a dual channel RTK GNSS receiver to accurately measure the position and heading of the sensor platform. The Hemisphere Vector VS330 is a dual channel RTK receiver that directly measures vessel heading. To achieve RTK quality, the VS330 uses a GPS base station comprising either a local GPS receiver or a station that is part of a CORS network. Differential GPS corrections are sent to the VS330 via a cellular data connection. During the survey, the onboard MLFXMarine data acquisition program captures the GPS and sensor positioning data and performs the calculation of the UUTA-LT array. A sonar transducer mounted on the bow of the boat assists the boat captain with advance warning of water bottom changes.

The sensor array will be flown at a nominal height of 16 inches (i.e., 0.4 meters) above the river bottom. Exceptions will include localized areas where the UUTA-LT array must be raised to avoid an underwater obstruction or hazard.

NAEVA/3Dg will collect an additional three miles of UDGM data outside the footprint of the AOPIs, using the UUTA-LT system. The transects will span the study area in a north to south orientation and will not undergo blind seeding. These transects will be biased towards the water's edge but collected where the survey vessel can still safely and appropriately operate to acquire high quality data.

UDGM Field QC: The UDGM system will be field tested each day of data collection for proper functionality by the survey team. The following QC procedures will be performed and documented in the master project database: GPS geodetic test, static spike, and background test (i.e., sensor function test), pressure sensor test, and UIVS survey. The ongoing UIVS surveys will be completed once at the beginning of the day, prior to the start of production surveying. This survey will be completed once due to the operational challenges with transitioning the survey vessel and UUTA-LT array from the production area to the UIVS. Additionally, because the UDGM survey will likely be completed during a time of year with reduced daylight working hours, performing one UIVS survey maximizes productivity and schedule efficiency due to the time needed to break down survey operations and transition to the UIVS location.

UDGM Data Processing: NAEVA/3Dg will perform data processing for this project IAW NAEVA/3Dg SOP 2. Data delivery packages will be submitted to USACE after completion of all data collection. Data packages will include raw and processed data, daily field records, false color mosaics of the UDGM system response, and derived target locations in accordance with the target picking criteria in the accepted UIVS Technical Memorandum. Raw and processed data will be submitted in Geosoft-readable format and will include QC test data, UIVS survey data and transect production data. An updated master project Access database containing running QC summaries will accompany each submittal.

UDGM Report: After completion of the surveys, Tetra Tech will prepare and submit a UDGM Report summarizing the field operations, survey methods, data processing steps, target selection and results. This report will document achievement of the MQOs, lessons learned and usability of the data relative to the project MPC and DQOs. Relevant interim reports (e.g., UIVS Technical Memorandum) and the derived target list will be appended to this report. Blind seed details will not be included in this report to keep that information firewalled through the intrusive phase of work. The UDGM report will be submitted IAW Tetra Tech AGC SOP 13.

17.6 DFW 6: Target Reacquisition and Intrusive Investigation of Dig List

Mobilization for reacquisition and intrusive investigation of UDGM targets will not begin until USACE has accepted the UDGM Report and targets identified for digging.

Training and Set-up: On arrival at the project location, the Tetra Tech dive team will set up their equipment, install an FCA, conduct project-specific training and a medical emergency response drill, and participate in the USACE dive inspection before dive operations commence. Tetra Tech uses a mobile dive locker which provides a secure storage area for the dive equipment, a supply of spare parts, a technical library, and an administrative space to prepare dive logs and records. The dive team will operate out of Mk3 Zodiacs or equivalent boats that will be launched from the Oxbow National Wildlife Refuge boat ramp. The boats will be moored at the dock at the Bill Ashe Visitors Center when not in use.

The six-person Dive Team will be comprised of a dual-hatted SUXOS/DS UXOSO, UXOQCS, a UXO diver, a UXO standby diver, and a dive tender. All members of the dive team will be qualified UXO divers. A UXO Technician I will provide support to the dive team and assist with any exclusion zone (EZ) closures along the shoreline that may be required.

The divers will use a full-face AGA mask with voice communication to the SUXOS/DS. SCUBA tanks and the required auxiliary emergency air tank will be used as the diver's air source. The standby diver will be dressed out with the same dive gear as the primary diver.

Functional Check Area Establishment: The UXOQCS will establish a FCA on the shore near the equipment storage location by placing three small ISOs buried 12 to 18 inches deep 24 inches apart. The divers will verify each handheld analog detector that will be used that day is functioning properly by passing the detectors over the FCA and observing the audible, visual, and tactile response signals each morning prior to transiting to that day's target locations.

Underwater Intrusive Investigation: During the intrusive UXO investigations, the SUXOS/DS will deploy a single tended diver equipped with a handheld all metals analog detector, underwater camera, and Shark Diver Navigation tablet, which will have the target list uploaded daily. The diver will self-navigate from target to target and intrusively investigate each target to a depth of up to two feet within the established search radius. The diver will increase the search radius to the distance agreed upon by the project team if the recovered anomaly source is inconsistent with the DGM anomaly characteristics.

The preferred method for investigating the targets will be to start at the most downstream target and progress upstream throughout the day. This is a safety consideration in that the diver approaches targets from downstream into the current so if the diver is not able to maintain position or becomes fouled, he will not be carried into potential military munitions by the current.

The dive boat will contain the SUXOS/DS, primary diver, stand-by diver, and dive tender. The UXOQCS and UXOSO will be in a second safety/chase boat to monitor any required exclusion zones or be used as the rescue boat. Throughout the day, the divers will rotate through the dive bill so the diver will become the tender, the tender becomes the standby diver, and the standby diver transitions to the primary diver.

If military munitions/MPPEH is located, the diver will notify the SUXOS/DS via the voice communication system and take a photograph. The diver will then return to the surface and consult with the SUXOS/DS and UXOSO. If they determine through positive identification and condition of the military munitions/MPPEH that it is deemed acceptable-to-move, the diver will return to the target location and recover the military munition. The military munitions will then be transferred to the safety/chase boat. The diver will return to the target location and verify the target is clear with no remaining military munitions/MPPEH. As required, the safety/chase boat will transfer the recovered military munition to the designated collection point where it will be guarded until disposal operations can be conducted at the disposal location identified in the ESP.

If the military munition is deemed not acceptable-to-move, it will be marked for in-place detonation. As an alternative, high input mechanized operations will be employed and the military munition will be towed underwater at a depth that ensures no fragmentation from an unintentional detonation to a designated collection point on the shore in accordance with the ESP.

If the target is MD or non-munitions-related debris (NMRD), the source of the anomaly will be recovered and transferred to a floating collection container. The items in the container will be emptied and inspected at the end of each day. MDAS will be segregated after inspection and stored in a 55-gallon drum stored in the dive locker for disposal at the completion of fieldwork by a licensed recycling facility. Any NMRD will be transferred to a locked dumpster at the staging area and recycled at the completion of fieldwork.

Tetra Tech personnel will maintain the EZ determined by the ESP. If any non-essential personnel enter the EZ radius, the field team will be notified and cease operations until the non-essential personnel have passed out of the EZ radius.

Military Munition/MPPEH Management and Disposition: Military munitions/MPPEH management and disposition will be performed IAW the approved ESP. MPPEH and MD will be processed IAW DoD Instruction (DoDI) 4140.62, DESR 6055.09, DoD Manual (DoDM) 4140.72, EM 385-1-97 and applicable Errata Sheets, and the approved ESP. Tetra Tech will follow all Massachusetts blasting, explosives, and fireworks requirements, and disposal operations will be led by personnel with a Massachusetts Blasters License. All work will be conducted under Tetra Tech's Bureau of Alcohol, Tobacco, Firearms, and Explosives License.

Military munitions /MPPEH recovered during the daily intrusive investigations will either be bunkered with sandbags on the safety boat or kept in a sealed bag and towed behind the safety boat at a depth determined by the Buried Explosion Module to ensure fragmentation will not reach the surface. The military munitions disposal operations will be conducted, as needed, by a disposal team consisting of a minimum of a Demolition Supervisor, the UXOSO, and a UXO Technician II or higher. Donor explosives will be ordered and delivered on an "as needed" basis. A detailed accounting of all donor explosives used during disposal operations will be maintained. All military munitions/MPPEH will be guarded until disposed IAW the projected disposal operations detailed in the ESP.

Per EM 200-1-15 and IAW Performance Work Statement 6.4, a detailed accounting will be maintained of all MPPEH and military munitions items/components encountered to include nomenclature, quantities, locations, and depths of all military munitions located and the final disposition. MPPEH and MD recovered during field activities will be inspected, documented, and transported IAW DoDI 4140.62. Digital photographs of all military munitions/MPPEH and examples of MD/range-related debris found during the investigation will be taken. These photographs will be attached to the military munitions/MPPEH accountability database and included in the RSE Addendum.

Disposal/Disposition of Material Documented as Safe: Any MD recovered during the investigation will be properly inspected, characterized, containerized, labeled, and secured IAW UXO SOP 1. Upon completion of the field activities, all waste will be disposed IAW all DoD, Department of the Army, USACE, federal, state, and local guidance and regulations. The certification/verification process will be documented on form DD 1348-1A. Dual independent 100% inspections will be performed on all MDAS prior to being shipped off-site. The Tetra Tech SUXOS/DS will sign the DD 1348-1A as the certifier, and the UXOQCS will sign as the MDAS verifier.

Anomaly Resolution: Throughout intrusive operations, the QC Geophysicist will review the dig records, recovered anomaly sources, and underwater photographs (as applicable) and perform a qualitative assessment of the recovered anomaly relative to the geophysical anomaly characteristics (e.g., amplitude, proximity to other anomalies, etc.). The anomaly resolution process will be documented in the master project database. The QC Geophysicist will coordinate with the UXOQCS regarding any need to potentially revisit target locations to verify whether the anomaly source was appropriately documented.

17.7 DFW 7: Submit Data for RSE Addendum

Upon completion of the fieldwork, we will prepare an RSE Addendum documenting the UDGM and underwater intrusive investigation findings. The RSE Addendum will include background information, a summary of UDGM results, details on the intrusive investigation results, with supporting field logs and photos, military munitions disposition, and other pertinent information to support the results of the project investigation.

QAPP WORKSHEET #21 – STANDARD OPERATING PROCEEDURES

SOP # or reference	Title, Revision, Date, and URL (if available)	Originating Organization	Reviewed for Project-Specific Conditions? Y/N	Comments
Dive SOP 1	Shark Marine Underwater Navigation System	Tetra Tech	Y	NA
Dive SOP 2	Underwater Intrusive Investigation	Tetra Tech	Y	NA
Dive SOP 3	Removal of MEC in a Marine Environment	Tetra Tech	Y	NA
UXO SOP 1	MEC Management and Disposal	Tetra Tech	Y	NA
UXO SOP 2	MPPEH and MDAS Management and Disposal	Tetra Tech	Y	NA
AGC SOP 11	Civil Survey	Tetra Tech	N	NA
AGC SOP 13	Technical Reporting	Tetra Tech	N	NA
NAEVA/3Dg SOP 1	SSS and Bathymetry Collection	NAEVA/3Dg	Y	NA
NAEVA/3Dg SOP 2	Underwater Electromagnetic Data Collection and Processing	NAEVA/3Dg	Y	NA

QAPP WORKSHEET #22 – EQUIPMENT TESTING, INSPECTION, AND QUALITY CONTROL

Table 22-1. Preparation

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Reporting Method/ Verified by:	Acceptance Criteria	Failure Response
Survey control accuracy	1	Once during establishment of temporary control points by the land surveyor	PLS subcontractor/ running QC summary; land survey report/ QC Geophysicist	Project network must be tied to HARN, CORS, VRS network, Online Positioning User Surface, or other recognized network and verify control meets or exceed third-order (1:10,000) accuracy.	Establish ties to a recognized network; re-verify.
Initial topside geodetic equipment function test (UDGM RTK)	2	Once prior to operations	Field Team Lead/running QC summary/QC Geophysicist or designee	Measured position at temporary control point within ±4 inches of reported ground truth.	If error is identified during equipment setup before data collection begins or if control point integrity appears to have been compromised, make adjustments and re-verify. Otherwise, RCA/CA
Initial topside geodetic equipment function test (UXO dive team positioning system)	3	Once prior to operations	Field Team Lead/running QC summary/UXOQCS; QC Geophysicist	Measured position at temporary control point within ±12 inches of reported ground truth.	If error is identified during equipment setup before data collection begins or if control point integrity appears to have been compromised, make adjustments and re-verify. Otherwise, RCA/CA
Construct UIVS: Verify construction against design plan and SOP(s)	4	Once following UIVS construction	Project Geophysicist/ UIVS Technical Memorandum/ Lead Organization	UIVS construction consistent with design plan. Candidate seed locations are derived from pre-seeded survey results.	Make necessary adjustments and re-verify. Otherwise, RCA/CA. Exception: Documented location-specific conditions necessitate deviation from planned UIVS design. Document conditions in UIVS Technical Memorandum.

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Reporting Method/ Verified by:	Acceptance Criteria	Failure Response
Verify correct assembly (all sensors)	5	Once following assembly	Field Team Lead/ Daily DGM Report/field log/ Project Geophysicist	As specified in appropriate SOP.	If problem observed after assembly and before production work begins, make necessary adjustments and re-verify. If equipment found to be defective or inoperable upon assembly, make adjustments and re-verify with replacement or repaired equipment. Otherwise, RCA/CA.
Initial Function Test (SSS/bathymetry equipment)	6	Once following assembly	Field Team Lead/ Daily DGM report/field log; running QC summary/ Project Geophysicist	As specified in appropriate SOP.	If problem observed after assembly and before production work begins, make necessary adjustments and re-verify. If equipment found to be defective or inoperable upon assembly, make adjustments and re-verify with replacement or repaired equipment. Otherwise, RCA/CA.
Topside Initial Sensor Function Test (UDGM)	7	Once following assembly	Field Team Lead/ Daily DGM report/field log; running QC summary; Initial UIVS Memorandum/ Project Geophysicist	Response (mean static spike minus mean static background) within ±20% of expected response for reference object at known position and distance relative to the sensor array.	If failure observed before production work begins, make necessary adjustments on-site and re-verify. Otherwise, RCA/CA.
Initial Dynamic Positioning (UIVS)	8	Once during system validation at UIVS	Field Team Lead/ Running QC Summary/ Project Geophysicist	After target picking threshold is established, seeds are targeted in UIVS data set with amplitudes greater than established threshold. Additionally, derived target locations from UIVS seeds are within ±5 feet of measured ground truth at time of emplacement.	If failure observed before production work begins, make necessary adjustments on-site and re-verify. Otherwise, RCA/CA.

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Reporting Method/ Verified by:	Acceptance Criteria	Failure Response
Initial Instrument Function Test (Analog Instruments)	9	Once following assembly	Field Team Lead/daily UXO QC report; running QC Summary/ UXOQCS or designee	Response consistent with expected change in tone in presence of reference objects in FCA based on instrument settings.	If failure observed before production work begins, make necessary adjustments on-site and re-verify. Otherwise, RCA/CA.

Table 22-2. SSS/Bathymetry and UDGM Surveys

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Reporting Method/ Verified by:	Acceptance Criteria	Failure Response
Topside Ongoing Sensor Function Test (UDGM)	10	Beginning of the day	Field Team Lead/ daily DGM report/field log; running QC summary/ QC Geophysicist	Response (mean static spike minus mean static background) within ±20% of initial response	If failure observed before daily production work begins, make necessary adjustments on-site and re-verify. If failure persists, RCA/CA.
Ongoing topside geodetic equipment function test (UDGM RTK)	11	Once prior to operations	Field Team Lead/running QC summary/QC Geophysicist or designee	Measured position at temporary control point within ±4 inches of reported ground truth.	If error is identified during equipment setup before data collection begins or if control point integrity appears to have been compromised, make adjustments and re-verify. Otherwise, RCA/CA
Rub Test (SSS/Bathymetry)	12	Beginning of the day	Field Team Lead/ daily DGM report/field log; running QC summary/ QC Geophysicist	If the SSS is operating properly a distinctive “streaking” signature will be observed in the waterfall display. This test is an observed qualitative test of basic system functionality	If failure observed before daily production work begins, make necessary adjustments on-site and re-verify. Otherwise, RCA/CA
Sonar Positioning Test (SSS/Bathymetry)	13	Beginning of the day	Field Team Lead/ daily DGM report/field log; running QC summary/ QC Geophysicist	A single line of data will be collected to image a known, fixed-position object in or along the river. Measured position is within ±3.3 feet of derived position from first day or ground truth measurement if	If failure observed before daily production work begins, make necessary adjustments on-site and re-verify.

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Reporting Method/ Verified by:	Acceptance Criteria	Failure Response
				one can be independently and safely recorded.	Otherwise, RCA/CA
SSS/Bathymetry Survey Coverage	14	Each data set	Field Team Lead/ running QC summary/ QC Geophysicist	100% coverage of accessible portions of the study area. Goal is to maintain line spacing of ≤25 feet, but conditions (e.g., wind, current) which may result in deviations from this spacing are permissible, provided effective 100% coverage is achieved for UDGM planning purposes.	Collect additional data for gaps which do not fit excepting conditions. Otherwise, RCA/CA
Topside Pressure Sensor Function Test (UDGM)	15	Beginning of the day	Field Team Lead/ daily DGM report/field log; running QC summary/ QC Geophysicist	Measured depth results within ±3 inches of known depth using water-filled bucket. Additionally, free air test reads 0 inches.	If failure observed before daily production work begins, make necessary adjustments on-site and re-verify. If failure persists, RCA/CA
Survey Coverage (UDGM)	16	Each data set	Field Team Lead/ running QC summary/ QC Geophysicist	100% coverage of accessible portions of each AOPI. Exceptions: Portions of AOPIs identified as inaccessible prior to start of UDGM survey, challenging vessel navigation conditions (e.g., localized current fluctuations) or underwater obstructions (from SSS survey).	Collect additional data for gaps which do not fit excepting conditions. Otherwise, RCA/CA.
Downline Data Density (UDGM)	17	Each data set	Field Team Lead/ running QC summary/ QC Geophysicist	98% ≤10 inches along line. Exception: documented obstruction or navigation hazard results in gap exceeding this threshold.	Collect additional data for gaps which do not fit excepting conditions. Otherwise, RCA/CA
Ongoing Dynamic Positioning (UIVS)	18	Beginning of each day	Field Team Lead/ running QC summary/ QC Geophysicist	Seeds are targeted in UIVS data set with amplitudes greater than established threshold. Additionally, derived target locations from UIVS seeds are within ±5 feet of initial derived positions.	RCA/CA

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Reporting Method/ Verified by:	Acceptance Criteria	Failure Response
Sensor Array Height (UDGM)	19	Each data set	Field Team Lead/ running QC summary/ QC Geophysicist	95% ≤16 inches above the river bottom. Exception: documented obstruction or navigation hazard results in need to increase array altitude	Collect additional data for gaps which do not fit excepting conditions. Otherwise, RCA/CA
Dynamic Survey Performance (Blind Seeds)	20	Each dataset with seed encountered	Field Team Lead/ running QC summary/ QC Geophysicist; USACE Geophysicist (for QA seeds)	100% of blind seeds are detected above established picking threshold. Derived seed positions are within ±5 feet of measured ground truth at time of emplacement.	RCA/CA

Table 22-3. Intrusive Investigation

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
Ongoing topside geodetic equipment function test (UXO dive team positioning system)	21	Once prior to operations	Field Team Lead/running QC summary/UXOQCS; QC Geophysicist	Measured position at temporary control point within ±12 inches of reported ground truth.	If error is identified during equipment setup before data collection begins or if control point integrity appears to have been compromised, make adjustments and re-verify. Otherwise, RCA/CA

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
Ongoing Instrument Function Test (Analog Instruments)	22	Once prior to operations	Field Team Lead/daily UXO QC report; running QC Summary/ UXOQCS or designee	Response consistent with expected change in tone in presence of reference objects in FCA based on instrument settings.	If failure observed before production work begins, make necessary adjustments on-site and re-verify. Otherwise, RCA/CA.
Documenting recovered sources	23	Daily	UXOQCS/ daily UXO QC report; master project database/ QC Geophysicist	Recovered sources documented for the following attributes: Designation as military munitions, MD, or NMRD; military munitions and MD described by type, weight, and depth. Photos displaying recovered MD (individual MD photos not necessary), and photos showing all surfaces of each military munitions are recorded. Exception: objects cannot be extracted by hand due to size or weight; source cannot be positively identified due to burial depth of anomaly source.	Document Left-in-Place sources in database and associated extraordinary conditions. Otherwise, RCA/CA.
Anomaly resolution (1 of 2)	24	Evaluated for all intrusive results	UXOQCS or designee/ master project database/ QC Geophysicist	Intrusive findings confirm recovered source is consistent with DGM anomaly characteristics. Source(s) recovered within agreed-upon search radius (from Worksheet #11 decision rules) or as otherwise indicated by DGM data processor on the final dig list. Exception: No Contact result is verified and appears to be associated with noise or movement of the UDGM array.	Re-inspection of dig location as directed by UXOQCS and/or QC Geophysicist and re-verify. 100% of No Contacts will be re-inspected and verified. Otherwise, RCA/CA.

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
Anomaly resolution (2 of 2)	25	Evaluated for all intrusive results	UXOQCS or designee/ master project database/ QC Geophysicist; USACE Geophysicist (for QA seeds)	100% of blind seeds are recovered by UXO dive team.	RCA/CA

QAPP WORKSHEET #29 – DATA MANAGEMENT, PROJECT DOCUMENTS AND RECORDS

Part 1: Data Management Specifications

Computer Files and Digital Data: All final document files, including reports, figures, and tables will be submitted in electronic format. Documents that can be e-mailed will be sent as attachments. Data packages, documents, and deliverables too large to effectively e-mail will be posted to a secure Tetra Tech (i.e., SharePoint) or DoD site for retrieval by USACE. In addition, large data packages (e.g., SSS data) may be delivered to USACE on CD-ROM or portable hard drives.

Part 2: Control of Documents, Records, and Databases

Table 29-1. Minimum Required Documents and Records

Document/Record	Purpose	Completion/ Update Frequency	Format/ Storage Location/ Archive Requirements
Daily field progress report	Record daily field events, personnel on-site (including visitors), tasks performed, weather conditions, deviations, and reasons for deviations from planned field operations	Daily	Hard copy or electronic/ project SharePoint site/ project file
Daily DGM field report	Record UDGM team daily activities, status of QC tests and function tests, deviations, and reasons for deviations from standard procedures	Daily (during UDGM survey) UDGM team daily field log may be submitted in lieu of this report, provided aforementioned information is included	Hard copy or electronic/ project SharePoint site/ project file
Daily UXO QC report	Documentation of inspections, instrument QC checks, status of open NCRs and FCRs associated with UXO dive operations	Daily (during UXO dive operations)	Hard copy or electronic/ project SharePoint site/ project file
Weekly UDGM QC Report	Document UDGM system performance relative to MQOs in Worksheet #22; status of open NCRs associated with DGM operations; serves as ongoing inspection phase of three phases of control process	Weekly	Electronic copy/project SharePoint site/project file
UXO field team daily log	Record of UXO Team's activities (analog instrument checks, military munitions/MD/other debris identified, targets excavated)	Daily	Hard copy or electronic/ project SharePoint site/ project file

Document/Record	Purpose	Completion/ Update Frequency	Format/ Storage Location/ Archive Requirements
SOP checklists	Verify completion of specific tasks governed by SOPs	As applicable per relevant SOPs	Hard copy or electronic/ project SharePoint site/ project file
Personnel qualifications/ certifications	Documentation that required certifications and training have been completed	Prior to mobilization/upon renewal of certifications or training/new personnel on-site	Hard copy or electronic/ project SharePoint site/ project file
Daily safety meeting attendance log	Project-specific training and safety documentation	Daily	Hard copy or electronic/ project SharePoint site/ project file
Safety inspection logs	Project is properly equipped with safety equipment, and operations are being performed in compliance with the Accident Prevention Plan/ Site Safety and Health Plan	Prior to field operations kickoff and weekly at a minimum	Hard copy or electronic/ project SharePoint site/ project file
Hours-worked record (included on daily field progress report)	Record maintained to comply with EM 385-1-97 and for contractor manpower reporting	Daily	Hard copy or electronic/ project SharePoint site/ project file
UDGM field team daily log	Record UDGM team daily activities, status of QC tests and function tests, deviations, and reasons for deviations from standard procedures	Daily for each day UDGM operations are performed on-site	Hard copy or electronic/ project SharePoint site/ project file
Land survey subcontractor report	Documents establishment of site-specific control and confirms geodetic accuracy meets project requirements	Once after control established; updated for new temporary control points that may be added	Electronic copy/project SharePoint site/project file
UIVS Technical Memorandum	Documents UIVS construction details and initial validation of UDGM system	Once after completion of initial UIVS surveys	Electronic copy/project SharePoint site/project file
Blind seed registry	Documents locations and emplacement details for QC seeds	Once after completion of seeding, updated with new seed locations added in the field	Electronic copy/project SharePoint site/project file
Running QC summary	Tracks UDGM system performance and UXO-related equipment performance relative to MQOs in Worksheet #22	Updated with each QC test result as well as with each processed data set	Electronic copy/project SharePoint site/project file

Document/Record	Purpose	Completion/ Update Frequency	Format/ Storage Location/ Archive Requirements
UDGM data package deliverables	Digital record of UDGM raw, processed, and final data submittals	UDGM data packages submitted on or before the following Friday after data collection, unless otherwise communicated in advance with USACE Geophysicist.	Digital data files and electronic copies/ project SharePoint site/ project file
Master project (Access) database	Record of project data gathered during the investigation.	Updated database submitted on or before the following Friday after new data collection, unless otherwise communicated in advance with USACE PM.	Digital data files and electronic copies/ project SharePoint site/ project file
Military munitions accountability log	Record of military munitions identified (date, team, type, location, disposition)	When military munitions are identified	Hard copy or electronic/ project SharePoint site/ project file
Disposal operations checklist	Demolition Supervisor Checklist to be followed and documented during disposal operations	As required	Hard copy or electronic/ project SharePoint site/ project file
Explosives usage record	Record of shots performed (time, date, military munitions item, donor explosives)	As required (when shots are performed)	Hard copy or electronic/ project SharePoint site/ project file
Non-hazardous MDAS demilitarization chain of custody, DD 1348-1A	Certification that MDAS is free of explosives	As required	Hard copy or electronic/ project SharePoint site/ project file
NCR	Documentation of non-conformance and applicable response	As required	Electronic copy/ project SharePoint site/ project file
RCA/CA	Documents identification of the root cause of a non-conformance and the proposed CA	As required per failure response in Worksheet #22	Electronic copy/ project SharePoint site/ project file
FCRs and Log	Record of major QAPP change and documentation of project team approval	As required	Electronic copy/ project SharePoint site/ project file
Project GIS	Updates to master project GIS incorporating data gathered during the investigation.	As updated	Electronic copy/ project SharePoint site/ project file
DUA	Provides documentation of the evaluation of the data quality.	As required per Worksheet #37.	Electronic copy/ project SharePoint site/ project file

QAPP WORKSHEET #31, #32, & #33 – ASSESSMENTS AND CORRECTIVE ACTION

For this project, related activities are grouped as follows IAW Worksheet #17:

1. Survey Area Setup and Temporary Control Points (DFW 1)
2. SSS/Bathymetry, UDGM Survey and reporting (DFWs 2-5)
3. Intrusive Investigation (DFW 6)
4. Prepare and Submit RSE Addendum (DFW 7)

For each group of related activities, assessment activities will occur during the following phases. DFW 7 is excluded from these inspection phases because it addresses document preparation and submittal as part of the investigation reporting stage. Progress on the document will begin and continue as data and information are gathered to support its development prior to submittal to USACE for review.

Preparatory Phase: Comprises the planning and design process leading up to field activities. The QC Geophysicist or UXOQCS will perform a Preparatory Phase assessment before beginning each DFW. The purpose of this assessment is to review applicable specifications and plans to verify that the necessary resources, conditions, and controls are in place and comply with specifications before fieldwork begins.

Initial Phase: Occurs at the startup of field activities. The purpose of this phase is to check preliminary work for compliance with specifications, check for omissions, and resolve differences of interpretation.

Follow-up Phase: Covers the routine, day-to-day activities in the field. One or more follow-up assessments will be conducted during each related group of activities, depending on the duration of field activities, and the nature of any assessment findings.

Table 31-1. DFW Assessments (Three Phases of Control)

Assessment Type	Responsible Party	Schedule	Assessment Deliverable	Deliverable due date
Preparatory Phase (DFW 1)	SUXOS and QC Geophysicist	Prior to first time task is performed.	Preparatory Inspection Checklist (Tetra Tech QP-01)	Within 3 business days of completion of preparatory inspection
Initial Phase (DFW 1)	SUXOS and QC Geophysicist	First time task is performed.	Initial Inspection Checklist (Tetra Tech QP-01)	Within 3 business days of completion of initial inspection
Preparatory phase (DFWs 2-5)	QC Geophysicist	Prior to first time task is performed.	Preparatory Inspection Checklist (Tetra Tech QP-01)	Within 3 business days of completion of preparatory inspection

Assessment Type	Responsible Party	Schedule	Assessment Deliverable	Deliverable due date
Initial phase (DFWs 2-5)	QC Geophysicist	First time task is performed.	Initial Inspection Form (Tetra Tech QP-01)	Within 3 business days of completion of initial inspection
Follow-up phase (DFWs 1-5)	QC Geophysicist	Each time QC inspection and review is completed.	Weekly DGM QC report	Weekly
Preparatory phase (DFW 6)	UXOQCS	Prior to first time task is performed.	Preparatory Inspection Form (Tetra Tech QP-01)	Within 3 business days of completion of preparatory inspection
Initial phase (DFW 6)	UXOQCS	First time task is performed.	Initial Inspection Form (Tetra Tech QP-01)	Within 3 business days of completion of initial inspection
Follow-up phase (DFW 6)	UXOQCS	Daily, until all tasks under this DFW are completed.	Daily UXO QC report	Daily

Table 31-2. Assessment Response and Corrective Action

Assessment Type	Responsibility for responding to assessment findings	Assessment Response Documentation	Timeframe for Response	Responsibility for Implementing Corrective Action	Responsible for monitoring Corrective Action implementation
All phases (DFW 1)	SUXOS or Project Geophysicist, depending on nature of finding	As required by Worksheet #22	Within 3 working days of notification	SUXOS	PM; QC Geophysicist
All phases (DFWs 2-5)	Project Geophysicist or NAEVA/3Dg Senior Geophysicist depending on nature of the finding	As required by Worksheet #22	Within 5 working days of notification	NAEVA/3Dg Field Lead, Data Processor	Tetra Tech QC Geophysicist; NAEVA/3Dg QC Geophysicist
All phases (DFW 6)	SUXOS/DS	As required by Worksheet #22	Within 5 working days of notification	PM; SUXOS/DS	UXOQCS

QAPP WORKSHEET #34 – DATA VERIFICATION, VALIDATION, AND USABILITY INPUTS

Requirements/Specifications:
Contract No.: W912DR-21-D-0002, Delivery Order: W912DR22F0121

Quality Assurance Surveillance Plan: May 2022

SOPs are contained in Appendix C.

Table 34-1. Data Verification, Validation and Usability Inputs

Item	Description	Verification (completeness)	Validation (conformance to specifications)	Usability (achievement of DQOs and MPCs)
Field Records				
1	Blind seeding records	X	X	
2	Photographs (as applicable)	X		
3	Analog geophysical instrument function test results	X	X	X
4	UDGM sensor function test results	X	X	X
5	UIVS construction details	X	X	
6	SOP checklists (as applicable)	X	X	X
7	Daily field logs	X		X
8	Daily field reports	X	X	
Electronic Data				
9	Blind seed registry	X	X	X
10	Raw data files	X	X	
11	Geosoft-format databases (processed UDGM QC and production data)	X		X
12	Geosoft-format map files (as applicable)	X	X	X
13	Dig list	X	X	X
14	Updated project GIS	X	X	X
15	Updated master project database	X	X	X
16	Final data archive (for each delivered subset)	X	X	
Interim & Final Reports/Deliverables				
17	SOP checklists (as applicable)	X	X	X
18	UIVS Technical Memorandum	X		X
19	UDGM Report	X		X
20	RSE Addendum	X		X

QAPP WORKSHEET #35 – DATA VERIFICATION AND VALIDATION PROCEDURES

Table 35-1. Data Verification and Validation Procedures

Activity and Records Reviewed	Requirements/ Specifications	Process Description/Frequency	Responsible Person	Documentation
Field Logs	QAPP WS#17 & 22; SOPs	Documentation is complete for each day of field activities. Any changes/exceptions are documented and have been reported IAW requirements. Required signatures are present (digital signatures accepted).	PM	Daily Field Progress Reports and Daily Raw Data Uploads
Instrument Assembly/ Daily DGM Field Report/Log	QAPP WS#17 &22	MQOs have been achieved, with any exceptions noted. If appropriate, corrective actions have been completed. Signatures and dates are present (digital signatures accepted).	SUXOS; Field Team Leads	Daily Field Progress Report; Daily DGM Report
UIVS Construction and Initial Surveys/ Daily DGM Field Report/Log	QAPP WS#17 & 22	Initial UIVS Survey has been conducted IAW applicable SOPs in Worksheet #21. Applicable checklists have been completed. Performance metrics have been achieved, or exceptions noted. If appropriate, corrective actions have been completed. Signatures and dates are present (digital signatures accepted).	Project Geophysicist	UIVS Technical Memorandum
QC seeding records	QAPP WS#17 & 22	Seed items are placed IAW specification listed in Worksheet #17. Equipment checks performed IAW QAPP requirements and applicable SOPs in Worksheet #21. Applicable checklists have been completed. Performance metrics have been achieved, or exceptions noted. If appropriate, corrective actions have been completed. Signatures and dates are present (digital signatures accepted).	UXOQCS; QC Geophysicist	Blind Seed Registry
Running QC summary	QAPP WS#22	Performance metrics, function check results and QC test results are compiled and tracked as results are known and available. Running summary is updated as new data are gathered or data are processed, as applicable. Nonconformances are noted and appropriate failure response is initiated IAW Worksheet #22.	UXOQCS; QC Geophysicist	Master project Access database

Activity and Records Reviewed	Requirements/ Specifications	Process Description/Frequency	Responsible Person	Documentation
Data Package Deliverables/ SOP Checklists	QAPP WS#17, 22, 29; SOPs	Data are collected and processed IAW applicable SOPs listed in Worksheet #21. Information has undergone appropriate QC review prior to delivery to USACE. Performance metrics have been achieved, or exceptions noted. Nonconformances are noted and appropriate failure response is initiated IAW Worksheet #22 and completed prior to data delivery.	PM; Project Geophysicist; SUXOS	Data upload notification and record when transmitted to USACE

QAPP WORKSHEET #37 – DATA USABILITY ASSESSMENT

Personnel responsible for performing Data Usability Assessment (DUA):

- Tetra Tech PM – Jennifer Harlan, PMP
- Project QCM– Eugene Mikell, CQA
- Project Geophysicist – Matt Barner
- QC Geophysicist – Jessie Powers
- SUXOS – Don Schwalback
- UXOQCS – Kevin Borkowski

Throughout the field investigation, Tetra Tech will perform periodic assessments of data quantity and quality as a means of verifying the appropriateness of the data in supporting the overall project objective. Table 17-1, together with individual DFW descriptions in Worksheet #17, identifies critical decision points within the overall workflow process and identifies the supporting documentation generated to each point. A usability assessment of the UDGM data collected will be presented in the DGM Report. A final usability assessment of intrusive results will be included with the RSE Addendum; the final UDGM Report and associated DUA will be included with this addendum as an attachment. Assessments of data usability will follow the four steps outlined in the table below.

Step 1	**Review the project's objectives and sampling design** Review the data quality objectives. Are underlying assumptions valid? Were the project boundaries appropriate? Review the sampling design and changes to the design documented via the FCR process, for consistency with stated objectives. Was the sampling design appropriate for achievement of the project objectives? Were sources of uncertainty accounted for and appropriately managed?
Step 2	**Review the data verification/validation outputs and evaluate conformance to MPCs documented on Worksheet #12** Review available QA/QC reports quality inspection records, corrective action reports and data verification/validation documentation. Evaluate conformance to MPCs documented on Worksheet #12 and implications of nonconformances to these MPC.
Step 3	**Document data usability, update the CSM, apply decision rules, and draw conclusions** Determine if the data can be used as intended, considering deviations from planned approach, nonconformances and corrective actions as applicable. Assess the performance of the sampling design, apply decision rules, and identify limitations on data use as applicable. Update the CSM as appropriate and document conclusions.
Step 4	**Document lessons learned and make recommendations** Summarize lessons learned to be used for informing potential future actions at the study area or similar investigations elsewhere.

REFERENCES

Engineering Technologies Associates, Inc., 1993. Ground Water Flow Model at Fort Devens, Massachusetts Final Report. May

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APPENDIX A
Figures

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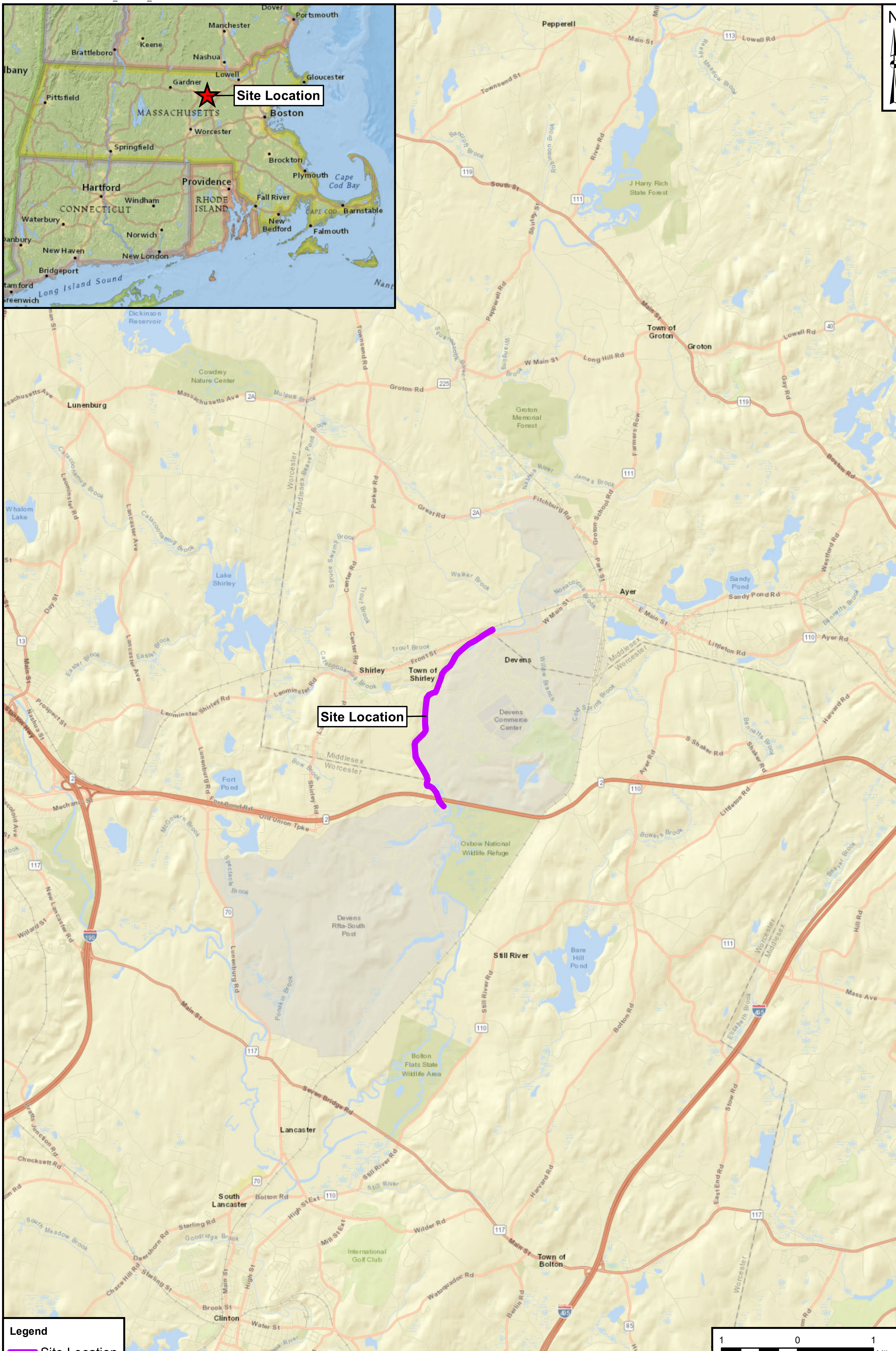

SITE LOCATION MAP
DEVENS NASHUA RIVER
DEVENS, MA

US Army Corps of Engineers
Baltimore District

DRAWN BY	DATE	PROJECT #
J.MADDEN	07/18/22	179-8038-0002
CHECKED BY	DATE	FIGURE NUMBER
J.HARLAN	07/18/22	A-1

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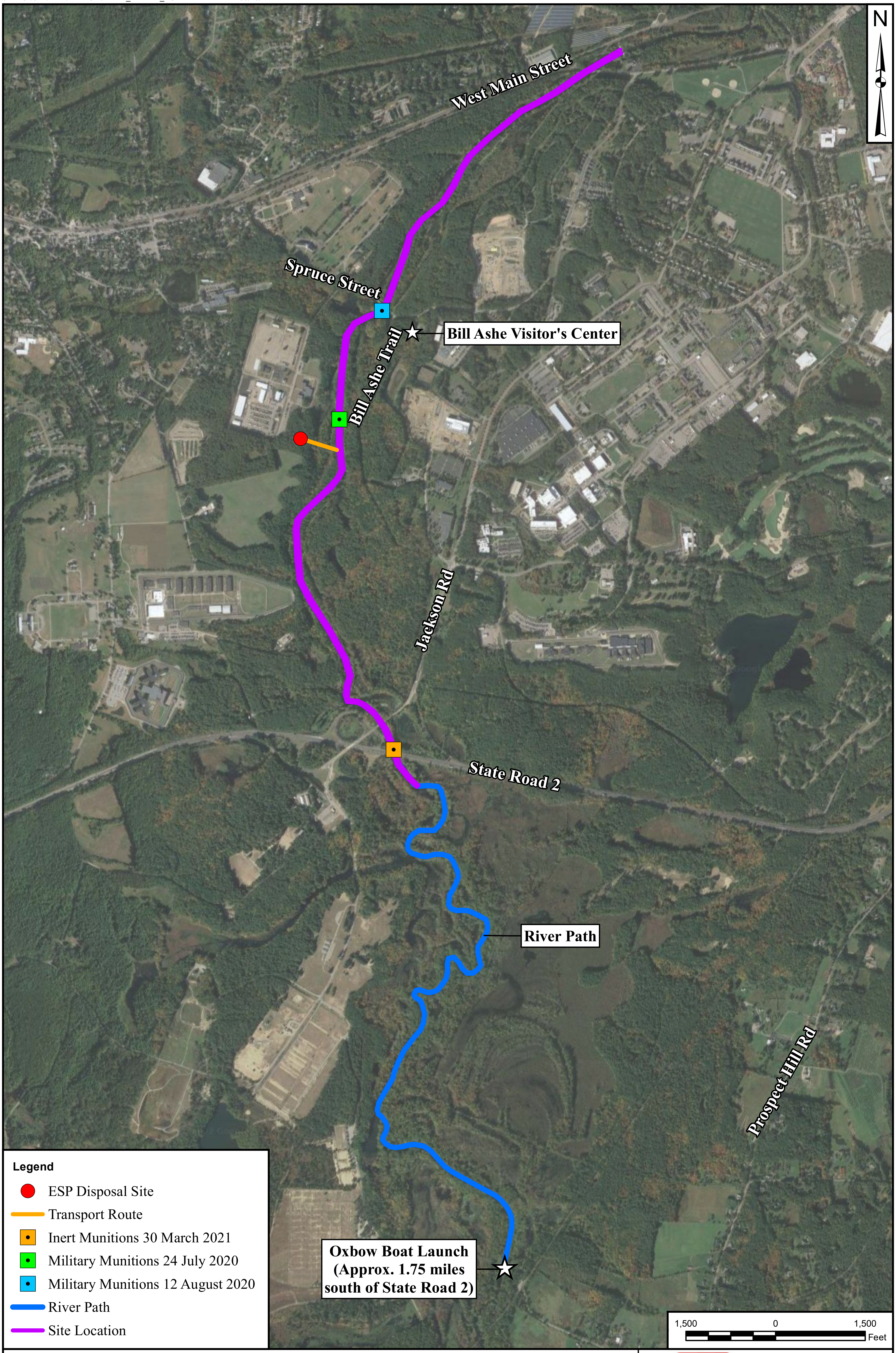

SURVEY AREA MAP
DEVENS NASHUA RIVER
DEVENS, MA

US Army Corps of Engineers
Baltimore District

DRAWN BY	DATE	PROJECT #
J.MADDEN	09/26/22	179-8038-0002
CHECKED BY	DATE	FIGURE NUMBER
J.HARLAN	09/26/22	A-2

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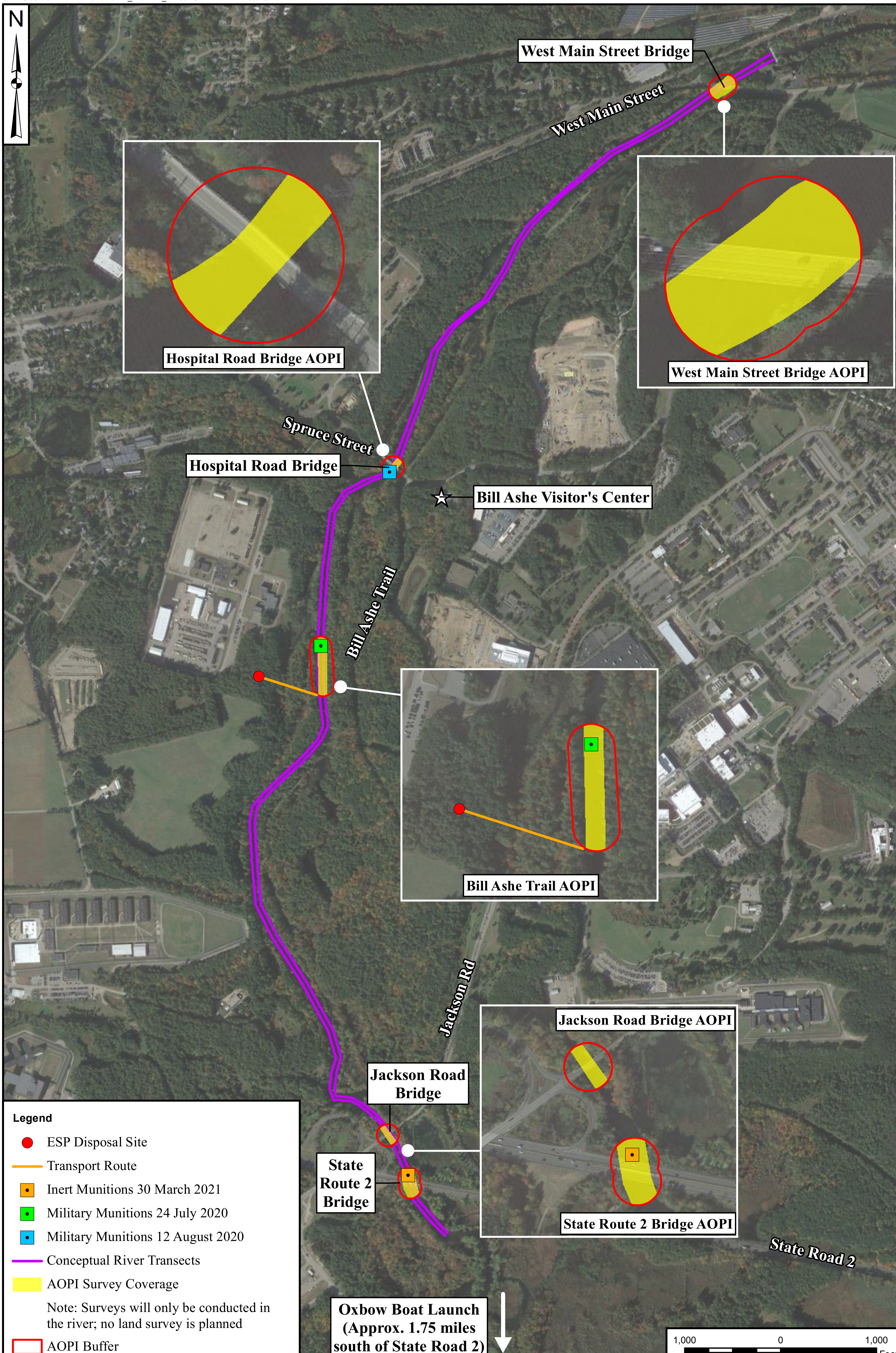

STUDY AREA MAP
DEVENS NASHUA RIVER
DEVENS, MA

US Army Corps of Engineers
Baltimore District

DRAWN BY	DATE	PROJECT #
J.MADDEN	09/26/22	179-8038-0002
CHECKED BY	DATE	FIGURE NUMBER
J.HARLAN	09/26/22	A-3

APPENDIX B
Blind Seed Firewall Plan

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FINAL

BLIND SEED FIREWALL PLAN

FOR

FORMER FORT DEVENS ARMY INSTALLATION

DEVENS, MASSACHUSETTS

Contract No.: W912DR-21-D-0002**, Delivery Order** W912DR22F0121

Prepared for:

US Army Corps of Engineers, Baltimore District

November 2022

PROJECT IDENTIFYING INFORMATION

1. Project Identifying Information
2. Former Fort Devens Army Installation
    a. Military Munitions Investigation Nashua River Former Fort Devens
    b. Contract Number: W912DR-21-D-0002
    c. Delivery Order Number: W912DR22F0121

3. Geophysical Contractor
    a. QC Geophysicist

    Jessie L Powers

    Jessie Powers, Tetra Tech

    b. Contractor Quality Manager

    Eugene M. Mikell III, CQA, Tetra Tech

CONTENTS

ABBREVIATIONS AND ACRONYMS

GSV	Geophysical System Verification
MMRP	Military Munitions Response Program
MR-QAPP	Munitions Response-Quality Assurance Project Plan
QC	Quality Control
QMS	Quality Management System
RCA/CA	Root Cause Analysis/Corrective Action
SOP	Standard Operating Procedure
USACE	United States Army Corps of Engineers
UXOQCS	Unexploded Ordnance Quality Control Specialist

1.0 INTRODUCTION

Work on this project is being performed by Tetra Tech, Inc. (Tetra Tech) in support of the Military Munitions Investigation Nashua River Former Fort Devens task order at the Former Fort Devens Army Installation in Devens, Massachusetts. This work is being performed in accordance with the Munitions Response Quality Assurance Project Plan (MR-QAPP), Tetra Tech's Quality Management System, and applicable Standard Operating Procedures (SOPs).

As part of the Geophysical System Verification (GSV) process, Tetra Tech is responsible for the identification of suitable locations for blind quality control (QC) seeds within the project areas, physical emplacement of the seeds, documentation of their emplacement, and their successful detection, classification (as applicable) and eventual recovery. In order to confirm the results of the blind seeding effort are unbiased, this Blind Seed Firewall Plan will be implemented to ensure seed details are not accessible to the clearance or survey teams, data processors, their team partners, or any subcontractors involved with these production tasks.

2.0 ORGANIZATIONAL STRUCTURE

MR-QAPP Worksheets #3 and #5 present the team organizational structure for the project. It is the responsibility of the Tetra Tech QC Geophysicist and Unexploded Ordnance Quality Control Specialist (UXOQCS) to implement this firewall plan.

3.0 COMMUNICATIONS FIREWALL

Worksheet #6 in the UFP-QAPP presents the communication pathways for the project. As part of this firewall plan, the QC team will have no direct written or verbal communication with other project team members regarding blind seed locations or seed emplacement details. Direct communication with field teams will be limited to what is necessary to coordinate on-site logistics, address health and safety matters and to execute field operations in accordance with the requirements in the QAPP. Specific details may be released by the QC Geophysicist to the Project Geophysicist, as necessary, to support development of a root cause analysis/corrective action (RCA/CA) in response to a nonconformance.

4.0 DATA FIREWALL

The QC Geophysicist and UXOQCS will oversee emplacement and documentation of the seeds in accordance with the MR-QAPP. They, or their designees, may perform the field work, provided the individuals performing the work are not involved with production aspects of the project. The QC Geophysicist will be responsible for preparing, updating daily, and sending the U.S. Army Corps of Engineers (USACE) Quality Assurance Geophysicist a spreadsheet of blind seed attributes as a password-protected file. The QC Geophysicist will password-protect the data files containing seed locations and photos of the emplaced seeds and back them up to a secure Tetra Tech network server or Share Point site. The Corporate Quality Manager will be provided with all relevant passwords as a backup measure in the event that personnel with that knowledge become unable to support the project.

APPENDIX C
STANDARD OPERATING PROCEDURES

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Dive SOP 1 - Shark Marine Underwater Navigation System

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will use the shark marine underwater navigation system (SM) for munitions response projects. Any changes or deviations will be included in the project specific plans and approved by the Marine Operations Program Manager. SOPs will be reviewed annually.

TMR Senior Diving Supervisor, Don Schwalback		Date:	04/26/2022
TMR Director of Quality, Eugene Mikell III, CQA		Date:	04/26/2022
TMR Marine Operations Program Manager, Scot Wilson, PMP		Date:	04/26/2022
TMR Diving Safety Officer, Patrick Oberley		Date:	04/26/2022

Review Date	Reviewer	Next Review
02/18/22	TMR Senior Diving Supervisor, Don Schwalback	02/2023

SUPERVISOR'S STATEMENT

I have read and understood this SOP. To the best of my knowledge, the procedures described in this SOP can be performed in a safe and environmentally sound manner. I have confirmed that all persons assigned to this process are qualified, have read and understood the requirements of this SOP, and have signed the worker's statement for this purpose. I will ensure the SOP contains current procedures. If a major change to the SOP is necessary, I will ensure active processes are suspended until the SOP is revised and approved. If unexpected safety, health, or environmental hazards are identified, I will make sure the process is stopped until the hazards have been eliminated.

SUXOS/ Diving Supervisor   Date

WORKER'S STATEMENT

I have read Dive SOP – Shark Marine Underwater Navigation System and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

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ACRONYMS AND ABBREVIATIONS

AC	alternating current
AHA	activity hazard analysis
AOI	areas of interest
BEM	buried explosion module
DC	direct current
DDESB	department of defense explosives safety board
DGM	digital geophysical mapping
DMM	discarded military munitions
DS	diving supervisor
ESP	explosives site plan
ESS	explosive safety submission
ETA	equipment test area
EZ	exclusion zone
GPS	global positioning system
HPR	heading pitch roll
JSA	job safety analysis
MC	munitions constituents
MD	munitions debris
MDAS	material documented as safe
MEC	munitions and explosives of concern
MPPEH	material potentially presenting an explosive hazard
MQO	measurement quality objective
MSD	minimum separation distance
NMRD	non-munition related debris
PDA	personal digital assistant
RRD	radiological dispersal device
SM	shark marine underwater navigation system
SOP	standard operating procedure
SUXOS	senior UXO supervisor
TL	team leader
TP	technical paper
U.S.	United States

UXO	unexploded ordnance
UXOQCS	UXO quality control specialist
UXOSO	UXO safety officer

1.0 PURPOSE AND SCOPE

The purpose of this standard operating procedure (SOP) is to provide procedures for the shark marine underwater navigation system (SM). The SM is a self-contained, navigation and underwater imaging system that provides the diver with target location, navigation information, and situational awareness of upcoming underwater features and potential hazards. These operations include:

- Underwater surveys and mapping
- Underwater remedial investigations
- Targets of Interest (TOI) and Areas of Interest (AOI) reacquisition

Training on this equipment or software will be either formal from the manufacturer or on-the-job training. This training will be documented by site personnel and subject to review for accuracy and completeness. The project UXO Safety Officer shall verify this training is complete and documented.

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials that are required for SM operations and setup.

2.1 PERSONNEL

The following personnel are required for SM operations in support of munitions response operations:

- UXO divers qualified in accordance with the United States (U.S.) Department of Defense Explosives Safety Board (DDESB) technical paper (TP) 18, Minimum Qualifications for Personnel Conducting Munitions and Explosives of Concern-Related Activities.
    - Senior UXO supervisor/diving supervisor (SUXOS/DS). Responsible for planning, directing, and executing all field operations.
    - Field UXOQCS. Responsible for all aspects of project quality.
    - Project UXO safety officer (UXOSO)/site safety and health officer (SSHO). Responsible for all aspects of health and safety on the project site.
    - UXO divers. Responsible for performing the SM operations under the guidance and direction of the SUXOS/DS.
    - Field geophysical personnel as required to support the project specific work plan.
- Subcontractors (Marine/boat services, biologist/marine mammal observer, geophysics technicians, security support, etc.)
- Visitors or other site personnel

2.2 EQUIPMENT

The following general equipment is required for SM operations:

- Personal protective equipment outlined in the Activity Hazard Analysis (AHA)/Job Safety Analysis (JSA)
- Shark marine underwater navigation system. (SM)
- Hand-held geophysical instruments - underwater all metals detectors.
- Global Positioning System (GPS) unit.
- Underwater video system or camera.
- Operations support vehicles.
- Markers, floats, or buoys with appropriate anchoring as authorized in the project specific work plan.
- Support vessels as required in the project specific work plan and outlined in the pre-operation checklists.
- Health and safety equipment per project specific work plan pre-operation checklists.
- Diving equipment as outlined in the project work plan and the Tetra Tech Munitions Response Diving Safe Practices Manual.

2.2.1 CASE CONTENTS

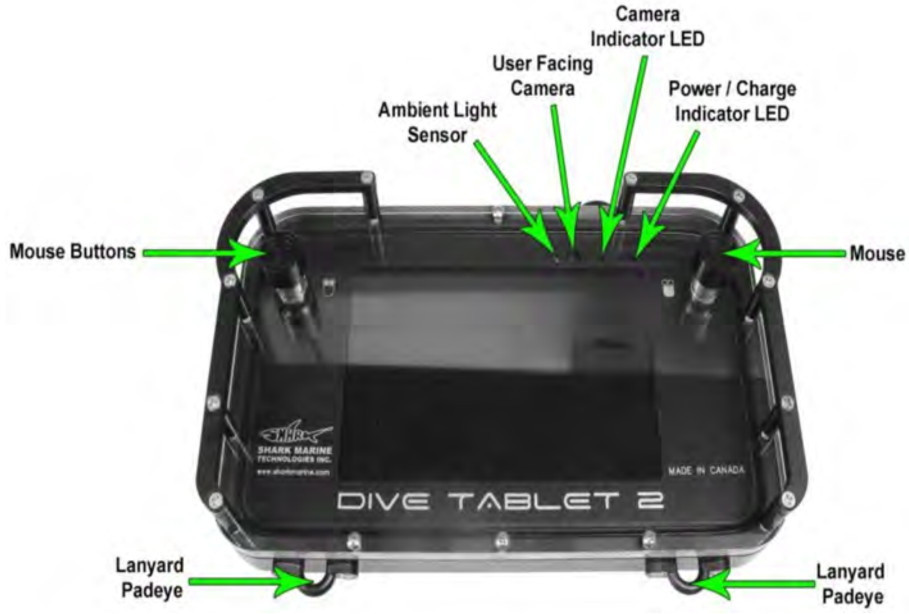
The SM is supplied in rugged cases suitable for transportation and storage. The standard case will also have accessories stored under the foam, beneath the Dive Tablet 2.

The SM case typically contains the following items:

- Dive tablet 2 system
- Dive tablet 12V power supply
- USB adapter cable
- Vacuum pump
- DiveLog software and dedicated USB drive for setup
- Silicone lube in canister
- DiveLog mission planning dongle
- Lens cap, yellow (1 installed, 1 Spare)

2.2.2 EXTERNAL OVERVIEW

2.2.2.1 External Components Overview



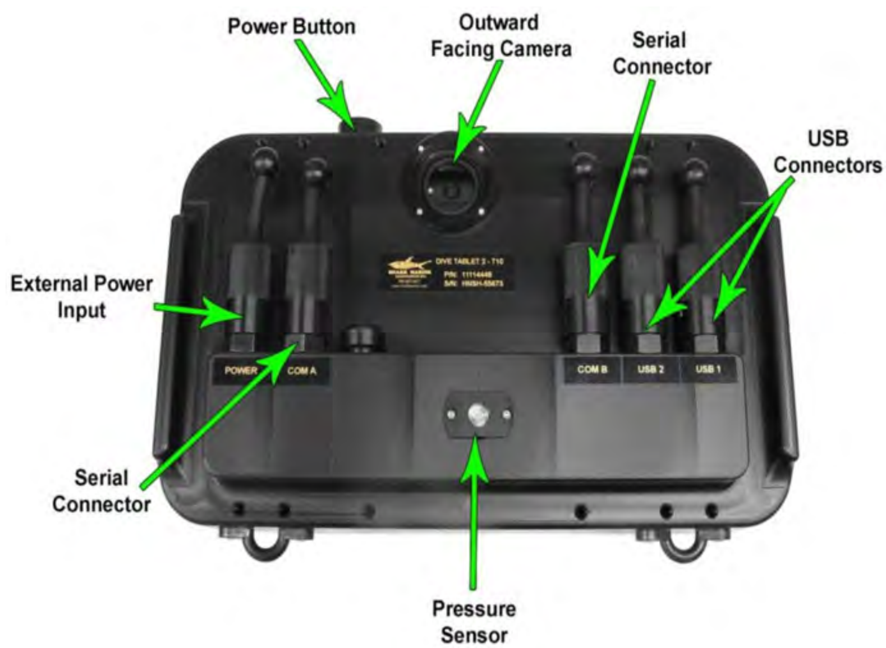


Figure 1. Dive Tablet 2 External View

2.2.2.2 Left/Right Mouse Buttons

The Dive Tablet 2's user input is primarily accomplished through the two thumb controls. The thumb control on the right, performs the on-screen cursor movement, like a mouseon a standard PC. The thumb control on the left emulates the right and left mouse buttons. Press it to the left to perform a left-click and press it to the right to perform a right-click.

Note: *Do not use the thumb controls on the Dive Tablet 2 while the system is powering up, they self-calibrate during power-up.*

2.2.2.3 Main Power Switch

The only other control on the Dive Tablet 2 is the main power button. Press the power button to turn on power to the Dive Tablet 2. The Dive Tablet 2 will vibrate momentarily to indicate start-up.

Pressing the button during operation will cause the tablet to hibernate (power down), if the tablet becomes unresponsive, you can force a power down by holding the power button for 5 seconds.

Note: *Always press the power button gently; excessive force may damage the tablet PC.*

2.2.3 External Power Input

The Dive Tablet 2 can run for an extended period on the internal battery, for applications requiring higher power the Dive Tablet 2 can be run from an external 12V battery. When at the surface, attach the provided alternating current (AC) power supply to the tablet to provide external power as well as charging of the internal battery.

2.2.3.1 Serial Bulkhead Connector

The serial connector can be used to connect a variety of RS-232 accessories, including extension GPS, LBL, SubNet, Sidescan sonar, and other devices. This port also provides 12V power, some devices may require an external battery to supply enough power, please check operating specifications to ensure power requirements. The maximum power without the external battery is 150 mA, with the battery is 3 Amps.

2.2.3.2 USB Bulkhead Connector

The USB connector allows connection of standard USB devices to the Dive Tablet 2. This port supplies 5V and 12V power for Shark Marine devices. A USB adapter cable is provided to convert from the underwater connector to a standard surface USB connection.

2.2.4 OTHER COMPONENTS

2.2.4.1 Internal Cameras

The Dive Tablet 2 contains 2 internal cameras, one facing outward and one facing the user. The cameras are used to take still pictures or video using the DiveLog software, consult the DiveLog software manual for details.

2.2.4.2 Accessory Slide Mount

The optional accessory slide mount can be mounted to the back of the Dive Tablet 2 and used to mount additional accessories on the SM. The Accessory slide mount can be optionally moved to different locations depending on the application.

2.2.4.3 Lanyard Pad eye

The lanyard pad eyes are used to provide a strain relief or connection point for any cables or connections that require it. The power lanyard typically connects to the bottom right pad eye when external battery is used.

3.0 PROCEDURES AND GUIDELINES

The SUXOS, UXOSO, and UXO Team Leader (TL) will review the project specific work plan prior to commencing SM operations. Any changes to the procedures will be made by a field change request as outlined in the project work plan.

3.1 EQUIPMENT SET-UP

Materials or equipment received at the site will be inspected for serviceability and system operations manuals. Photos will be taken and filed with the daily quality control reports, the quality receipt inspection report, or equivalent record.

- Shark marine underwater navigation system will be assembled and operated following this SOP. This includes daily equipment checks and data recordings as appropriate to their use.
- GPS systems will be assembled and operated following the appropriate SOP. This includes daily equipment checks and data recordings as appropriate to their use in support of SM operations.
- Cameras and video systems, when used, will have video cards and batteries checked for their use in support of SM operations as applicable.

All tests will be reported to the field management team and be documented for inclusion in the daily reporting.

3.2 SYSTEM SET-UP

3.2.1 PRE-DIVE CHECK

The Dive Tablet 2 has been designed to allow for very quick set-up. It can be deployed within seconds of arriving on site. The Dive Tablet 2 comes with the DiveLog software already installed and set to load automatically when the Dive Tablet 2 boots up.

Note: If the Dive Tablet 2 has been opened recently or has been idle for an extended period, a vacuum test should be performed. See Section 5.6 or Appendix 1 for complete instructions on performing a vacuum test.

1. ***CAUTION: Check that the vacuum plug is in the Dive Tablet 2.***
2. If applicable, plug in an external battery with the Power Cable/Lanyard, clip the PowerCable/ Lanyard to the battery, and clip the battery to the operator.
3. Turn the power dial clockwise to power on the Dive Tablet 2.
4. Once completely powered up, quickly check that DiveLog is reporting data from all expected sensors.
5. Ensure all external components are in place and tightly secure, dummy plugs are fitted to unused connectors, and all cabling is secured, and no cables are dangling, which could get caught on underwater objects.
6. Enter the water.

3.2.2 POST DIVE CHECKS

1. Power down the Dive Tablet 2 to hibernate or use the windows start menu to shut down.
2. Check the unit for any signs of damage. Clean off any dirt or debris.
3. If used in salt or dirty water, rinse off the Dive Tablet 2 as soon as possible in clean fresh-water. It is best to fully immerse the Dive Tablet 2 in fresh water if possible. Take extra care to flush out the pressure transducer port since the thin stainless steel wall of the diaphragm may corrode if left dirty.
4. Dry off the Dive Tablet 2 and place it back into the case. ***Caution:* Do not leave the Dive Tablet 2 sitting in direct sunlight.**
5. When convenient or for storage, open the case a bit to allow any moisture to evaporate andavoid mildew.
6. Charge the battery by plugging it in using AC power adapter.

Note: *Always maintain the Dive Tablet 2 battery in a charged state so that the system is ready to go at a moment's notice.*

3.3 USING THE DIVE TABLET 2 ON THE SURFACE

The SM can be used above water for mission planning, boat operated surveys, and surface navigation. The Dive Tablet 2 can be used above water for indefinite periods of time, providing the unit is not in direct sunlight for extended durations. To save on underwater batteries, the Dive Tablet 2 is designed to operate from any 12 V direct current (DC) power source, such as the vessel power with the optional DC power cable. This also saves the underwater battery power for the dive tasking.

4.0 MAINTENANCE

4.1 O-RINGS

O-rings are used for most of the seals on the SM. These small rings made of rubber are important for keeping seawater from entering the internal electronics of the Dive Tablet 2. The O-rings should be replaced:

- Once a year during a regular maintenance (except for the bulkhead connector O-rings).
- When the faceplate on the Dive Tablet 2 is removed or any service is performed, the condition of the O-rings should be checked carefully and replaced if questionable.

Inspect an O-ring as follows:

- Rolling it in your fingers,looking for any signs of nicks, cuts, or defects.
- The O-rings should have a smooth surface, and a perfectly round cross-section.
- O-rings should always have a thin film of silicone lubricant on their surface.
  - Apply the lubricant by dabbing a small amount onto your finger and working it over the entire O-ring surface.
- Inspect the O-ring seat or grove for smallscratches or debris.
- Always clean the mating surface carefully and thoroughly to prevent debris from compromising the seal.

4.2 CONNECTORS

All the connectors used on the Dive Tablet 2 housing are **underwater mateable.** Make sure that all underwater connectors are clean and free of dirt before plugging them together. It is important that the rubber mating surfaces for each pin have a thin layer of dielectric silicone lubricant (Dow-Corning 111, CRC or equivalent) before the connectors are mated.

- Lubricant should be applied to each pin as well as a small amount to the entrance of each socket.
- Lubrication should be performed every 5 to 6 mating cycles. *Note: Mating of non- lubricated connectors will cause damage to the surface of the rubber and compromise the sealand electrical connection*.
- Cleaning of the pins and sockets can be done using pressurized aircan be used if it is done lightly not to build up pressure in the sockets.

4.3 DESICCANT PACKS

When the faceplate is removed from the Dive Tablet 2 for O-ring replacement, it is recommended that the internal desiccant packs be replaced as well. They will absorb moisture after performing the vacuum tests and become ineffective over time.

4.4 BATTERIES

To preserve the life of the battery, charge it after every use. The battery monitoring electronics system in the Dive Tablet 2 will turn off the battery if the external battery is drained too low. This protects the battery from potential damage caused by over discharge.

If not used for extended periods of time, the batteries (both external and internal) should be charged once a month as part of a maintenance schedule to maximize the life of the battery.

4.5 MAINTENANCE SCHEDULE

The following is the recommended maintenance schedule is to be performed for the SM. Please refer to Appendix 1 for details of these procedures.

Recommended Maintenance		
Task	**Timeframe**	**Description**
Underwater connector lubrication	After 5 to 6 mating cycles	✓ All the connectors on the main housing of the Dive Tablet 2 are underwater mateable. ✓ Ensure the underwater mateable connector pins/sockets are lightly lubricated with Dow-Corning 111 silicone lubricant (or equivalent) frequently. ✓ If the underwater mateable connectors require cleaning, the pinsand sockets can be cleaned using a cotton swab and rubbing alcohol. ✓ Pressurized air can be used if it is done lightly, as not to build up pressure in the sockets.
Charge batteries	Monthly and after use	✓ To preserve the life of the battery, charge them after every use. ✓ If not used for extended periods of time, the batteries (external and internal) should be charged once per month.
Clean	After use	✓ Rinse the Dive Tablet 2 and external accessories in clean freshwater, then dry and store. ✓ This is particularly important after use in contaminated/dirty water or saltwater.

Visual inspection	Before and after use	✓ Visually inspect the Dive Tablet 2 for problems such as damage to the housing, acrylic faceplate, or other components. ✓ Ensure all external physical components are secure.
Vacuum test	After opening, prolonged storage, shipping, or rough handling.	✓ The purpose of the vacuum test is to simulate an external pressure on the housing and to check for any signs of leaks. ✓ This is particularly important after the unit has been open, to verify the proper installation of the seals and after storage, shipping, or rough handling.
Inspect vacuum plug O-rings	Semi- annually and when plug removed.	✓ The O-rings on the vacuum plug should be examined each time the plug is removed and replaced if there is any concern regarding their condition. ✓ The O-rings should be lightly coated with Dow-Corning 111 silicone lubricant (or equivalent).
Detailed inspection	Every year	✓ Ensure all internal electrical connections are secure. Ensure all screws and nuts are secure. ✓ Examine the system for any signs of corrosion or damage, replace parts as necessary.

Figure 2. Maintenance Schedule

5.0 TROUBLE SHOOTING

The following troubleshooting measures described below are for field use to ensure the SM is available for project support. If these procedures do not work or the diagnosis of an issue can is not determined, the field team will contact the manufacturer to see if resolution can be provided.

5.1 DIVE TABLET WILL NOT TURN ON

- ✓ Ensure internal battery is charged,
- ✓ Plug in Dive Tablet to AC power adapter and wait a minimum of 10 minutes
- ✓ Attempt to power on again.

5.2 DIVE TABLET IS NOT READING “LEVEL” WHEN IT IS LEVEL

- ✓ Double click the heading value in DiveLog to select the proper heading, pitch, and roll (MRU) configuration.
- ✓ In MRU configuration, check that the proper mount is selected.
- ✓ In MRU configuration, either tune the offsets with the arrow buttons, or press the button to automatically set the pitch and roll offset.
- ✓ For complete MRU calibration details see Appendix 3 - DiveLog Software Manual.

5.3 DATA FROM A SENSOR OR EXTERNAL DEVICE NOT IN DIVELOG

- ✓ Verify COM port settings in DiveLog. See the Appendix 3 - DiveLog Software Manual.
- ✓ Try using different COM port if available, to determine if the problem is with the port or the device.
- ✓ Verify power settings in DiveLog. See the appendix 3 for details on enabling/ disabling power to specific devices and ports.
- ✓ Turn off the unit and disconnect from the power source. Re-start the SM system.
- ✓ Check all the cables for damage.

5.4 EXTERNAL BATTERY PROBLEMS

The NiMH battery has a built-in resettable fuse. In the event of a short or over- current, the battery will temporarily cut off the output power. If this occurs, disconnect the battery, and allow it to cool down. After a few minutes, the battery should be operable again.

If the battery does not last very long, it is possible that the battery cells have been damaged due to over-discharge or improper charging procedures.

If the battery feels hot, wait one hour. Use a voltmeter and check the output voltage of the battery. If the battery reads no output voltage (0V) and the battery has cooled down, then there may be a problem with the reset-able fuse internal to the battery pack. The battery pack may need to be replaced. Consult the manufacturer.

5.5 SOFTWARE IS UNRESPONSIVE

If DiveLog has frozen and become unresponsive, try to use the Windows task manager to close DiveLog, then restart it. If this does not work, try to restart via the Windows start menu.

If Windows has become frozen and the system is unresponsive, turn the power dial clockwise and hold for 5 seconds to cut power to the system. Unplug the external battery if connected for 5 seconds then reconnect the external battery and restart the system. (Do not unplug anything at depth, any trouble shooting of this level should be done on the surface.)

If Windows remains unresponsive, try unplugging any external devices. The thumb stick control can become unresponsive if the attached devices are drawing too much power.

5.6 PERFORMING A VACUUM TEST

The purpose of the vacuum test is to simulate an external pressure on the housing and to check for any signs of leaks. *<u>Note</u>: This is particularly important after the unit has been open, to verify the proper installation of the seals and after storage, shipping, or rough handling.*

- ✓ Test the vacuum pump. To test the vacuum pump, seal the end of the port fitting at theend of the hose, pump the vacuum, and confirm that it does not leak.
- ✓ Remove the vacuum plug located at the back of the Dive Tablet.
- ✓ Using the vacuum pump supplied in the tool kit, push the fitting into the vacuum port.
- ✓ Pump to 10” of mercury (Hg). Let sit for about 15 minutes, longer if practical, and make sure the

vacuum is holding (the needle may drop about ¼" mercury due to temperature changes).

- ✓ ***Do not power up the Dive Tablet during the vacuum test*** since the air inside allows for cooling of the electronics. Powering up the Dive Tablet during a vacuum test may cause overheating of the internal electronics and damage to the unit.

- ✓ When complete, press the pressure release button on the vacuum pump to remove the vacuum and remove vacuum pump.

- ✓ Check that the O-rings on the vacuum plug are lubricated and in good condition.

- ✓ *Re-insert the vacuum plug*.

CAUTION***: If the vacuum test is not successful, DO NOT PUT THE DIVE TABLET IN THE WATER. Troubleshoot the issue and contact the manufacturer if difficulties are encountered.***

6.0 DIVE LOG 4 QUICK START PROCEDURES

DiveLog is an all-in-one maritime operations software. With the ability to record, analyze, andplayback data from a multitude of sonars and sensors, DiveLog simplifies any diver, ROV, or vessel-based operation. Originally designed for easy underwater navigation, DiveLog evolved to provide an array of easy-to-use tools for pre-mission planning, data acquisition, and post- mission data analysis and presentation. By linking all recorded data by time and location, details are easily viewed and analyzed amid hours of mission data.

The main two components of DiveLog are the Navigation View and the Active Screens. The Navigation View shows all navigation and project information in real-time or playback mode.The Active Screens give DiveLog the rest of its functionality, allowing peripheral use and fileplayback. These work simultaneously to make creating and viewing data as easy as possible.

Note: *This SOP gives a quick introduction to DiveLog4, for more detailed instruction, refer to Appendix 2.*

6.1 PRIMARY

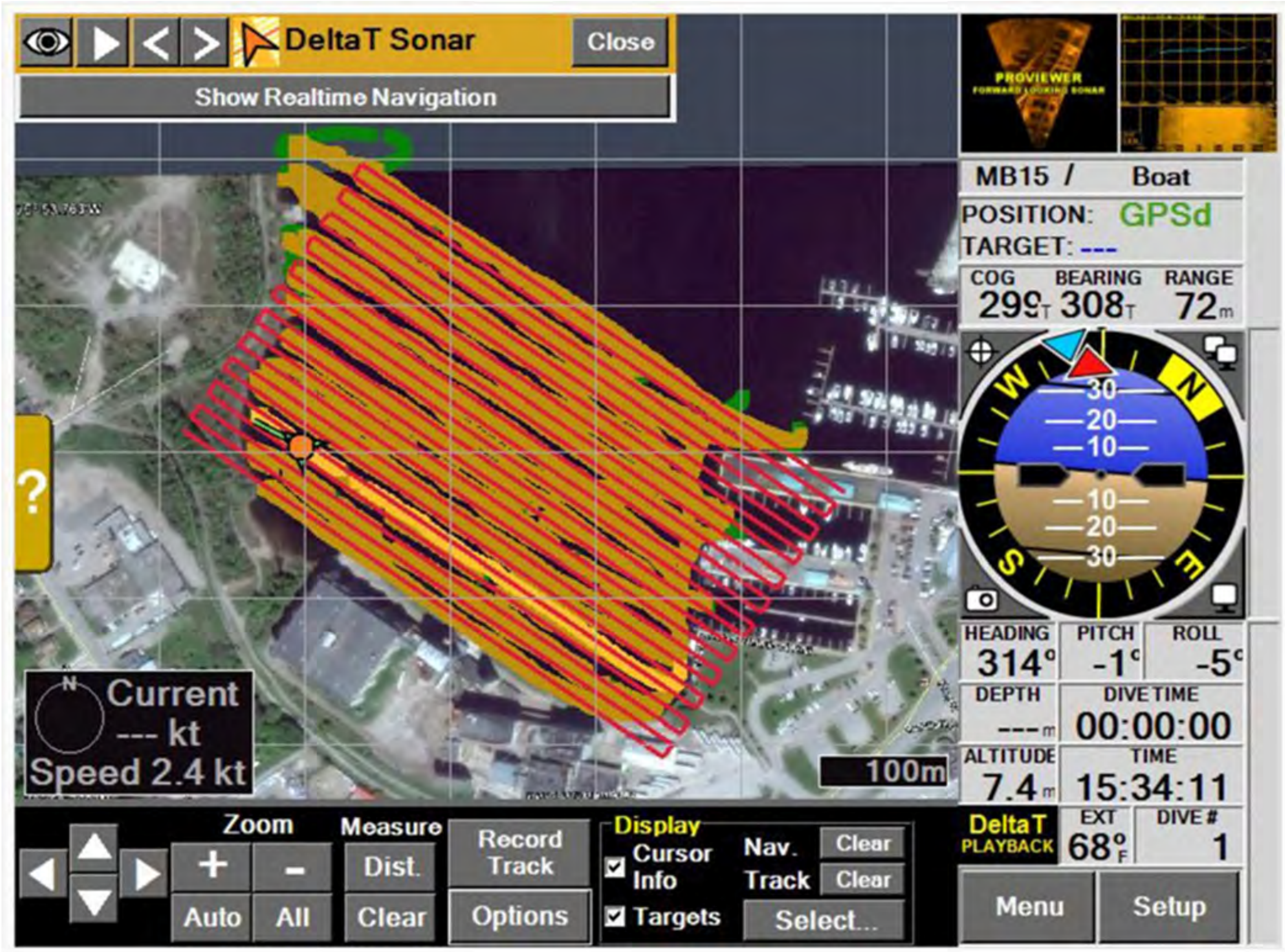


Figure 3. Primary Screen of Dive Tablet 2

6.2 MODES

DiveLog can be run in three main modes, each adding new functionality:

	View Only	Mission Planning	Survey
View Project Data	✓	✓	✓
Create/ Edit Project Data	-	✓	✓
Run Devices/ Sensors	-	-	✓
Record	-	-	✓

Figure 4. DiveLog Modes Table

Other modules, providing support for various sonars and data analysis tools, are enabled separately.

If you are using a SM hardware product, such as the Navigator, Dive Tablet, or Topside Controller, these modes and modules will be enabled internally. If you are using DiveLog on any other hardware, a security dongle will be required to verify your authorization. If a security dongle isn't present, DiveLog will revert to view-only mode.

6.3 PROJECTS

In DiveLog, data is organized into folders called **Projects**. A project stores all information related to a certain location or mission, including pre-mission planning, and collected data.

This makes viewing and summarizing this information easier. Each project resides in the "Projects" folder. A shortcut to this folder is placed by default on the desktop.

The **Project Setup** window contains all the tools for managing your projects. You can open it by clicking the project code text in the top-left of the Navigation View or selecting **Main/ Setup/ or Project Setup** in the Main menu in the bottom-right.

6.4 IMPORTING A PROJECT

To import a project, click the **Import** button on the **Project Setup** window to bring up the **Import Data** window. **Entire Project** will be the selected data type by default, so you can simply click **Browse** to select the project folder you want to import. After you select a project, click **OK** to finish the import.

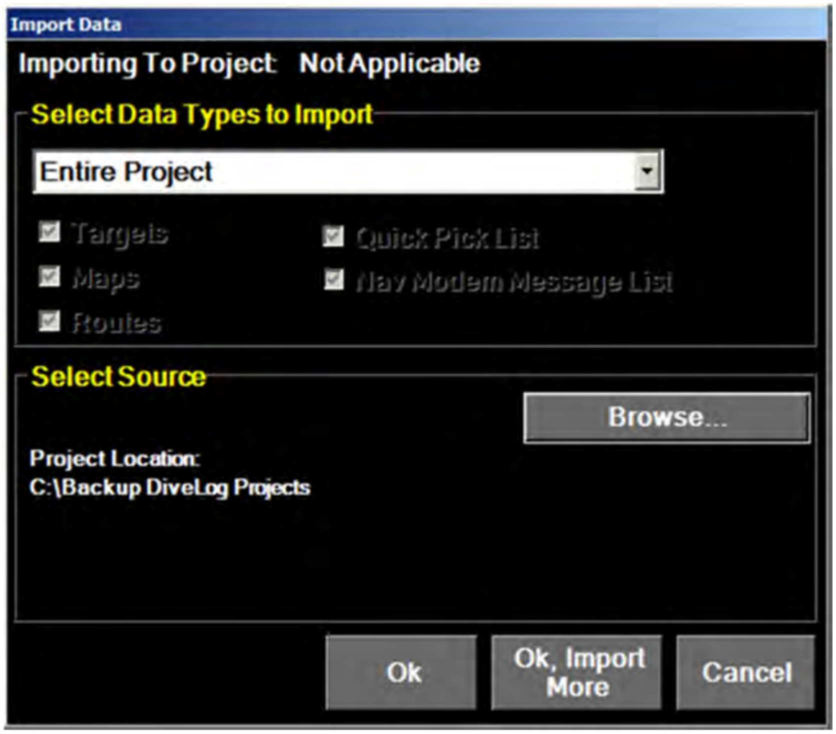


Figure 5. Project Screen

6.4.1 Changing and Creating Projects

To switch between projects, select a project other than the current one from the **All Projects** list on the project setup window and click the blinking change current project button.

To create a new project, click **New Project**, and fill in the project name, code (short representation of the name), and date, before clicking **Ok**.

6.4.2 Active Screens

For the most important DiveLog tasks, such as running a sonar or planning a mission, there are dedicated windows called **Active Screens**. Multi-tasking can be difficult, so each screen can be placed in 3 different locations to make managing different tasks more convenient.

1. Primary Screen: Fills the main view of DiveLog beside the Navigation View.
2. Secondary Screen: Fills a small preview window in the top-right of the main window.
3. Detached Screen: Fills a regular window outside of the main window. You can turn on or off any Active Screen from the System Setup window

6.4.3 Run, Record, and Playback

Most active screens run a specific hardware device and are all controlled in the same way. To start or stop a connected device, click the **Run** button. Once the device is running, click **Record** to start or stop saving the incoming data. Each active screen has an Options window for setting up your device. You can access this window by clicking the **Options** button. To playback recorded files, open this window, and click **File**… to view a list of saved files for this device.

Choose a file from the list, or by clicking **Browse**, and click **OK** to start playing the file. You can control playback using the bar at the bottom of the screen.

6.4.4 The Track Screen

The **Track Screen** brings all the project data into one map view. You can use it to plan operational routes, as well as view tracks of collected data, on a geodetically calibrated map. This window is always present and displays either the real-time position and navigation information, or past information being played back in any active screen.

6.4.5 Tracks

All data collected with a valid position creates a **Track**; a trail of points where data was collected. The Track Screen displays tracks as a series of points, with device-dependent colors. Hovering the mouse over a track gives you information about when, where, and what was being collected at that track point. Right-clicking on a track point allows you to open that recorded file, starting at that time, in that device's active screen.

Figure 6. Track Screenshot

When any other active screen is recording or playing back a file, the track screen shows the position and navigation info of each data point. It also displays the coverage for any track whose device has an area of effect, such as a sidescan sonar, multi-beam profiling sonar, or forward-looking sonar.

6.4.6 Routes

A **Route** can be used to guide a diver to a target or along a path. All route options can be accessed by clicking the **Manage Routes** button on the **Track Options** window.

To start a route, select a route from the list and click the **Goto Route** button. A route control bar will appear at the top of the primary screen and allow you to control and view your progress along the route. You can cancel the route by right-clicking that control bar and selecting **Cancel Goto**.

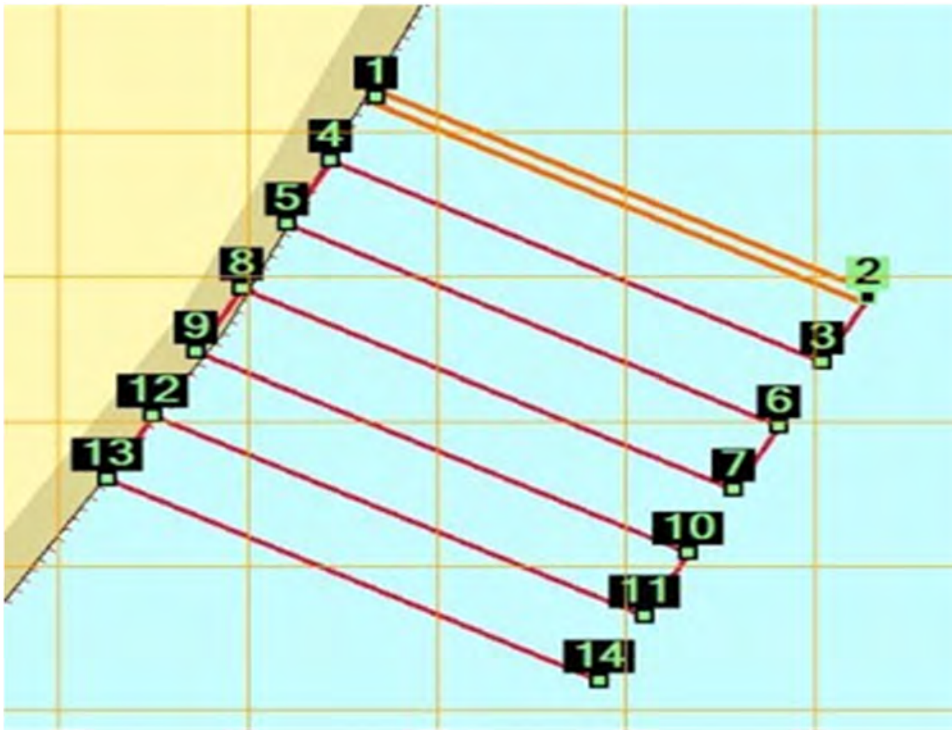


Figure 7. Example Planned Route Screen

To quickly set a Goto route to a target, just **right-click** on that target and select **Goto Target**.

6.4.7 Targets

An object or position of interest can be marked as a **Target** in DiveLog. Each target has a position, name, description, and any number of associated files (images, videos, sonar files). Targets are linked by time and position to associated files, allowing quick review of target data.

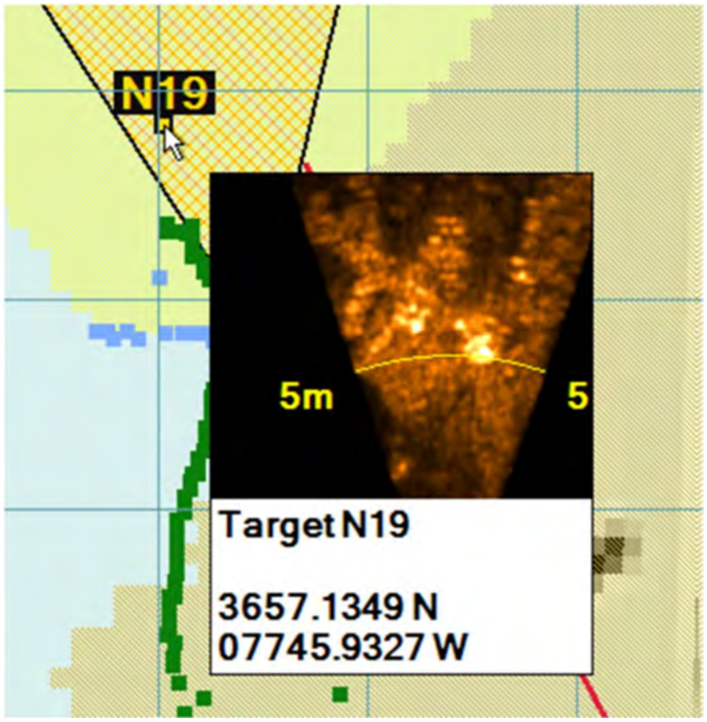


Figure 8. Example Target Screen

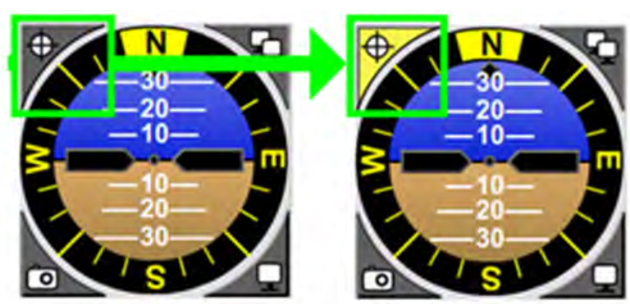
Targets are displayed across all active screens when the location is visible. To see target info, hover over a target label on any active screen.

6.4.8 Marking and Linking Targets

Marking a target on any active screen creates a new target at that position or repositions an existing target. Linking a target on an active screen marks a moment in that file the target has been seen, so important target data can be quickly switched to later.

Marking and linking targets in DiveLog is done the same way, regardless of which screen is the primary screen. The targets are also marked the same way in real-time or in playback mode. To mark or link a target, left, or right-click the target icon, as seen below, and select a position on any active screen.

Right- Click (LINKING)



Left-Click (MARKING)

Figure 9. Linking and Marking

6.4.9 Editing a Target

Target information can be edited from the manage targets window, accessed by clicking the target label at the top of the navigation view, or by selecting **Main / Targets / Manage Targets** in the main menu. This window also allows you to export, import, and remove targets.

6.4.10 Sensors and Ports

DiveLog can control a wide array of sensors and peripherals, from sonars to magnetometers, pressure sensors to full ROVs and diver vehicles. Since each of these devices may have a unique communication setup, DiveLog gives simple interfaces to manage and monitor these connections.

6.4.11 System Setup

The **System Setup** window controls communication and power to peripherals, as well as which active screens are visible. You can open this window by clicking the setup button in the bottom right corner of the main DiveLog window.

6.4.12 COM Ports

The **COM** Setup tab in the system setup window allows you to set up serial communication to peripherals. Each device in the list has a set of controls to turn it ON or OFF, change the COM port it's connected to, or view/ set the port details, such as baud rate. The config button, if enabled, shows the device-specific settings for that peripheral.

6.5 DIVELOG RUN MODE

DiveLog will run in several different "run modes" depending on the hardware. Since the different systems have different hardware and features, the user interface in DiveLog will have some differences.

The following describes some differences between the run modes:

Navigator Delta: This is the mode for DiveLog when running on the navigator delta hardware. By default, port communications and real- time operation of standard sensors and accessories is **enabled** (some add-on features and sensors must be enabled separately). Differences in the user interface from other run modes include:

- An interface for monitoring the internal and external battery status and internal battery charging.
- An interface for setting the screen mode including screen brightness and changing screen setup (turning on/off the underwater head-mounted display).
- An interface for turning on/off the power to external peripherals (on the system setup window).
- Interface for setup and calibration for extended heading pitch roll (HPR) range (internal HPR #2, optional).

6.5.1 DIVE TABLET:

This is the mode for DiveLog will be in when running on the Dive Tablet hardware. By default, port communications and real-time operation of standard sensors and accessories is **enabled** (some add-on features and sensors must be enabled separately). Differences in the user interface from other run modes include:

- A display for the internal battery status and charging.
- An interface for setting the screen brightness.
- An interface for turning on/off the power to the external USB and serial port (on the system setup window).

6.5.2 NAVIGATOR GAMMA:

This is the normal mode that DiveLog will be in when running on the navigator gamma hardware. By default, all port communications and real time operation of accessories and sensors is **enabled** (except for certain cases where an add- on feature must be enabled separately). Differences in the user interface from other run modes include:

- A unique interface for the NavCam, for older legacy NavCam models.
- COM Port setup for internal depth and HPR sensors.

6.5.3 PC MODE:

This is the mode that DiveLog will be in when running on a PC/Laptop or topside unit. By default, port communications and real-time operation of accessories and sensors is **disabled**. Features in this mode are generally enabled with a security dongle. Depending on features enabled with a security dongle, the following may be enabled:

View Only Mode: The default when no security dongle is used. This mode allows the user to review previously recorded project data. A project may be imported to view data, but no edits to the project can be or saved. This mode can be used for data analysis and demonstrations.

Mission Planning Mode: When a Security Dongle is used with mission planning enabled, features allowing for playback, review/editing of data as well as project creation and setup are **enabled**. All accessory and sensor communication are **disabled** in this mode. Mission planning mode is commonly used on a PC by the personnel performing pre-mission planning (and project creation/setup) and post-mission data analysis. Each purchase of a navigator or SeaSAR system commonly includes two mission planning enabled security dongles.

Survey Mode: When a security dongle is used with survey operations enabled, in addition to mission planning features described above, COM port communication is **enabled** to allow standard accessories such as a GPS and HPR to be used. Accessories associated with active screens such as the forward-looking sonar, NavCam, magnetometer, et cetera, will be disabled by default unless individually enabled by the security dongle. This mode would be used on survey data collection system such as a SeaSAR topside or an ROV topside.

Note: DiveLog Projects on a navigator delta, dive tablet, navigator gamma and PC-topside are fully compatible with each other, so projects created with one system can be transferred to another system and used without any compatibility problems.

7.0 START-UP CHECKS

When DiveLog starts up, several things are checked to ensure compatibility with the operating system. DiveLog will first check that it is not already running. Only one instance of the DiveLog software can be running at once.

DiveLog will then check that the DPI setting in Windows is compatible. DiveLog will only display correctly if the DPI setting in Windows is set to “Smaller – 100%” rather than “Medium – 125%”. If the setting is not 100% then DiveLog will indicate the problem to the user and then close.

To change the DPI setting in Windows 7, right-click the Desktop and select Personalize, then select Display at the bottom left. Choose "Smaller - 100% (default)”.

DiveLog will also check that the language setting in Windows is compatible. DiveLog cannot run if the language uses commas to separate the decimals in numbers rather than periods, as this affects the way numbers are read from the various files that DiveLog uses. If there is a problem, then DiveLog will indicate it to the user and close.

To be safe, before changing the language setting you should close any software programs that are running, and restart Windows after the change has been made.

To change the language setting in Windows 7, go to Control Panel, then select “Region and Language”. On the first tab "Formats", the recommended setting under "Format:" is “English (United States)”.

In Windows XP, the option in Control Panel is called "Regional and Language Options", and the language is chosen at the top of the tab "Regional Options".

7.1 DIVELOG SOFTWARE OVERVIEW

The SM DiveLog software normally fills the entire display screen of the main display. DiveLog displays navigation data, track/map data, and accessory data such as a sonar image or magnetometer graph. DiveLog can be minimized or switched to “Navigation Only” mode where the navigation data only is displayed on the right side of the screen to allow a third-party software to be displayed on the rest of the screen. On a navigator, ROV topside, or SeaSAR survey topside, DiveLog will start automatically when the system boots up.

DiveLog always uses an active project, which consists of an organized folder of files containing various data such as maps, log files, track files, sonar files, et cetera. In any mode of operation, project files can be displayed and played back. If activated for real- time operations, DiveLog will also operate sensors and accessory equipment and display and record the sensor data.

Besides display data for sensors such as depth, altitude, and heading/pitch/roll on the navigation view, the main DiveLog screen real-estate consists of an “Active Screen”, which can display one of many sets of image and controls. The default active screen is the track screen which displays tracks of current or past recorded movements and other position data overlaid onto a map background. Other optional active screens consist of display/controls for different sonar models, display/controls for other as a magnetometer, and special operations such as the rapid beach profiling system. These active screens can also be simultaneously utilized: additional active screens exist as thumbnails called the “Secondary Screens”, and with a single click, a “Secondary Screen” can be toggled to the “Primary Screen”.

In general, targets can be marked in any of the active screens, whether the data source is real- time or playback. A target marked in any screen, either in real time or playback, is immediately shared across all modes of operation. All targets are marked as geodetic latitude/longitude co- ordinates and recorded with additional information to make documenting and classifying targets as easy as possible.

***Note**: On the Navigator or Dive Tablet, DiveLog is not meant as a replacement for a Dive Computer but instead aids the diver by providing extra information and logging the dive data.*

7.2 DIVELOG DISPLAY

7.2.1 Active Screens, Primary Screen and Secondary Screens

DiveLog consists of the navigation display, plus several add-on modules called Active Screens. The active screens give DiveLog the ability to expand to use any number of peripherals or functions by turning on various Active Screens.

The main screen of DiveLog consists of the “Primary Screen”, one or two “Secondary Screens”, and the navigation display. The primary screen takes up the largest area of the display (the left 75% of the screen) and consists of a graphical image plus controls. The primary screen will toggle positions with a secondary screen when a secondary screen is clicked. This allows quickly and easily changing between the track display, the sonar display, and the display for other accessory equipment.

The secondary screen is displayed as a thumbnail of the minimized display. They occupy the top right of the screen in DiveLog. In general, all screens will continue their current operation (such as recording) while minimized as a secondary screen; however, they will need to be toggled to primary to display the controls to change any settings.

This allows the user to visually monitor secondary screens while focusing on the primary screen.

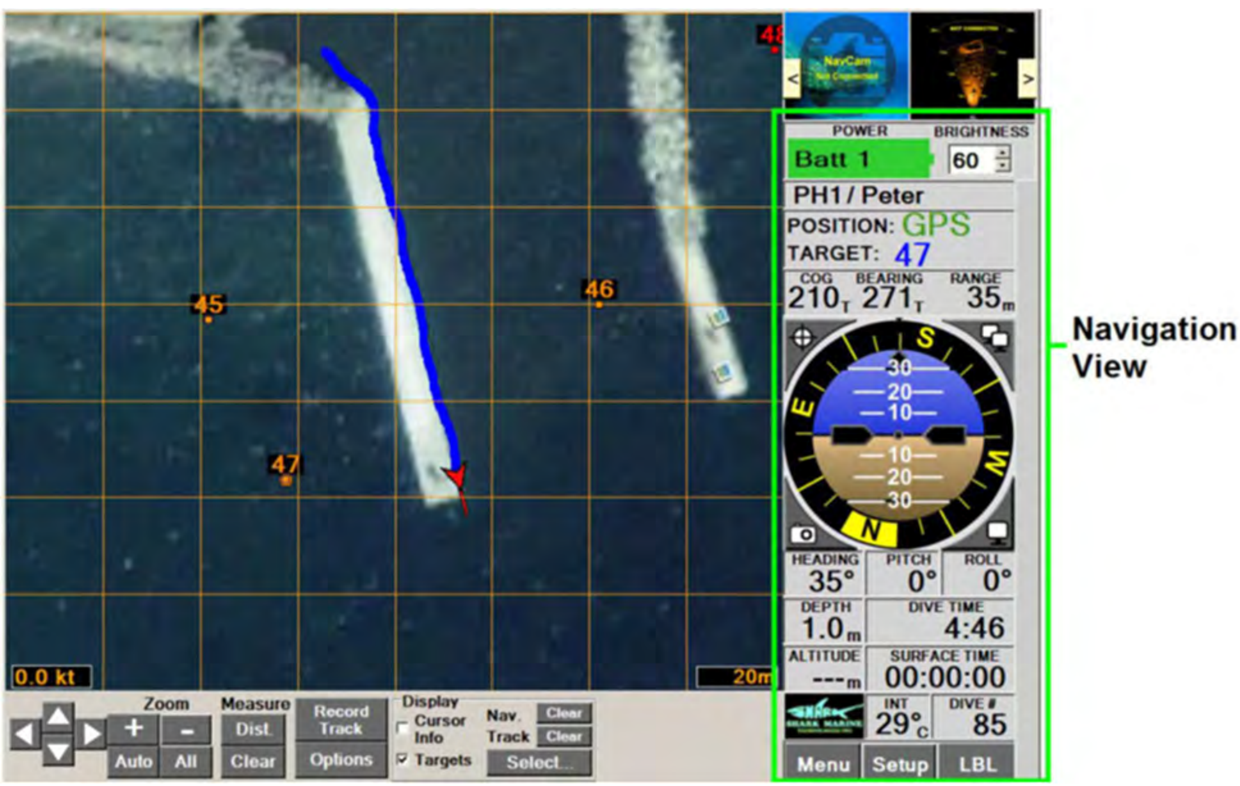


Figure 10. Active Screen Example

To select which active screens are used, the selection is made on the system setup window. Any number of Active Screens can be turned on (and used simultaneously).

7.2.2 Detaching Screens

Any secondary screen in DiveLog can be detached from the base window into a separate window. This is useful when using more than one monitor for display. Screens can be detached by right clicking on the secondary screen image and select "Yes" to the prompt.

Figure 11. Detached Screen

The following illustration breaks down the Navigation View:

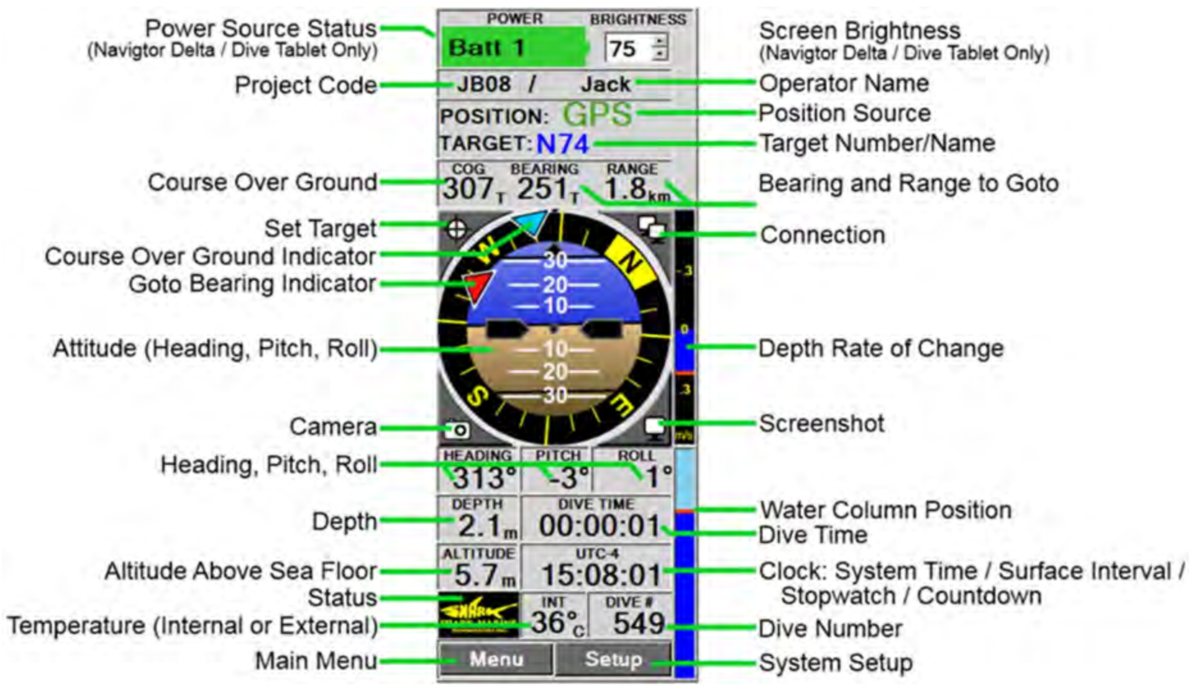


Figure 12. Navigation Screen

7.2.2.1 Position Sources

The position source is displayed as text near the top of the navigation view. The default text for the position source will be “***”, indicating there is currently no position data to use. To have a valid position, a positioning device must be connected. The possible source indicators are:

a) *** – No active position source
b) GPS – Primary GPS
c) GPS2 – Secondary GPS
d) GPSr – RTK Fixed GPS
e) GPS2r – Secondary GPS RTK Fixed
f) GPSd – Dual Head GPS (provides heading as well)
g) GPSi – Internal GPS (Dive Tablet only)
h) LBL – Long Baseline System
i) DNS – Doppler Navigation System
j) DNS-L – DNS and LBL simultaneously (DNS updates position between LBL fixes)
k) SET – The position has been manually entered or set on the Track Screen.
l) USBL – Ultra-short Baseline system
m) SUR – Position sent from a surface unit

n) DR – Dead Reckoning (position estimated from heading and swim speed)

o) BOAT – D.A.S. Boat GPS

p) BOATr – D.A.S. Boat GPS RTK Fixed

q) MPOS – MiniPOSNAV3 inertial navigation system

The color of the text represents the validity of the position. The text for the position source will be green if the current position is valid, and **red** if invalid.

7.2.2.2 Full Screen Navigation View

Click on the heading/pitch/roll display on the navigation view to bring up an option for full screen navigation.

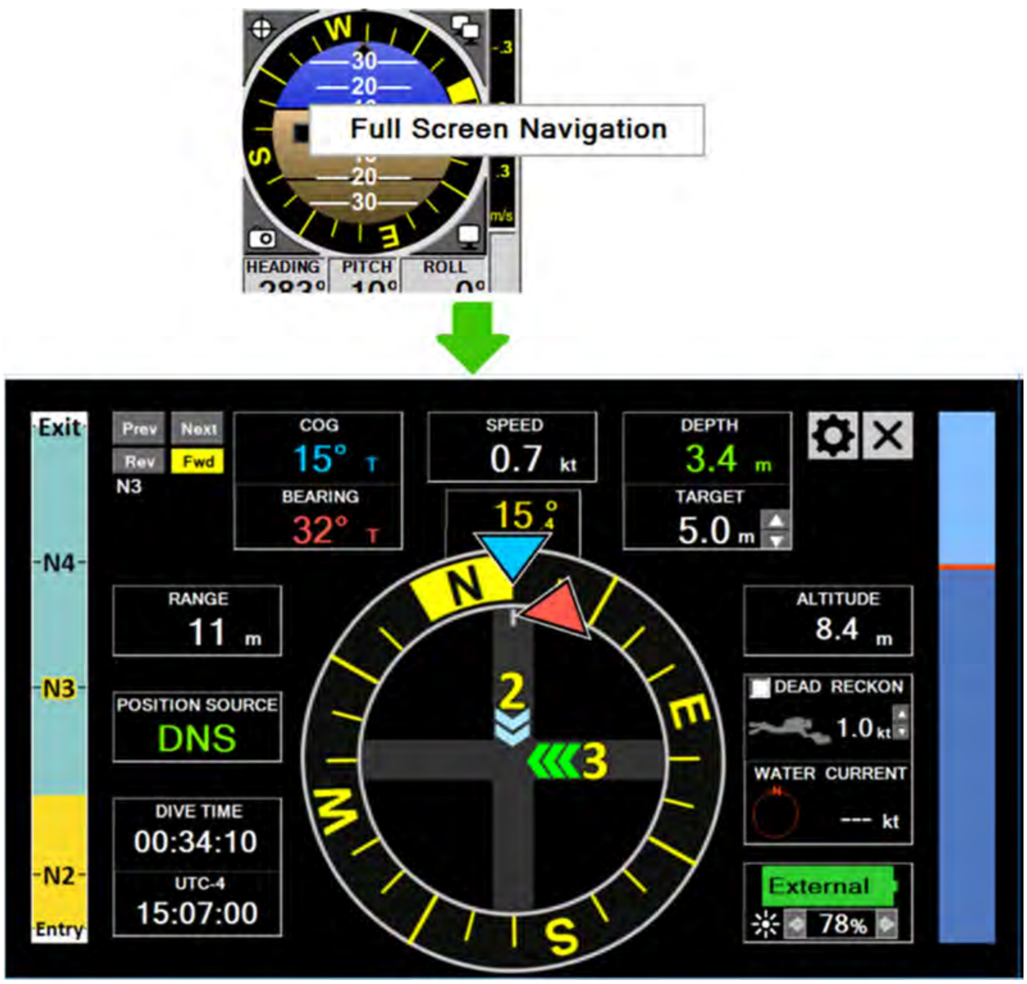


Figure 13. Full Navigation View

This view is useful when the primary task is navigating on a particular heading, navigating towards a target, or following a route. This view presents a much larger compass graphic with arrows to indicate how far your current position is from the desired position based on the current route.

Like the main screen navigation view, this view shows triangles on a compass ring to indicate the bearing to the goto location (red triangle) and the course over ground (blue triangle). Line- up these two triangles to travel on the correct bearing to the target position since the water current will cause your direction of travel to differ from your heading.

7.2.2.3 QUICK PAD ON-SCREEN KEYBOARD

The "Quick Pad" was developed to allow rapid text entry and editing on a touch screen, or the navigator thumb controls. When a text box in DiveLog is clicked, the quick pad will automatically come up (if turned on), taking up most of the screen real-estate. The quick pad will show a duplicate of the text box in a larger format to make the text clearly visible. The text box on the quick pad can be clicked to move the caret position or highlighted to delete a portion of it. Once the text entry is complete, click Accept to enter the changes, or cancel to discard the changes. Once Accept is clicked, the text may be validated depending on the window in DiveLog, and invalid text may be rejected. The quick pad can be turned on or off from the main menu, under **Setup>On**.

7.2.2.4 SCREEN KEYBOARD

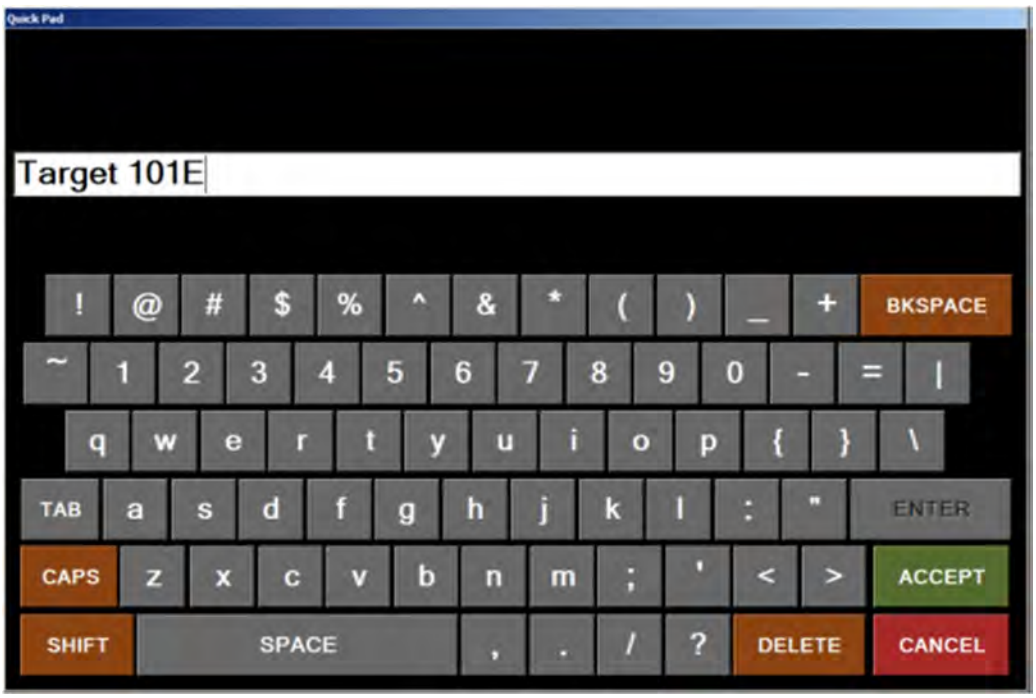


Figure 14. Keyboard Screen

7.2.2.5 TIMER OPTIONS

The timer options window can be reached by clicking on the **System Clock / Surface Interval / Stopwatch / Countdown** field on the navigation view of DiveLog.

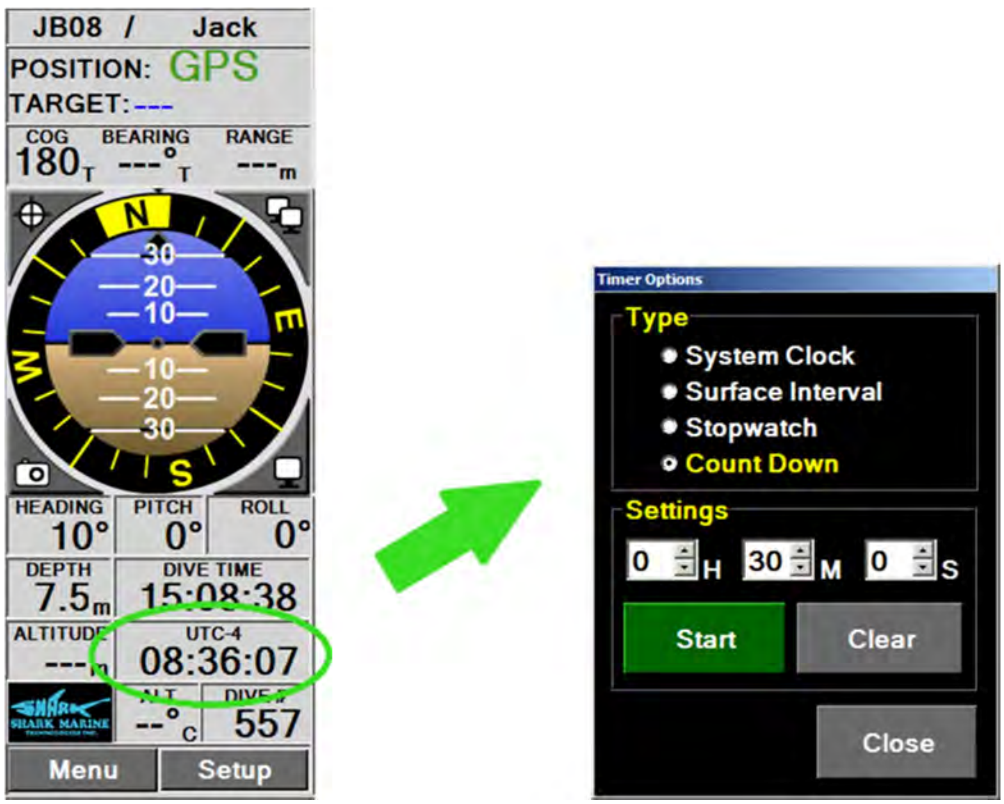


Figure 15. Timer - Countdown Function

The type of timer can be selected from four choices:

- System Clock: Displays the current computer clock time. It will also display the time zone offset from Coordinated Universal Time (*for example, UTC-4 indicates the displayed time is four hours earlier that UTC*). During file playback, this will display the time of the current playback data.
- Surface Interval: Displays the interval of time that the system has been on the surface between dives (see *Depth Configuration section* for more information).
- Stopwatch: Counts from zero in increments of one second until stopped.
- Count Down: Counts down from the start interval specified as a value in hours, minutes, and seconds and stops when it reaches zero.

To start the stopwatch or countdown timer, press the green start button. To reset or clear the count, press the clear/reset button.

For the countdown timer, enter the start value in a combination of hours, minutes, or seconds. When the countdown reaches 00:00:00, then the box displaying the value on the navigation view will flash red until the timer is stopped or cleared.

DiveLog Quick cards are easy to access, instructional images to assist the operator with any number of tasks, determined by the mission planner. They can be used as a lookup for typical DiveLog tasks, specific instructions during missions with little prep time, or as reference images to link to targets. Quick cards are useful in situations where the operator has had limited time for training.

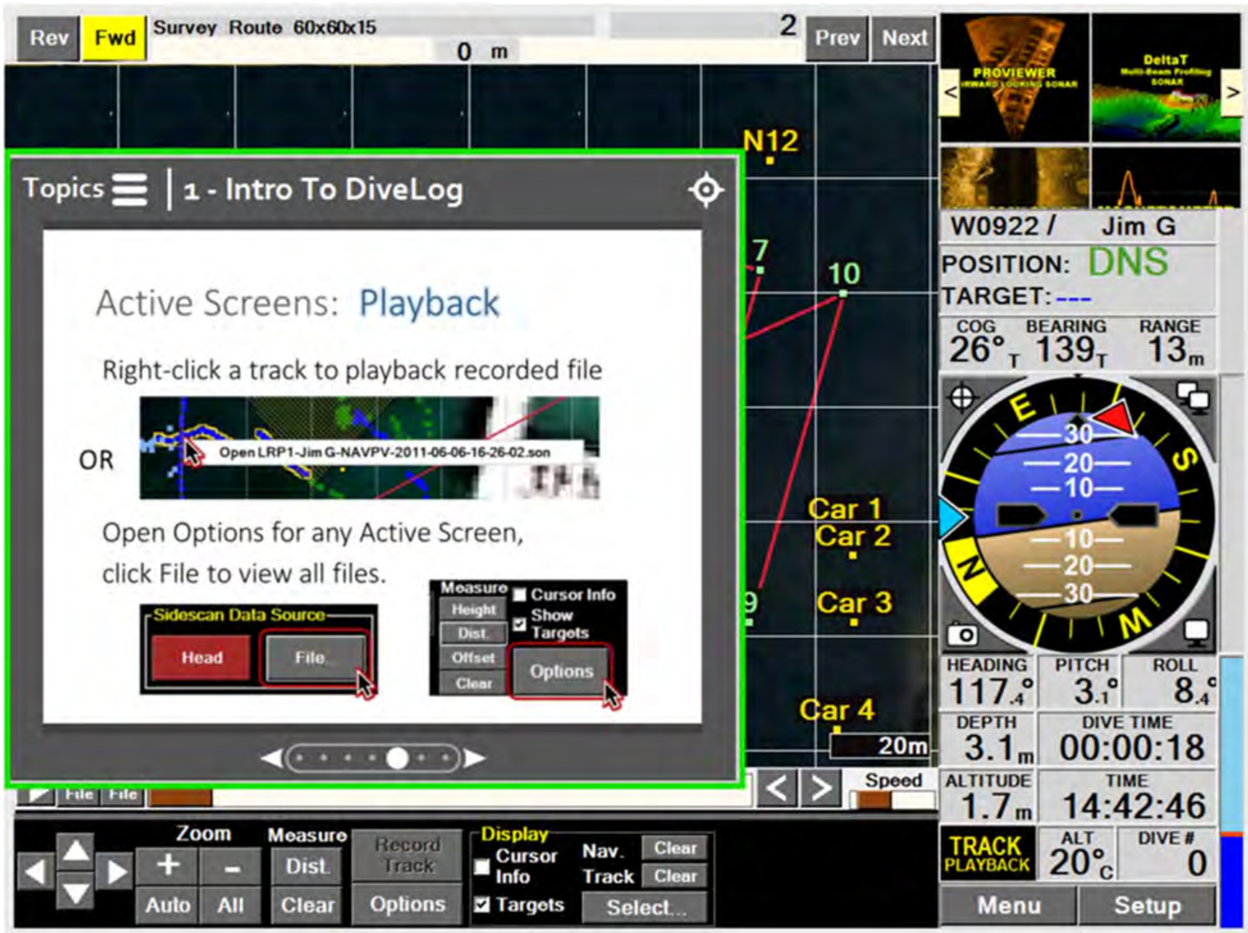


Figure 16. Quick Cards

Quick card topics are made up of one to twelve pages, and can be added or edited easily, at any time, by the mission planner.

There can be any number of different quick card topics (i.e., *sets of Quick Cards*). Quick cards can be any image, usually created by another software program. For example, any image editing software can be used to create quick cards, or Microsoft PowerPoint slides can be used as quick cards by exporting the slides as images.

7.2.2.6 LINKING A QUICK CARD TO A TARGET

Any quick card image can be linked to a target by clicking the Target icon in the top right corner of the quick cards window.

The standard target link window (shown right) will be displayed with the closest target, if any, selected. To link the quick card image to the target, simply choose the correct target in the drop-down list and click ***Link with Target***.

Figure 17. Link to Target

7.2.2.7 DIVELOG MAIN MENU

Clicking the menu button or right-clicking on the Shark Marine logo will bring up the main menu, as shown to the left. Many of the settings and forms discussed thus far in the manual can be accessed from this menu. All the menu items and sub-items are discussed below.

Figure 18. DiveLog Main Menu

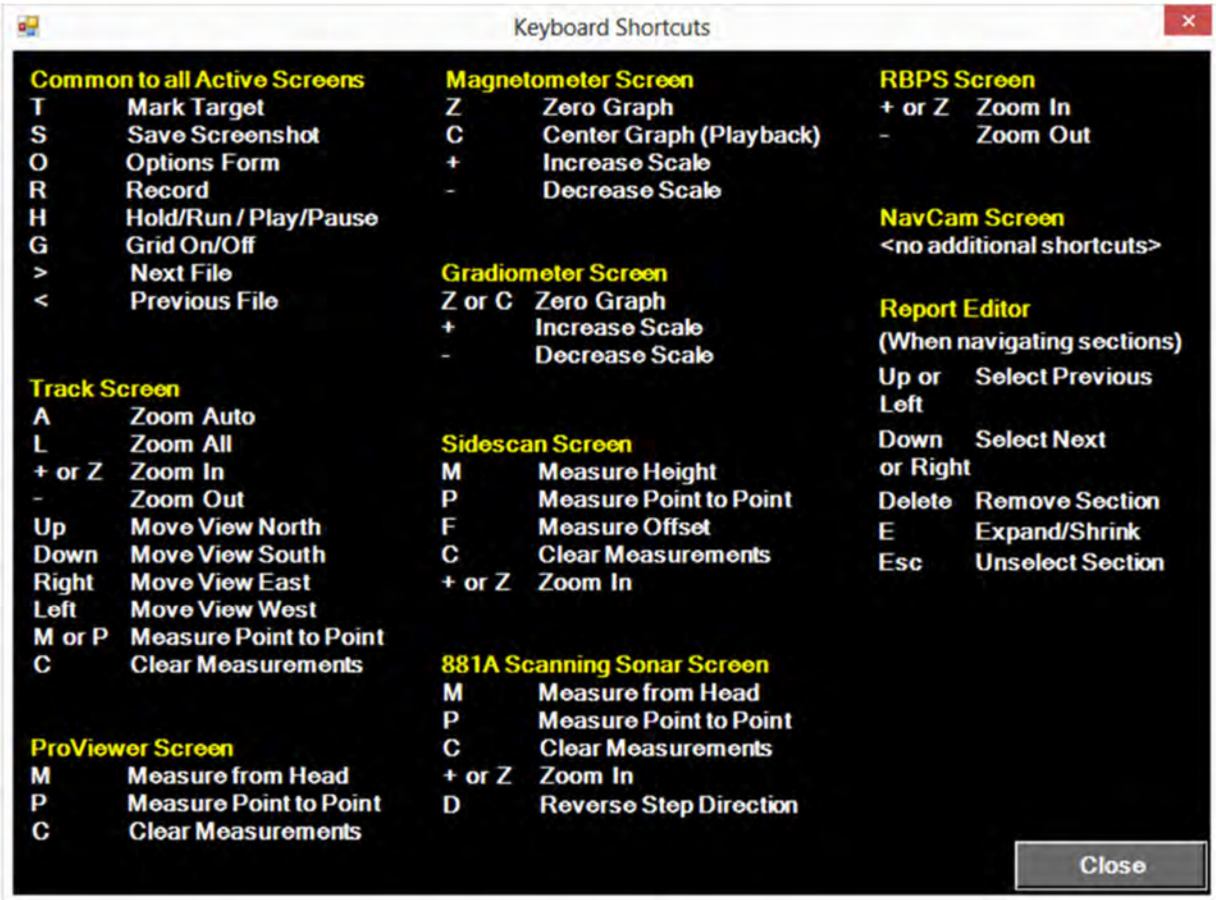


Figure 19. Keyboard Shortcuts

7.2.2.8 KEYBOARD SHORTCUTS

The keyboard shortcuts are useful for mission planning or analysis and for survey operations. The list of shortcuts can be viewed in DiveLog by clicking **Menu/Help/Keyboard** shortcuts. Some shortcuts are common to all Active Screens. Shortcuts for a particular active screen will only work if that active screen is in the primary position.

7.2.2.9 SETTING UP THE SESSION

When DiveLog starts each time, the "Setup Session" window will be displayed. This allows the user to specify (or confirm) four important items that will affect how DiveLog is used for the current session.

7.2.2.10 CONTINUING A PREVIOUS DIVE

If DiveLog closes or the computer shuts down when a dive is in progress, DiveLog will suspend the current dive. If DiveLog starts-up again and the system is still at depth, then the prompt to the right will be shown rather than the session setup window. This allows the operator to shut down the system (or close DiveLog) and continue recording data under the same dive number when the DiveLog is running again. When a dive is continued in this fashion, the Diver Log track will continue with the same file, but other recorded files will need to be started again with a new file name (*such as a sonar file*).

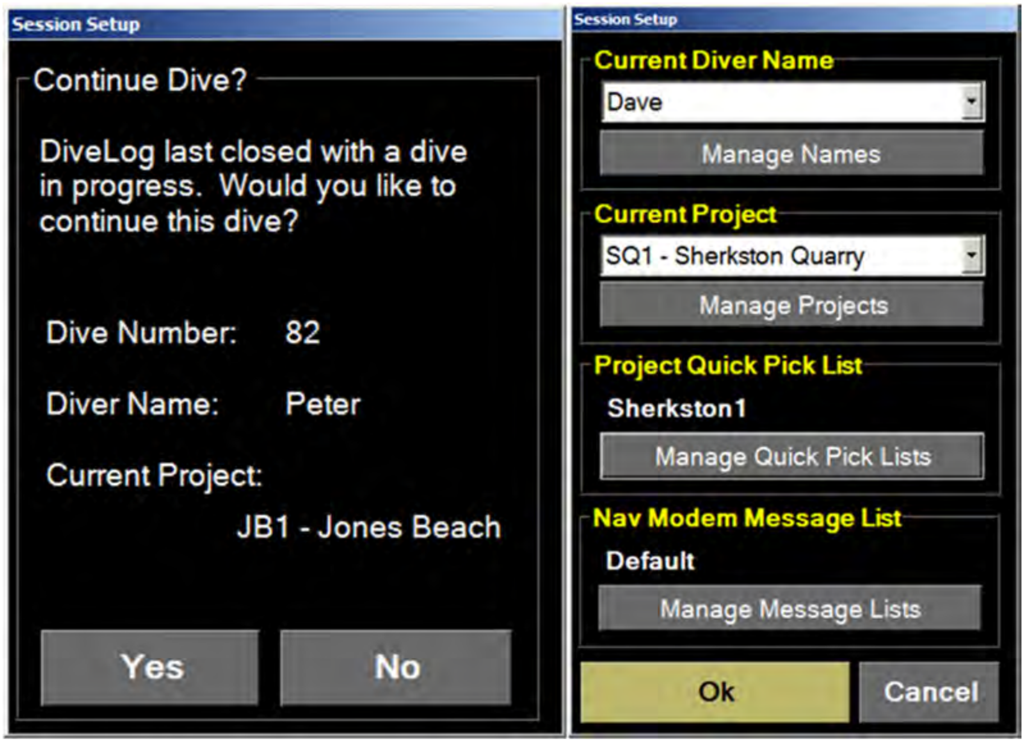


Figure 20. Session Setup

7.2.2.11 DIVER/OPERATOR NAMES

The use of diver/operator names allows all recorded data to be easily referenced to the person operating the system at the time that the data was recorded. The diver/operator's name will be used in all recorded files and will be displayed when files are played back. The diver's name should be specified when the session is started, but "Diver" may be chosen as a generic name. The name "Boat" may also be used if DiveLog is being used for a surface/boat application, where multiple people may be operating DiveLog.

The term "Diver" is used by DiveLog when running on a navigator, while the term "Operator" is used when DiveLog is running in survey mode.

7.2.2.12 Managing Diver/ Operator Names

This window allows adding, editing, and deleting diver/operator names, as well as setting the current diver/operator's name. This window can be accessed by clicking on the diver's name on the navigation view, by clicking on Manage Names on the Session Setup window, or by selecting **Menu>Setup>Manage Diver/Operator Names**. At the top of the window is a drop-down list of all diver/operators, and the buttons below allow for several different.

Figure 21. Manage Names

8.0 PROJECT SETUP

The Project Setup window can be accessed in by clicking the project code on the main navigation view, or by selecting **Menu>Setup>Project Setup**. Information on the current project is displayed:

- the project name
- the date and time the project was created
- the project code
- the incident number (which may be edited)
- the project quick pick list
- user entered notes for the project

Under all projects on this window, a list of all projects located in the projects folder on the system is shown. Clicking on a different project in the list will display the information listed above for that project but will not switch to that project. If no project has been selected or created, the default project will be the **GEN - General Data** project.

The Notes text box is an area that allows the entry of text that can be modified or added to at any time. This text will remain with the project and is a good place to keep general information about the project.

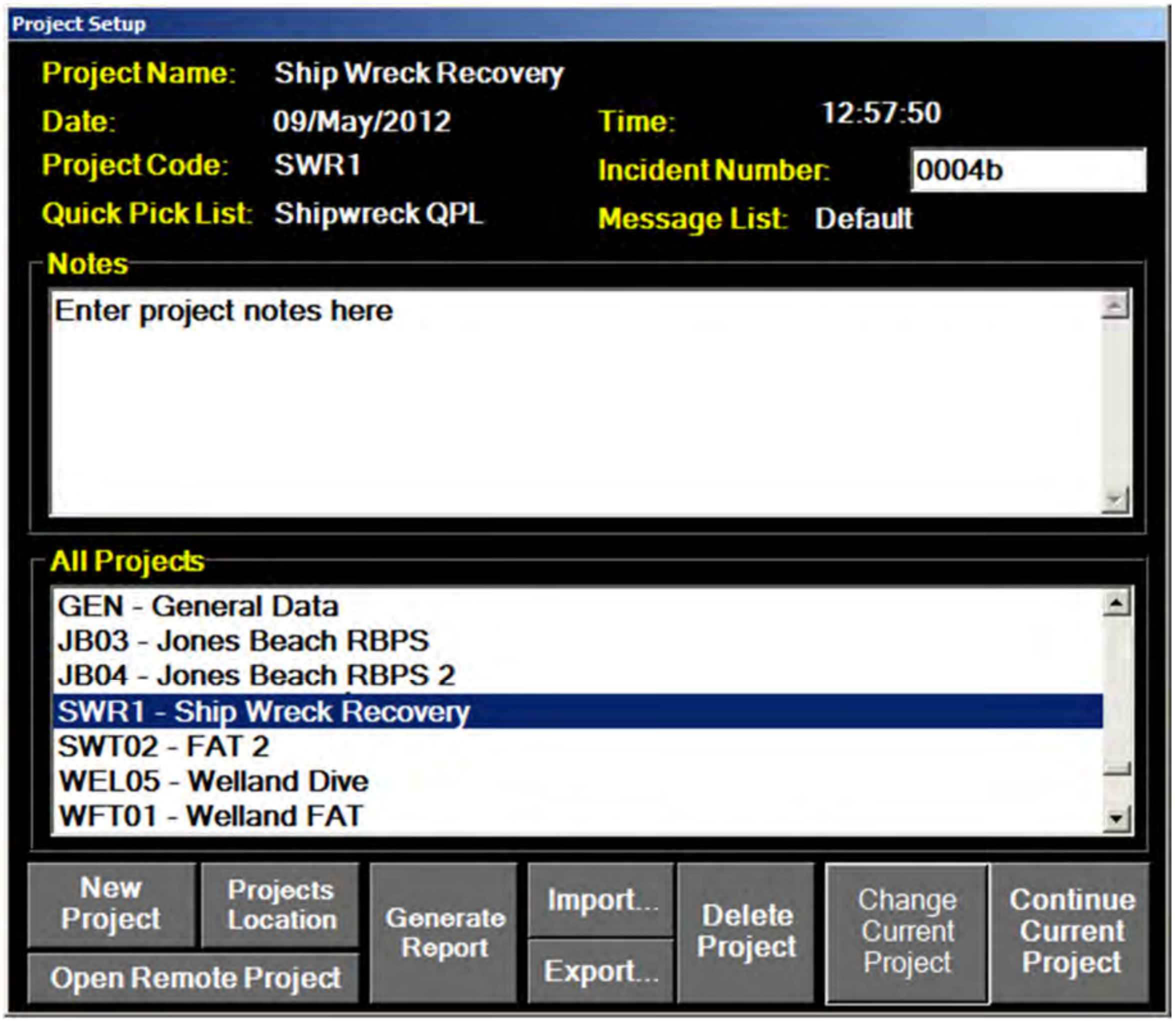


Figure 22. Project Setup Screen

Note: *Further technical data can be found in the Appendix 3 - DIVELOG4 Software manual.*

9.0 EMERGENCY PROCEDURES

In the case of any emergency, the procedures detailed in the project specific work plan and APP/SSHP will be followed. A copy of the APP/SSHP is maintained at the project site.

9.1 QC CHECKLIST FOR THE SHARK MARINE UNDERWATER NAVIGATION SYSTEM

TEAM INFORMATION		
Team:	Location:	Date:
Team Leader:		
Personnel Present:		
Contract #:		
Task Order #:		

QC CHECKLIST POINTS

Item	Ref.	Inspection Points	Yes	No	N/A	Comments
1	UXO SOP	Have personnel read and signed the workers' statement?				
2	UXO SOP	Has the equipment been checked out, and is it documented correctly?				
3	UXO SOP	Have all activities been fully and appropriately documented?				
4	UXO SOP	Have the appropriate DQOs and/or MQOs been achieved for SM operations?				
5	UXO SOP	Has all post dive procedures and data download completed correctly?				

FINDINGS

Item	Comments

Signature:

UXOQCS or Designee: ______________________ Date: ____________

APPENDIX 1 SHARK MARINE DIVE TABLET 2 MANUAL

Shark Marine Technologies Inc.
www.sharkmarine.com

DIVE TABLET 2

Hardware Operations Manual

Rev. 2016-11-01

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Table of Contents

1. Introduction

The Shark Marine Dive Tablet 2 is a self-contained, navigation and underwater imaging system that provides the diver with target location, navigation, and situational awareness.

The Dive Tablet 2 is a very versatile, compact diver held unit, which can be utilized for many underwater and surface functions such as: Navigation, (both underwater and surface), Video and still imagery, communication and documentation, as well as interfacing with other accessory equipment.

The Shark Marine Dive Tablet 2 has a daylight viewable screen, internal solid state drive and Windows 8 operating system. The Dive Tablet 2 provides external ports for RS-232, USB, and power.

The Shark Marine DiveLog software (included) is a multi platform, multi sensor command and control software, that provides mission planning, navigation, data acquisition, operational situational awareness and report generation. DiveLog provides powerful, easy-to-use, mapping and tracking capabilities and complete geodetic positioning. DiveLog also provides advanced, user-friendly target management.

The Dive Tablet 2 can also provide communication, diver to diver or surface our SubNET acoustic modem system.

This manual covers set-up, operations, maintenance and trouble-shooting. Wiring diagrams for cables and connections are also included. This manual does not cover the DiveLog software, please refer to the DiveLog software manual for details on the DiveLog software.

To ensure the best possible performance of the Dive Tablet 2, please read this manual in its entirety. Shark Marine Technologies Inc. also provides detailed training programs on the Dive Tablet 2.

Shark Marine strives to provide our customers with the best possible products designed to meet their needs. We are always interested in customer comments and suggestions.

***It is recommended that the user of the Dive Tablet 2 read this entire manual to ensure maximum performance of the unit.**

2. Case Contents

The Dive Tablet 2 System is supplied in a rugged case suitable for transportation and storage. The standard case will also have accessories stored under the foam, beneath the Dive Tablet 2.

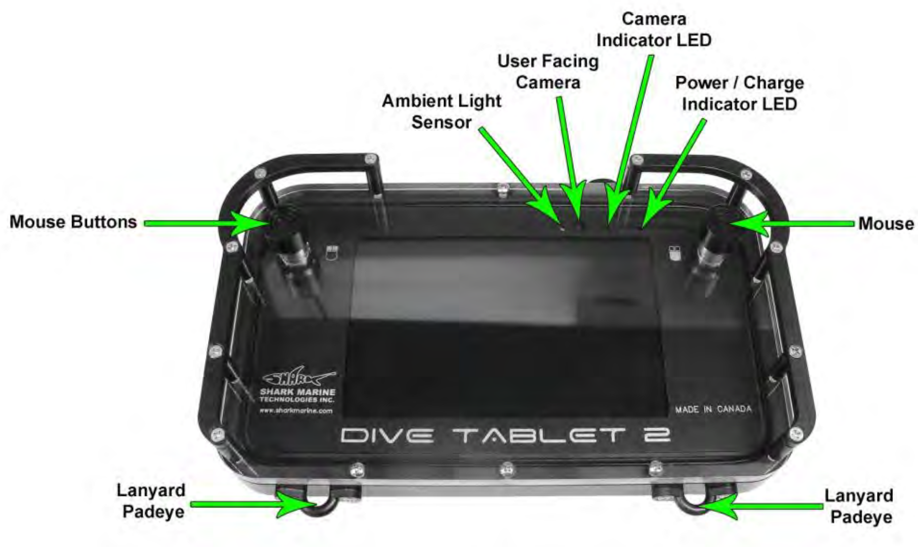
The Dive Tablet 2 Case typically contains the following items:

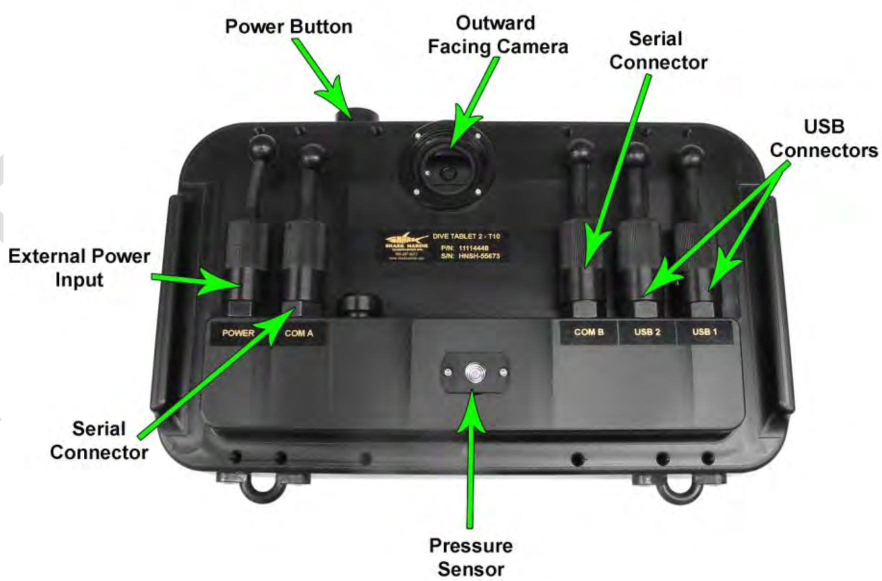
- 11114448 Dive Tablet 2 System
- 11114528 Dive Tablet 12V Power Supply
- NVG0047-0 USB Adapter Cable
- NVD0063-3 Vacuum Pump
- NVD0058 DiveLog Software and Setup USB Drive
- NVD0063-7 Silicone Lube in Canister
- NVD0067 DiveLog Mission Planning Dongle
- 11111440 Lens Cap, Yellow (1 Installed, 1 Spare)

The case contents, or configuration, may vary based on individual order requirements.

3. External Overview

3.1. External Components Overview





3.2. External Controls

3.2.1. Left/Right Mouse Buttons

The Dive Tablet 2's user input is primarily accomplished through the two thumb controls. The thumb control on the right, performs the on-screen cursor movement, similar to a mouse on a standard PC. The thumb control on the left emulates the right and left mouse buttons. Press it to the left to perform a left click, and press it to the right to perform a right click.

Do not use the Thumb Controls on the Dive Tablet 2 while the system is powering up, as they self-calibrate during power up.

3.2.2. Main Power Switch

The only other control on the Dive Tablet 2 is the main power button. Press the power button to turn on power to the Dive Tablet 2. The Dive Tablet 2 will vibrate momentarily to indicate start up.

Pressing the button during operation will cause the tablet to hibernate (power down), if the tablet becomes unresponsive you can force a power down by holding the power button for 5 seconds.

Note: Always press power button gently, excessive force may damage the tablet PC.

3.3. External Ports

3.3.1. External Power Input

The Dive Tablet 2 can run for an extended period of time on the internal battery, for applications requiring higher power the Dive Tablet 2 can be run from an external 12V Battery. When at the surface attach the provided AC power supply to the tablet to provide external power as well as charging of the internal battery.

3.3.2. Serial Bulkhead Connector

The Serial Connector can be used to connect a variety of RS-232 accessories including extension GPS, LBL, SubNet, Sidescan sonar and other devices. This port also provides 12V power, some devices may require an external battery to supply enough power, please check operating specifications to ensure power requirements. The maximum power without the external battery is 150 mA, with the battery is 3 Amps.

3.3.3. USB Bulkhead Connector

The USB connector allows connection of standard USB devices to the Dive Tablet 2. This port supplies 5V and 12V power for Shark Marine devices. A USB adapter cable is provided to convert from the underwater connector to a standard surface USB connection.

3.4. Other Components

3.4.1. Internal Cameras

The Dive Tablet 2 contains 2 internal cameras, one facing outward and one facing the user. The cameras are used to take still pictures or video using the Divelog software, consult DiveLog software manual for details.

3.4.2. Accessory Slide Mount

The optional Accessory Slide Mount can be mounted to the back of the Dive Tablet 2 and used to mount accessories such as a GPS. The Accessory slide mount can be optionally moved to different locations depending on the application.

3.4.3. Lanyard Padeye

The Lanyard Padeyes are used to provide a strain relief or connection point for any cables or connections that require it. The Power Lanyard typically connects to the bottom right padeye when external battery is used.

4. System Setup

4.1. Pre-Dive Check

The Dive Tablet 2 has been designed to allow for very quick set-up. It can be deployed within seconds of arriving on site. The Dive Tablet 2 comes with the DiveLog software already installed and set to load automatically when the Dive Tablet 2 boots up.

Note: If the Dive Tablet 2 has been opened recently, or has been idle for an extended period of time, a vacuum test should be performed. See Appendix B for Instructions on performing a vacuum test.

1. Check that the vacuum plug is in the Dive Tablet 2!
2. If applicable, plug in an external battery with the Power Cable/Lanyard, clip the Power Cable/Lanyard to the Battery and clip the battery to the operator.
3. Turn Power Dial clockwise to Power on the Dive Tablet 2.
4. Once completely powered up, quickly check that DiveLog is reporting data from all expected sensors.
5. Ensure all external components are in place and tightly secure, dummy plugs are fitted to unused connectors and all cabling is secured and no cables are dangling which could get caught on underwater objects.
6. Enter the water.

4.2. Post Dive Checks

1. Power down the Dive Tablet 2 to hibernate or use the Windows Start Menu to shut down.
2. Check the unit for any signs of damage. Clean off any dirt or debris.
3. If used in salt or dirty water, rinse off the Dive Tablet 2 as soon as possible in clean fresh-water. It is best to fully immerse the Dive Tablet 2 in fresh water if possible. Take extra care to flush out the pressure transducer port since the thin stainless steel wall of the diaphragm may corrode if left dirty.
4. Dry off the Dive Tablet 2 and place it back into the case. **Do not leave the Dive Tablet 2 sitting in direct sunlight.**
5. When convenient or for storage, open the case a bit to allow any moisture to evaporate and avoid mildew.
6. Charge the battery by plugging it in using AC power adapter.

Note: Always maintain the Dive Tablet 2 battery in a charged state so that the system is ready to go at a moment's notice.

4.3. Using the Dive Tablet 2 Above Water

The Dive Tablet 2 can be used above water for mission planning, boat operated surveys, and surface navigation. The Dive Tablet 2 can be used above water for indefinite periods of time, providing the unit is not in direct sunlight for extended durations. To save on underwater batteries, the Dive Tablet 2 is designed to operate from any 12 Vdc power source such as the vessel power with the optional DC power cable. This also saves the underwater battery power for the dive.

5. Maintenance

5.1. O-Rings

O-rings are used for most of the seals on the Dive Tablet 2. These small rings made of rubber are important for keeping seawater from entering the internal electronics of the Dive Tablet 2. O-rings are inexpensive and should be replaced once a year during a regular maintenance (with the exception of the bulkhead connector O-Rings). When the faceplate on the Dive Tablet 2 is removed or any service is performed, the condition of the O-rings should be checked carefully and replaced if questionable. Inspect an O-ring by rolling it in your fingers, looking for any signs of nicks, cuts, or defects. The O-rings should have a smooth surface, and a perfectly round cross-section. O-rings should always have a thin film of silicone lubricant on their surface. Apply the lubricant by dabbing a small amount onto your finger and working it over the entire O-ring surface. Also inspect the O-ring seat or grove for small scratches or debris. Always clean the mating surface/grooves carefully and thoroughly to prevent debris from compromising the seal.

5.2. Connectors

All of the connectors used on the Dive Tablet 2 housing are **underwater mateable.** Make sure that all underwater connectors are clean and free of dirt before plugging them together. It is important that the rubber mating surfaces for each pin have a thin layer of silicone lubricant (Dow-Corning 111, or equivalent) before the connectors are mated. Silicone lubricant should be applied to each pin as well as a small amount to the entrance of each socket. Lubrication should be performed every 5 to 6 mating cycles. Mating of non-lubricated connectors will cause damage to the surface of the rubber and compromise the seal and electrical connection. Cleaning of the pins and sockets can be done using pressurized air can be used as long as it is done lightly not to build up pressure in the sockets.

5.3. Desiccant Packs

When the faceplate is removed from the Dive Tablet 2 for O-ring replacement it is recommended that the internal desiccant packs be replaced as well. They will absorb moisture after performing the vacuum tests and become ineffective over time.

5.4. Batteries

To preserve the life of the battery, charge it after every use. The battery monitoring electronics internal to the Dive Tablet 2 will turn off the battery if the external battery is drained too low. This protects the battery from potential damage caused by over-discharge.

If not used for extended periods of time, the batteries (external and internal) should be charged once per month as part of a maintenance schedule to maximize the life of the battery.

5.5. Maintenance Schedule

The following table details the maintenance schedule for the Dive Tablet 2.

Recommended Dive Tablet 2 Maintenance		
Task	**Timeframe**	**Description**
Underwater Connector Lubrication	5 to 6 mating cycles	All of the connectors on the main housing of the Dive Tablet 2 are underwater mateable. Ensure the underwater mateable connector pins/sockets are lightly lubricated with Dow-Corning 111 silicone lubricant (or equivalent) frequently. If the underwater mateable connectors require cleaning, the pins and sockets can be cleaned using a cotton swab and rubbing alcohol. Pressurized air can be used as long as it is done lightly, as not to build up pressure in the sockets.
Charge Batteries	Monthly and After Use	To preserve the life of the battery, charge them after every use. If not used for extended periods of time, the batteries (external and internal) should be charged once per month.
Clean	After Use	Rinse the Dive Tablet 2 and external accessories in clean freshwater, then dry and store. This is particularly important after use in contaminated/dirty water or saltwater.
Visual Inspection	Before and After Use	Visually inspect the Dive Tablet 2 for problems such as damage to the housing, acrylic faceplate or other components. Ensure all external physical components are secure.
Vacuum Test	After Opening, Prolonged Storage, Shipping or Rough Handling	The purpose of the vacuum test is to simulate an external pressure on the housing and to check for any signs of leaks. This is particularly important after the unit has been open, to verify the proper installation of the seals and after storage, shipping or rough handling.
Inspect Vacuum Plug O-rings	Semi-Annually and When Plug removed.	The O-rings on the vacuum plug should be examined each time the plug is removed and replaced if there is any concern regarding their condition. The O-rings should be lightly coated with Dow-Corning 111 silicone lubricant (or equivalent).

Detailed Physical Inspection	Every Year	Ensure all internal electrical connections are secure. Ensure all screws and nuts are secure. Examine the system for any signs of corrosion or damage, replace parts as necessary.
Replace Desiccant Packs	Every Year	When the faceplate is removed from the Dive Tablet 2 for O-ring replacement it is recommended that the internal desiccant packs be replaced as well.
Replace O-rings (except bulkhead connector O-rings)	Every Year	The O-rings, with the exception of the bulkhead connector O-rings, should be replaced at once per year. Any time the Dive Tablet 2 is opened for maintenance or repair, the condition of the main O-ring on the acrylic faceplate should be examined and replaced if the condition is questionable. The O-rings should be lightly coated with Dow-Corning 111 silicone lubricant (or equivalent).
Replace Bulkhead Connector O-rings	Every 2 Years	Every two years, the O-rings on the bulkhead connectors should be replaced. The O-rings should be lightly coated with Dow-Corning 111 silicone lubricant (or equivalent).

6. Troubleshooting

The Dive Tablet 2 will not turn on:

- Ensure internal battery is charged, plug in Dive Tablet 2 to AC power adapter and wait 10 minutes, then attempt to power on again.

The Pitch of the Dive Tablet 2 is not reading “level” when the Dive Tablet 2 is actually level:

- Double click the heading value in DiveLog to select the proper heading, pitch and roll (MRU) Configuration
- In MRU Configuration, check that the proper mount is selected
- In MRU Configuration, either tune the offsets with the arrow buttons, or press the button to automatically set the pitch and roll offset.
- For complete MRU calibration details see the DiveLog Software Manual.

Data from a sensor or external device is not displayed in DiveLog:

- Verify COM port settings in DiveLog. See the DiveLog Software Manual
- Try using different COM port if available, to determine if the problem is with the port or the device.
- Verify power settings in DiveLog. See the DiveLog Software Manual for details on enabling/disabling power to specific devices and ports.
- Turn off the unit and disconnect from the power source. Re-start the system.
- Check all of the cables for damage.

External Battery Problems:

- The NiMH battery has a built in resettable fuse. In the event of a short or over-current, the battery will temporarily cut off the output power. If this occurs, disconnect the battery, and allow it to cool down. After a few minutes, the battery should be operable again.
- If the battery does not last very long, it is possible that the battery cells have been damaged due to over-discharge or improper charging procedures.
- If the battery feels hot, wait one hour. Use a voltmeter and check the output voltage of the battery. If the battery reads no output voltage (0V) and the battery has cooled down, then there may be a problem with the reset-able fuse internal to the battery pack. The battery pack may need to be replaced. Consult Shark Marine.

Software is unresponsive:

- If DiveLog has frozen and become unresponsive, try to use the Windows task manager to close DiveLog, then restart it. If this does not work, try to restart via the Windows start menu.
- If Windows has hung and the system is unresponsive, turn the power dial clockwise and hold for 5 seconds to cut power to the system. Unplug the external battery if connected for 5 seconds then reconnect the external battery and restart the system.
- If Windows still remains unresponsive, try unplugging any external devices. The thumb stick control can become unresponsive if the attached devices are drawing too much power.

For further technical support contact Shark Marine Technologies Inc. at:

Phone:	905-687-6672
Email:	sales@sharkmarine.com
Office Hours:	Monday to Friday 8:30am to 5:00pm Eastern Standard Time

7. Warranty

Shark Marine Technologies Inc. warrants its products against defects in materials and workmanship under normal use for a period of ONE (1) YEAR from the date of purchase by the original end-user purchaser ("Warranty Period"). If a hardware defect arises and a valid claim is received within the Warranty Period, at its option, Shark Marine Technologies Inc. will either repair or replace the defect at no charge. Shark Marine Technologies Inc. may request that a customer may replace defective parts with user-installable parts that Shark Marine Technologies Inc. to provide fulfilment of its warranty obligation. A replacement product or part, including a user-installable part that has been installed in accordance with instructions provided by Shark Marine Technologies Inc, assumes the remaining warranty of the original product or ninety (90) days from the date of replacement or repair, whichever is longer. When a product or part is exchanged, the customer will be billed for this part and upon receipt of the replaced part at Shark Marine Technologies Inc. the customer will be credited in full for that part.

Parts provided by Shark Marine Technologies Inc. in fulfilment of its warranty obligation must be used in products for which warranty service is claimed.

EXCLUSIONS AND LIMITATIONS

This Limited Warranty applies only to products manufactured by or for Shark Marine Technologies Inc. The Limited Warranty does not apply to any non-Shark Marine Technologies Inc. components or any software, even if packaged or sold with Shark Marine Technologies Inc. hardware. Manufacturers, suppliers, or software publishers, other than Shark Marine Technologies Inc., may provide their own warranties to the end user purchaser.

Shark Marine Technologies Inc. does not warrant that the operation of the product will be uninterrupted or error-free. Shark Marine Technologies Inc. is not responsible for damage arising from failure to follow instructions relating to the product's use.

This warranty does not apply: (a) to damage caused by accident, abuse, misuse, flood, fire, earthquake or other external causes; (b) to damage caused by operating the product without proper instruction on operations and maintenance; (c) to a product or part that has been modified, to alter functionality or capability without the written permission of Shark Marine Technologies Inc. (d) to consumable parts, such as batteries, unless damage has occurred due to a defect in materials or workmanship; or (e) if any Shark Marine Technologies Inc. serial number has been removed or defaced.

To the extent permitted by law, this warranty and remedies set forth above are exclusive and in lieu of all other warranties, remedies and conditions, whether oral or written, statutory, express or implied. As permitted by applicable law, for Shark Marine Technologies Inc. specifically disclaims any and all statutory or implied warranties, including, without limitation, warranties of merchantability, fitness for a particular purpose and warranties against hidden or latent defects. If Shark Marine Technologies Inc. cannot lawfully disclaim statutory or implied warranties then to the extent permitted by law, all such warranties shall be limited in duration to the duration of this express warranty and to repair or replacement service as determined by Shark Marine Technologies Inc. in its sole discretion.

Except as provided in this warranty and to the extent permitted by law, Shark Marine Technologies Inc. is not responsible for direct, special, incidental or consequential damages resulting from any breach of warranty or condition, or under any other legal theory, including but not limited to loss of use; loss of revenue; loss of actual or anticipated profits (including loss of profits on contracts); loss of the use of monies; loss of anticipated savings; loss of business; loss of opportunity; loss of goodwill; loss of reputation; the replacement of equipment and property, any costs of recovering, or reproducing any program or data stored or used with Shark Marine Technologies Inc. products.

CONSUMER PROTECTION LAWS

This Limited Warranty is governed by and construed under the laws of the province of Ontario, in which the product purchase took place.

OBTAINING WARRANTY SERVICE

Shark Marine Technologies Authorized Representative will help determine whether your product requires service and, if it does, will inform you how Shark Marine Technologies will provide it. Shark Marine Technologies Inc. will provide warranty service on products that are tendered or presented for service during the Warranty Period, as permitted by law. You will be responsible prior to shipping any returns to obtain a Return Merchandise Authorization number from Shark Marine Technologies Inc. You will be responsible for all shipping and handling charges to and from Shark Marine Technologies Inc. Shark Marine Technologies Inc. will assist the shipper with documentation for customs clearance if required.

If your product is capable of storing data or software programs, you should make periodic backup copies of the data and programs contained on the product's hard drive or other storage media to protect your data and as a precaution against possible operational failures. Before you deliver your product for warranty service it is your responsibility to keep a separate backup copy of the system software, application software and data, and disable any security passwords. You will be responsible for reinstalling all such software, data and passwords. Shark Marine Technologies Inc. is not liable for any damage to or loss of any programs, data, or other information stored on any media covered by this warranty. Recovery and reinstallation of system and application software and user data are not covered under this Limited Warranty.

8. Appendix A: Dive Tablet 2 Specifications

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Shark Marine Dive Tablet 2 Specifications	
Dimensions	12.9" x 7.31" x 3.77" (32.76cm x 18.57cm x 9.57cm)
Weight	6.8 lbs (3.12 kg) in air, 1.8 lbs (0.57kg) in salt water
Rated Depth	100ft (30m)
Software	Windows 8.1 Pro OS, with DiveLog software
Processor	Quad Core Intel Atom 2.4Ghz, 2MB cache
Display	8.3" (21cm), 1920 x 1200 pixel, 800:1, 400 cd/m²
Cameras	Front facing HD, 2MP resolution Rear Facing FHD, 8MP resolution
Hard Drive	64 GB
Wireless	WLAN 802.11, Bluetooth
Power	Internal: Li Battery up to 2 hour in-water operation, External(Optional): 12V NiMH, small up to 10h, large up to 20h External Battery hot-swappable for continuous operation
Operating Temperature	to F (5˚ C to 50˚ C)
Controls	Shark Marine Dual thumb-sticks - mouse movement and selection
Internal Expansion	OPTIONAL: Motion Reference Unit
External Ports	Standard: 1 - USB 2.0, 1 – SERIAL RS232 Optional: 1 - USB 2.0, 1 – SERIAL RS232
	*Specifications subject to change without notice.

9. Appendix B: Performing a Vacuum Test

The purpose of the vacuum test is to simulate an external pressure on the housing and to check for any signs of leaks.

Note: This is particularly important after the unit has been open, to verify the proper installation of the seals and after storage, shipping or rough handling.

1. Test the vacuum pump. To test the vacuum pump seal the end of the port fitting at the end of the hose, pump the vacuum, and confirm that it does not leak.
2. Remove the vacuum plug located at the back of the Dive Tablet 2.
3. Using the vacuum pump supplied in the tool kit, push the fitting into the vacuum port.
4. Pump to ” of mercury (Hg). Let sit for about 15 minutes, longer if practical, and make sure the vacuum is holding (the needle may drop about ¼” mercury due to temperature changes).
5. **Do not power up the Dive Tablet 2 during the vacuum test,** since the air inside allows for cooling of the electronics. Powering up the Dive Tablet 2 during a vacuum test may cause overheating of the internal electronics and damage to the unit.
6. When complete, press the pressure release button on the vacuum pump to remove the vacuum and remove vacuum pump.
7. Check that the O-rings on the vacuum plug are lubricated and in good condition.
8. **Re-insert the vacuum plug.**

If the vacuum test is not successful, DO NOT PUT THE DIVE TABLET 2 IN THE WATER. Troubleshoot the issue, contact Shark Marine Technologies Inc. if difficulties are encountered.

APPENDIX 2 SHARK MARINE DIVELOG 4 QUICK START GUIDE

Shark Marine Technologies Inc.
www.sharkmarine.com

DiveLog4

Quick-Start Guide

P/N: 11114427 Rev. 2015-11-25

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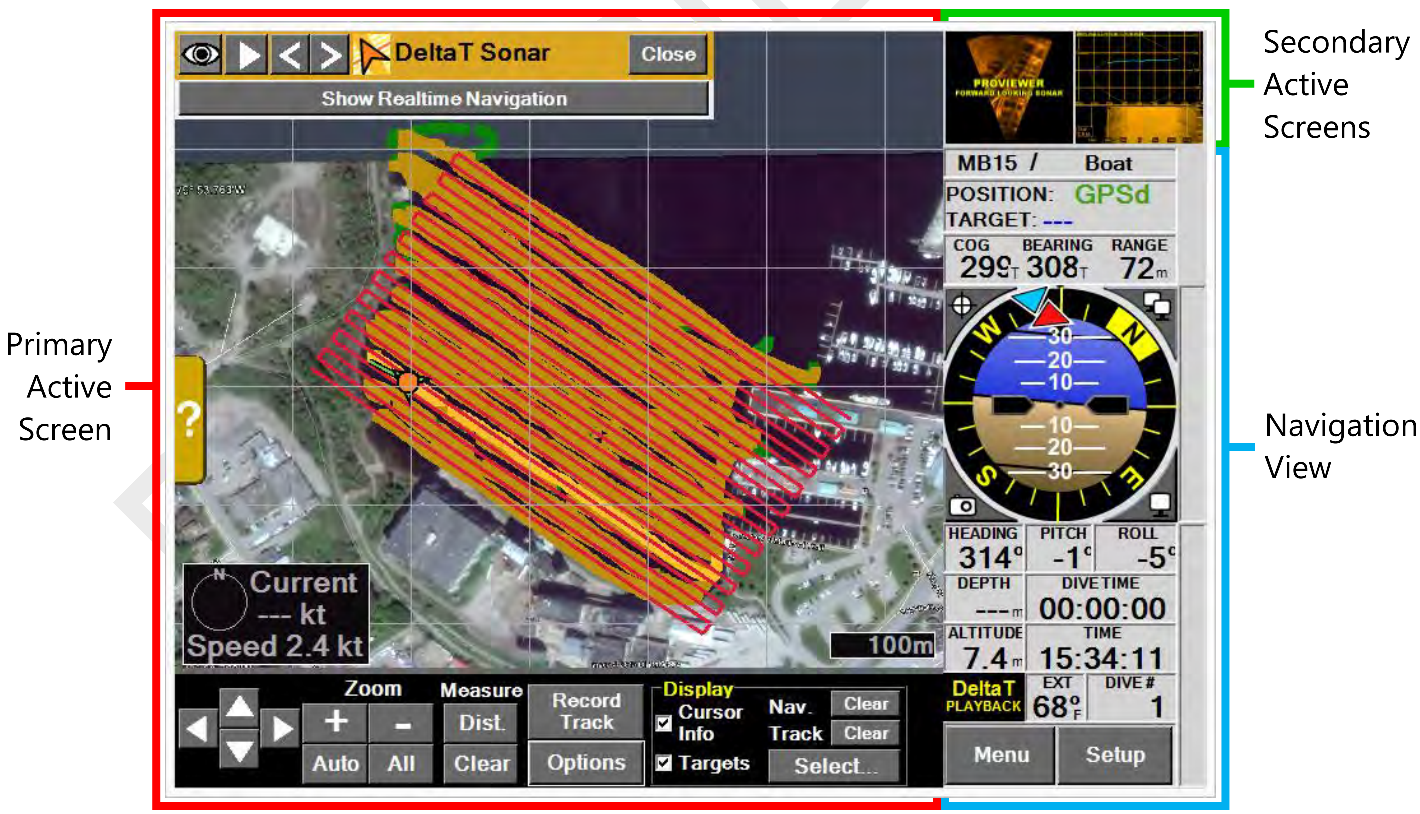
1. Introduction

DiveLog is an all-in-one maritime operations software. With the ability to record, analyze, and playback data from a multitude of sonars and sensors, DiveLog simplifies any diver, ROV, or vessel-based operation. Originally designed for easy underwater navigation, DiveLog evolved to provide an array of easy-to-use tools for pre-mission planning, data acquisition, and post-mission data analysis and presentation. By linking all recorded data by time and location, details are easily viewed and analysed amid hours of mission data.

This guide gives a quick introduction to DiveLog4, for more detailed instruction, refer to the full DiveLog Software Manual.

1.1. Window Overview

The main two components of DiveLog are the Navigation View and the Active Screens. The Navigation View shows all navigation and project information in real-time or playback mode. The Active Screens give DiveLog the rest of its functionality, allowing peripheral use and file playback. These two work synchronously to make creating and viewing data as easy as possible.



SHARK MARINE TECHNOLOGIES INC.

1.2. Modes

DiveLog can be run in 3 main modes, each adding new functionality:

	View Only	Mission Planning	Survey
View Project Data	✓	✓	✓
Create/Edit Project Data	-	✓	✓
Run Devices/Sensors	-	-	✓
Record Data	-	-	✓

Other modules, providing support for various sonars and data analysis tools, are enabled separately.

If you are using a Shark Marine hardware product, such as the Navigator, Dive Tablet, or Topside Controller, these modes and modules will be enabled internally. If you are using DiveLog on any other hardware, a security dongle will be required to verify your authorization. If a security dongle isn't present, DiveLog will revert to View Only mode.

2. Projects

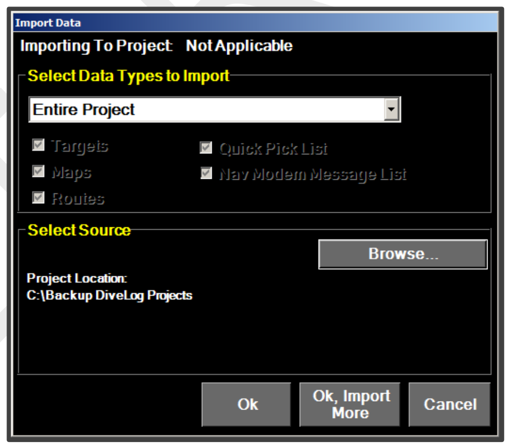
In DiveLog, data is organized into folders called **projects**. A project stores all information related to a certain location or mission, including pre-mission planning and collected data. This makes viewing and summarizing this information easier. Each project resides in the "Projects" folder. A shortcut to this folder is placed by default on the desktop.

The **Project Setup** window contains all the tools for managing your projects. You can open it by clicking the project code text in the top-left of the Navigation View, or selecting *Main → Setup → Project Setup* in the Main menu in the bottom-right.

2.1. Importing a Project

To import a project, click the Import button on the Project Setup window to bring up the Import Data window. *Entire Project* will be the selected data type by default, so you can simply click Browse to select the project folder you want to import.

After you select a project, click OK to finish the import.



2.2. Changing and Creating Projects

To switch between projects, select a project other than the current one from the *All Projects* list on the Project Setup window, and click the blinking Change Current Project button.

To create a new project, click New Project, and fill in the project name, code (short representation of the name), and date, before clicking Ok.

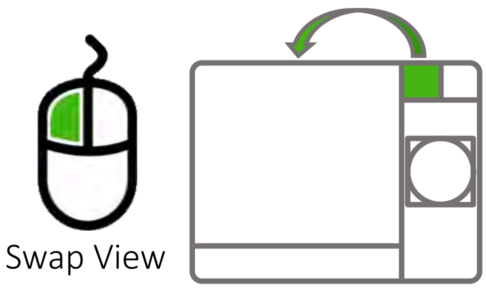
3. Active Screens

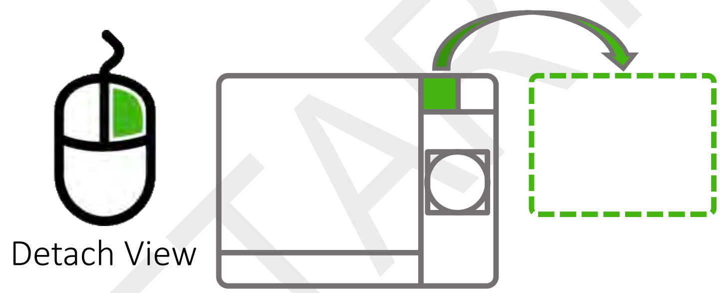
For the most important DiveLog tasks, such as running a sonar or planning a mission, there are dedicated windows called **Active Screens**. Multi-tasking can be difficult, so each screen can be placed in 3 different locations to make managing different tasks more convenient.

Primary Screen: Fills the main view of DiveLog beside the Navigation View.

Secondary Screen: Fills a small preview window in the top-right of the main window.

Detached Screen: Fills a regular window outside of the main window.



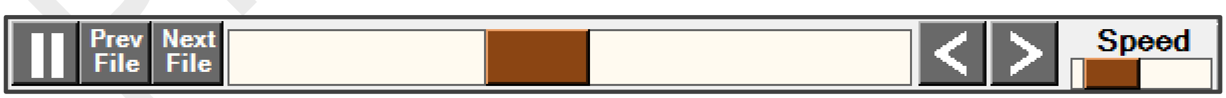


You can turn on or off any Active Screen from the System Setup window (see section *5.1 System Setup*)

3.1. Run, Record, and Playback

Most active screens run a specific hardware device, and are all controlled in the same way. To start or stop a connected device, click the Run button. Once the device is running, click Record to start or stop saving the incoming data.

Each active screen has an Options window for setting up your device. You can access this window by clicking the Options button. To playback recorded files, open this window and click File… to view a list of saved files for this device. Choose a file from the list, or by clicking Browse…, and click OK to start playing the file. You can control playback using the bar at the bottom of the screen.



3.1. The Track Screen

The **Track Screen** brings all of the project data into one map view. You can use it to plan operational routes, as well as view tracks of collected data, on a geodetically calibrated map. This window is always present and displays either the real-time position and navigation information, or past information being played back in any Active Screen.

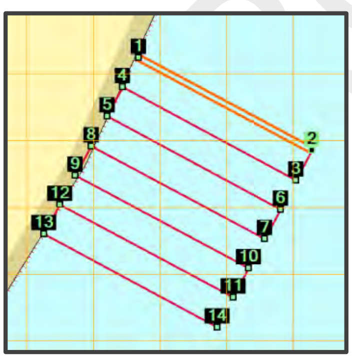
3.2. Tracks

All data collected with a valid position creates a **Track**; a trail of points where data was collected. The Track Screen displays tracks as a series of points, with device-dependant colours. Hovering the mouse over a track gives you information about when, where, and what was being collected at that track point. Right-clicking on a track point allows you to open that recorded file, starting at that time, in that device's Active Screen.

When any other Active Screen is recording or playing back a file, the Track Screen shows the position and navigation info of each data point. It also displays the coverage for any track whose device has an area of effect, such as a sidescan sonar, multi-beam profiling sonar, or forward-looking sonar.

3.3. Routes

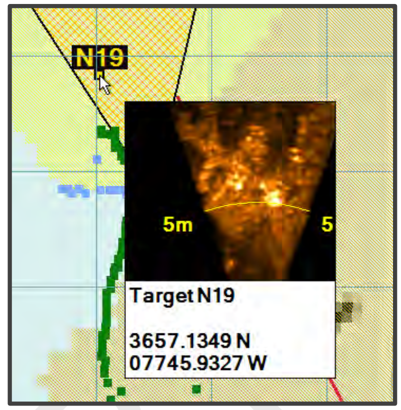
A **Route** can be used to guide a diver to a target or along a path. All route options can be accessed by clicking the Manage Routes button on the Track Options window.



To start a route, select a route from the list and click the Goto Route button. A route control bar will appear at the top of the Primary Screen and allow you to control and view your progress along the route. You can cancel the route by right-clicking that control bar and selecting Cancel Goto.

To quickly set a Goto route to a target, just right-click on that target and select Goto Target.

4. Targets



An object or position of interest can be marked as a **Target** in DiveLog. Each target has a position, name, description, and any number of associated files (images, videos, sonar files). Targets are linked by time and position to associated files, allowing quick review of target data.

Targets are displayed across all Active Screens, when the location is visible. To see target info, hover over a target label on any Active Screen.

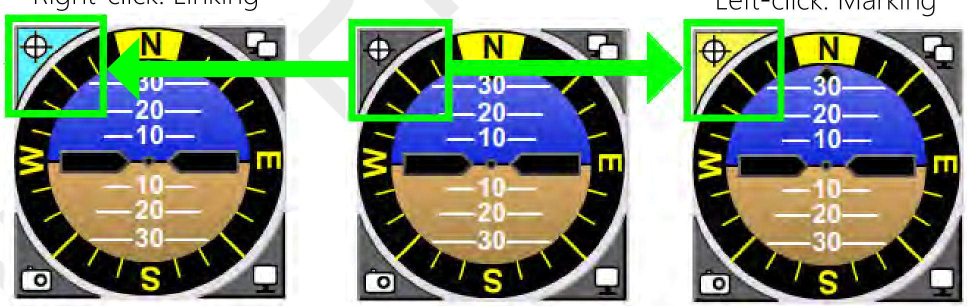
4.1. Marking and Linking Targets

Marking a target on any Active Screen creates a new target at that position or repositions an existing target. Linking a target on an Active screen marks a moment in that file the target has been seen, so important target data can be quickly jumped to later.

Marking and linking targets in DiveLog is done the same way, regardless of which screen is the Primary Screen. The targets are also marked the same way in real-time or in playback mode. To mark or link a target, left or right click the target icon, as seen below, and select a position on any Active Screen

Right-click: Linking

Left-click: Marking



4.2. Editing a Target

Target information can be edited from the Manage Targets window, accessed by clicking the Target label at the top of the Navigation View, or by selecting *Main* → *Targets* → *Manage* Targets in the Main menu. This window also allows you to export, import, and remove targets.

5. Sensors and Ports

DiveLog can control a wide array of sensors and peripherals, from sonars to magnetometers, pressure sensors to full ROVs and diver vehicles. Since each of these devices may have a unique communication setup, DiveLog gives simple interfaces to manage and monitor these connections.

5.1. System Setup

The **System Setup** window controls communication and power to peripherals, as well as which Active Screens are visible. You can open this window by clicking the Setup button in the bottom right corner of the main DiveLog window.

5.2. COM Ports

The COM Setup tab in the System Setup window allows you to set up serial communication to peripherals. Each device in the list has a set of controls to turn it ON or OFF, change the COM port it’s connected to, or view/set the Port Details, such as baud rate. The Config button, if enabled, shows the device-specific settings for that peripheral.

Each port also displays its status, beside the ON/OFF button, in one of three states:

APPENDIX 3 SHARK MARINE DIVELOG 4 SOFTWARE MANUAL

Shark Marine Technologies Inc.
www.sharkmarine.com

DIVELOG4

Software Manual

Version 4.4

P/N: NVD0060 Rev. 2017-09-21

Ph: (905) 687-6672, 23 Nihan Drive, St Catharines , Ontario, Canada, L2N 1L2

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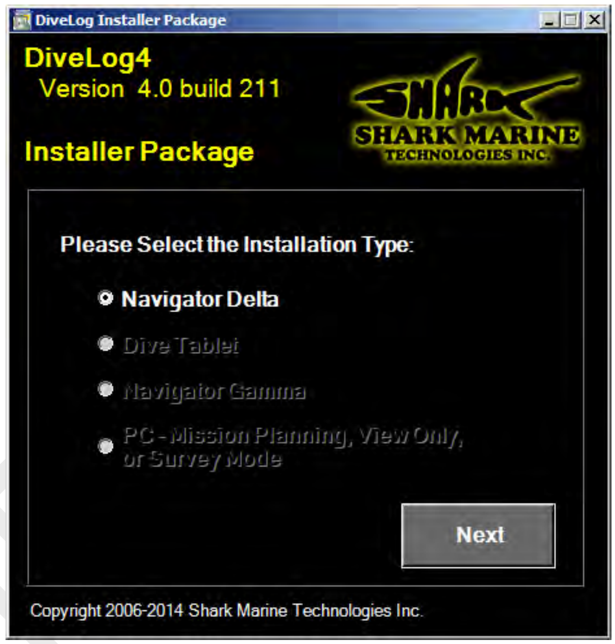
1. DiveLog Installation

1.1. Updating DiveLog

DiveLog is constantly evolving, and updates will generally be released on a semi-yearly basis. With the purchase of a DiveLog licence (often included with a hardware purchase), a “Software Maintenance Agreement” will be valid for one year after shipment of the system. Customers are entitled to DiveLog updates for that period of time. To continue to receive software improvements after this period, it is recommended that customers purchase additional years or renew their software maintenance agreement yearly.



Shark Marine is committed to the quality of our software. We test new features as much as possible, but if an issue or irregularity is discovered then please contact us with a description of the event. If a problem is verified and corrected, the customer will be entitled to an update while on the software maintenance agreement. We also value feedback relating to how the functionality in DiveLog aligns with Standard Operating Procedures. If a suggested change improves functionality for a large part of our customer base, then it may be implemented for the next released version of the software.

To update DiveLog, simply run the installer provided by Shark Marine as outlined in section *1.2 Installing DiveLog* below. The installer will automatically uninstall the older version of DiveLog and perform any required updates. This process will retain all user saved project and configuration data so no collected data will be lost.

If DiveLog has been previously setup on the system, the initial choice will already be selected and the other options will be disabled. The installation will proceed as a standard install (outlined above).

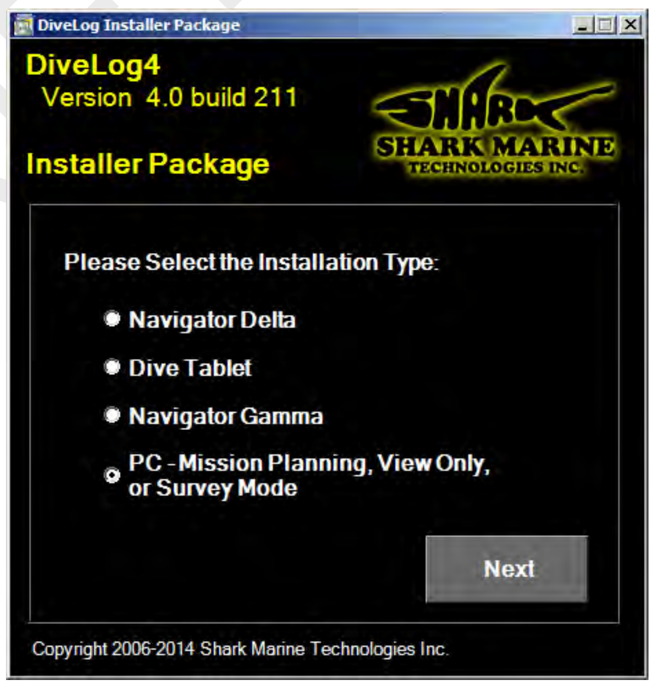
With each system, Shark Marine usually supplies a USB memory stick containing backups of key software components, including DiveLog. The installers for any DiveLog updates should be backed up to this memory stick.

1.2. Installing DiveLog

DiveLog will come pre-installed and configured on systems from Shark Marine that require the DiveLog software such as the Navigator, ROV Topsides, SeaSAR survey systems, et cetera. The following process is not required for a new system, however, DiveLog may be installed on additional desktop or laptop computers for mission planning, playback/review of data. DiveLog is installed using an installer program, "**DiveLog Installer Package vX.Y.Z.exe**", to guide the user through the installation process.

To install DiveLog, the customer must be on a software maintenance agreement with Shark Marine. The only exception to this is if the user is installing "View Only" mode for playback of files only.

Note: When installing/running DiveLog for realtime or survey operations, the user account in Windows should be set as the administrator account. If this is not the case then certain features in DiveLog may not function properly.



Run the installer, and select the installation type from the following options:

- Navigator Delta:
  Used when upgrading the software on a Navigator Delta unit (this option should only be used on the Navigator Delta hardware and never on a different type of computer).

- Dive Tablet:
  Used when upgrading the software on a Dive Tablet unit (this option should only be used on the Dive Tablet hardware).

- Navigator Gamma:
  Used when upgrading the software on a Navigator Gamma unit (this option should only be used on the Navigator Gamma hardware).

- PC – Mission Planning, View Only, or Survey Mode:
  This option is for installing DiveLog on a topside unit such as and ROV topside, a SeaSAR topside, or any pc/laptop intended for survey operations or mission planning (no realtime data collection) or viewing project files. Once DiveLog is

installed, by default it will run in “View Only” mode, which will allow opening and playback of project files, but will not allow editing of any files. If a Security Dongle with Mission Planning enabled is inserted into the computer, DiveLog will change to Mission Planning mode, and file creation and editing features will become available. If a Security Dongle with survey operations is connected, certain realtime data collection functions will become enabled. On an ROV topside or SeaSAR system, the Security Dongle would be built in to the unit so these operations are always enabled.

Click Next...

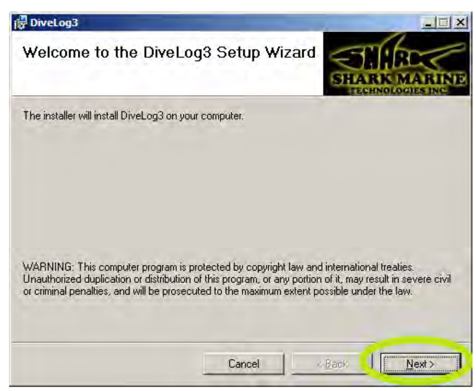
Security Dongle Driver installation: DiveLog often requires a Security Dongle to enable certain features. The drivers will be installed on this step (unless they have already been installed on the system).

After the driver install is complete, the user will be prompted to insert their security dongle if it is a Survey Mode installation or a Mission Planning / View Only installation. If installing in one of these two modes and you have a security dongle, you should plug it in when prompted by the installer. In the case of a View Only installation, the user will not have a Security Dongle, so check the box “Don’t have a Security Dongle”.

In survey mode, a security dongle is required at this stage, so you must have the security dongle present to proceed with the installation of DiveLog.

Click Next...

Ready to install DiveLog: Click Next to execute the Setup Wizard for DiveLog. A pop-up window will guide the user through the next steps of the installation process. Follow the prompts in this window to complete the installation.



1.3. Security Dongles

DiveLog uses USB security dongles to authorize particular functionality in the software. These USB security dongles are green and resemble a USB memory stick for use on a desktop or laptop computer. A security dongle obtained from Shark Marine will be clearly indicated as such. Do not confuse the USB security dongle for a USB memory stick. Underwater USB security dongles are available for use on the Navigator as well for special applications.

The security dongles are not linked to a particular installation of DiveLog, that is a dongle received with one Navigator system can be used to authorize functionality in any installation of DiveLog whether DiveLog came with that particular Navigator or survey system or not.

1.4. DiveLog Run Mode

As described in section *1 DiveLog Installation*, DiveLog will run in several different "run modes" depending on the hardware. Since the different systems have different hardware and features, the user interface in DiveLog will have some differences.

The following describes some differences between the run modes:

Navigator Delta: This is the mode for DiveLog when running on the Navigator Delta hardware. By default, port communications and real-time operation of standard sensors and accessories is **enabled** (some add-on features and sensors must be enabled separately). Differences in the user interface from other run modes include:

- o An interface for monitoring the internal and external battery status and internal battery charging.
- o An interface for setting the screen mode including screen brightness and changing screen setup (turning on/off the Underwater Head-Mounted Display.
- o An interface for turning on/off the power to external peripherals (on the System Setup window).
- o Interface for setup and calibration for extended Heading Pitch Roll range (internal HPR #2, optional).

Dive Tablet: This is the mode for DiveLog will be in when running on the Dive Tablet hardware. By default, port communications and real-time operation of standard sensors and accessories is **enabled** (some add-on features and sensors must be enabled separately). Differences in the user interface from other run modes include:

- A display for the internal battery status and charging.
- An interface for setting the screen brightness.
- An interface for turning on/off the power to the external USB and serial port (on the System Setup window).

Navigator Gamma: This is the normal mode that DiveLog will be in when running on the Navigator Gamma hardware. By default, all port communications and realtime operation of accessories and sensors is **enabled** (except for certain cases where an add-on feature must be enabled separately). Differences in the user interface from other run modes include:

- A unique interface for the NavCam, for older legacy NavCam models.
- COM Port setup for internal Depth and HPR sensors.

PC Mode: This is the mode that DiveLog will be in when running on a PC/Laptop or topside unit. By default, port communications and real-time operation of accessories and sensors is **disabled**. Features in this mode are generally enabled with a Security Dongle. Depending on features enabled with a Security Dongle, the following may be enabled:

- *View Only Mode:* The default when no Security Dongle is used. This mode allows the user to review previously recorded project data. A project may be imported to view data, but no edits to the project can be or saved. This mode can be used for data analysis and demonstrations.

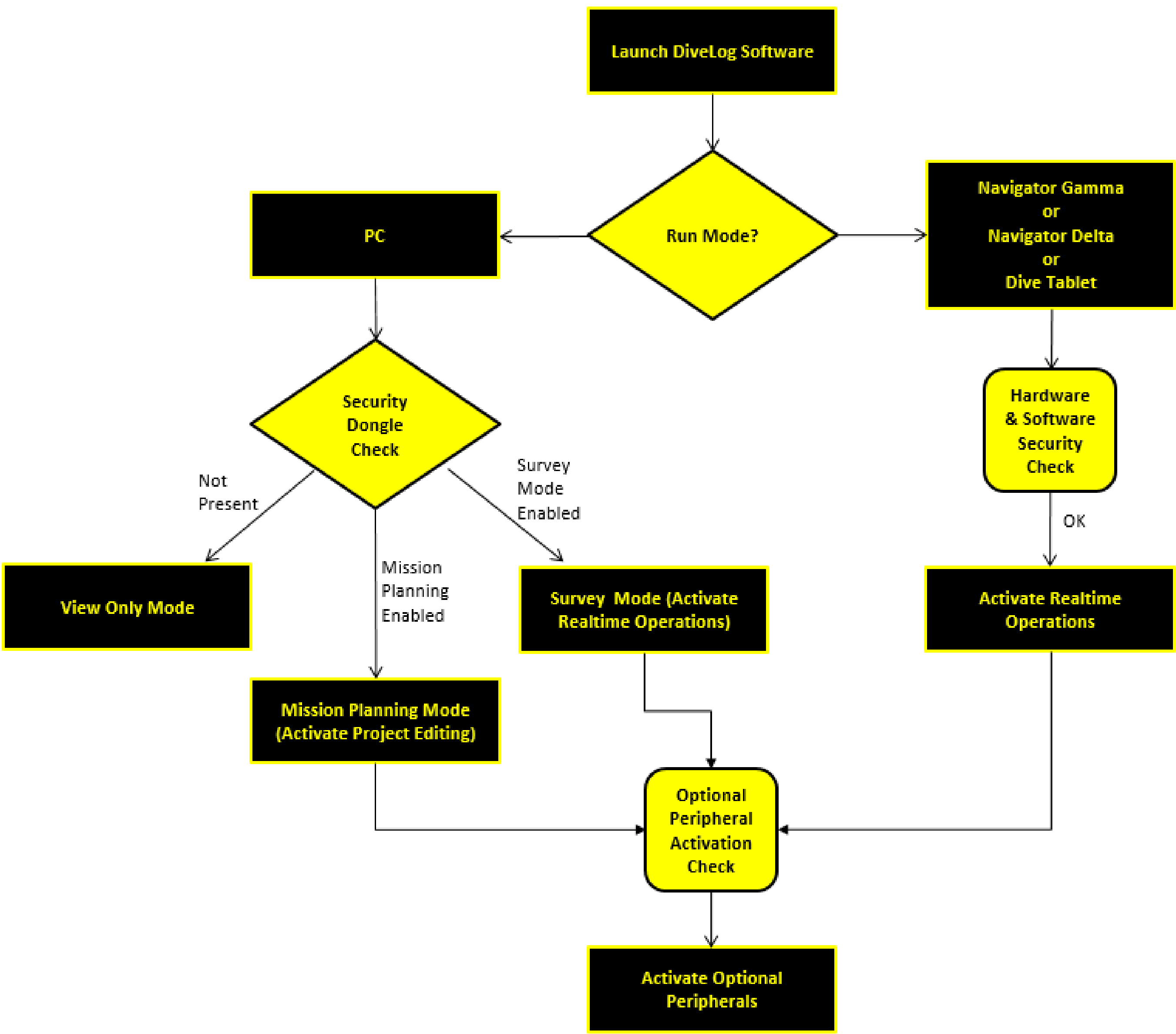
- *Mission Planning Mode:* When a Security Dongle is used with Mission Planning enabled, features allowing for playback, review/editing of data as well as project creation and setup are **enabled**. All accessory and sensor communication is **disabled** in this mode. Mission Planning mode is commonly used on a PC by the personnel performing pre-mission planning (and project creation/setup) and post mission data analysis. Each purchase of a Navigator or SeaSAR system commonly includes two Mission Planning enabled security dongles.

- *Survey Mode:* When a Security Dongle is used with Survey operations enabled, in addition to Mission Planning features described above, COM port communication is **enabled** to allow standard accessories such as a GPS and HPR to be used. Accessories associated with Active Screens such as the Forward-Looking Sonar, NavCam, Magnetometer, et cetera, will be disabled by default unless individually enabled by the Security Dongle. This mode would be used on survey data collection system such as a SeaSAR topside or an ROV topside.

Note: DiveLog Projects on a Navigator Delta, Dive Tablet, Navigator Gamma and PC/Topside are <u>fully compatible</u> with each other, so projects created with one system can be transferred to another system and used without any compatibility problems.

1.4.1. DiveLog Activation Flowchart

Depending on the conditions of the installation security checks, DiveLog will be activated for different functionality levels (as described in section *1.4 DiveLog Run Mode*). The following flow chart illustrates the DiveLog activation process.



1.5. Start-up Checks

When DiveLog starts up, several things are checked to ensure compatibility with the operating system.

DiveLog will first check that it is not already running. Only once instance of the DiveLog software can be running at once.

DiveLog will then check that the DPI setting in Windows is compatible. DiveLog will only display correctly if the DPI setting in Windows is set to “Smaller – 100%” rather than “Medium – 125%”. If the setting is not 100% then DiveLog will indicate the problem to the user and then close.

To change the DPI setting in Windows 7, right click the Desktop and select Personalize, then select Display at the bottom left. Choose "Smaller - 100% (default)”.

DiveLog will also check that the language setting in Windows is compatible. DiveLog cannot run if the language uses commas to separate the decimals in numbers rather than periods, as this affects the way numbers are read from the various files that DiveLog uses. If there is a problem then DiveLog will indicate it to the user and close.

To be safe, before changing the language setting you should close any software programs that are running, and also restart Windows after the change has been made.

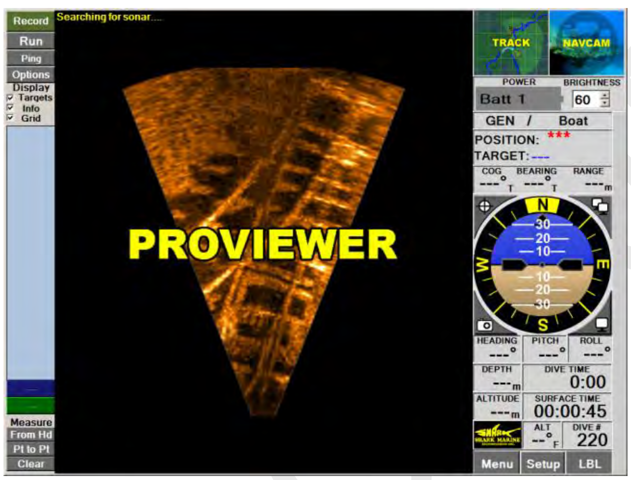
To change the language setting in Windows 7, go to Control Panel then select “Region and Language”. On the first tab "Formats", the recommended setting under "Format:" is “English (United States)”.

In Windows XP, the option in Control Panel is called "Regional and Language Options", and the language is chosen at the top of the tab "Regional Options".

2. DiveLog Software Overview

The Shark Marine DiveLog software normally fills the entire display screen of the main display. DiveLog displays Navigation data, Track/Map data, and accessory data such as a sonar image or magnetometer graph. DiveLog can be minimized or switched to "Navigation Only" mode where the Navigation data only is displayed on the right side of the screen to allow a third party software to be displayed on the rest of the screen. On a Navigator, ROV topside or SeaSAR survey topside, DiveLog will start automatically when the system boots up.

DiveLog always uses an active project, which consists of an organized folder of files containing various data such as maps, log files, track files, sonar files, et cetera. In any mode of operation, project files can be displayed and played back. If activated for real-time operations, DiveLog will also operate sensors and accessory equipment and display and record the sensor data.



Besides display data for sensors such as depth, altitude, and heading/pitch/roll on the Navigation View, the main DiveLog screen real-estate consists of an "Active Screen", which can display one of many sets of image and controls. The default active screen is the Track Screen which displays tracks of current or past recorded movements and other position data overlaid onto a map background. Other optional active screens consist of display/controls for different sonar models, display/controls for other sensors such as a magnetometer, and special operations such as the Rapid Beach Profiling System. These active screens can be also be simultaneously utilized: additional active screens exist as thumbnails called the "Secondary Screens", and with a single click, a "Secondary Screen" can be toggled to the "Primary Screen".

In general, targets can be marked in any of the active screens, whether the data source is real-time or playback. A target marked in any screen, either in real time or playback, is immediately shared across all modes of operation. All targets are marked as geodetic latitude/longitude co-ordinates and recorded with additional information to make documenting and classifying targets as easy as possible.

Note: On the Navigator or Dive Tablet, DiveLog is not meant as a replacement for a Dive Computer but instead aids the diver by providing extra information and logging the dive data.

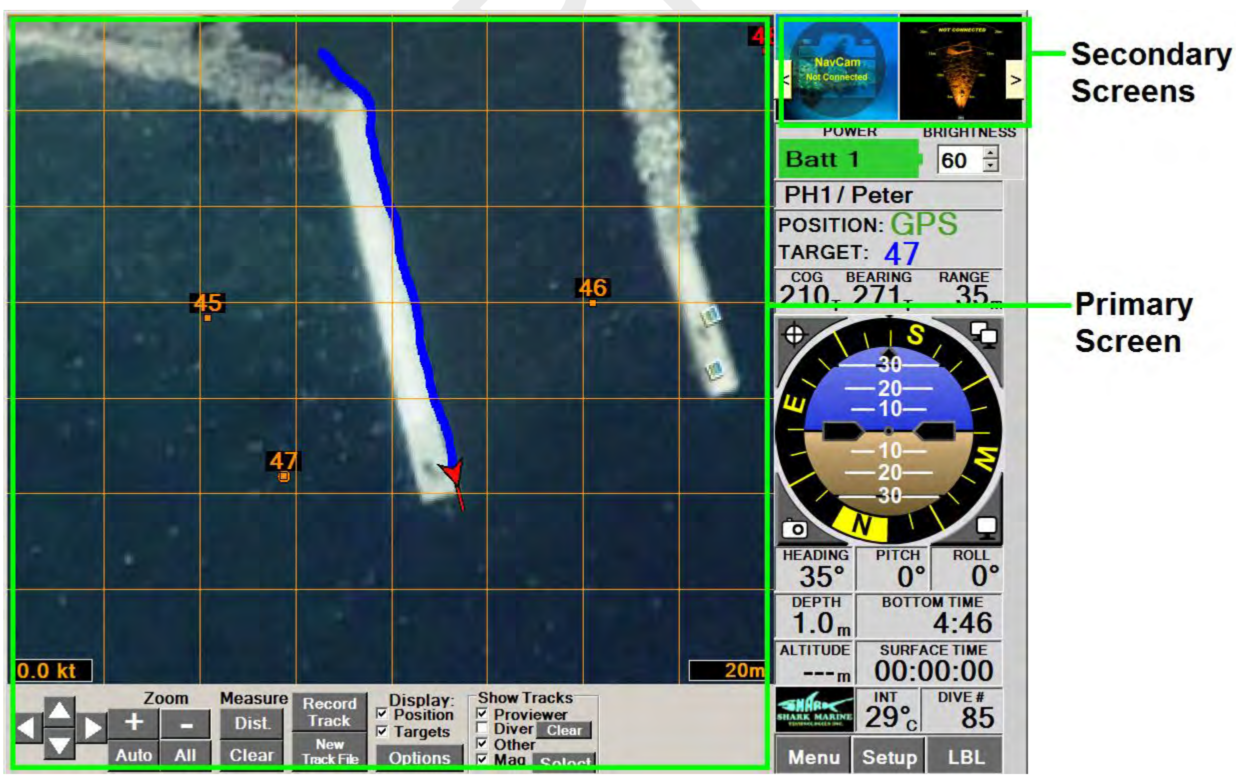
3. DiveLog Display

3.1. Active Screens, Primary Screen and Secondary Screens

DiveLog consists of the Navigation Display, plus a number of add-on modules called Active Screens. The Active Screens give DiveLog the ability to expand to use any number of peripherals or functions by turning on various Active Screens.

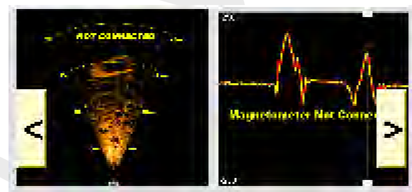
The main screen of DiveLog consists of the “Primary Screen”, one or two “Secondary Screens”, and the Navigation Display. The Primary Screen takes up the largest area of the display (the left 75% of the screen), and consists of a graphical image plus controls. The Primary Screen will toggle positions with a Secondary Screen when a Secondary Screen is clicked. This allows quickly and easily changing between the Track Display, the Sonar Display, and the display for other accessory equipment.

The Secondary Screen is displayed as a thumbnail of the minimized display. They occupy the top right of the screen in DiveLog. In general, all screens will continue their current operation (such as recording) while minimized as a secondary screen; however they will need to be toggled to primary to display the controls to change any settings. This allows the user to visually monitor Secondary Screens while focusing on the Primary Screen.

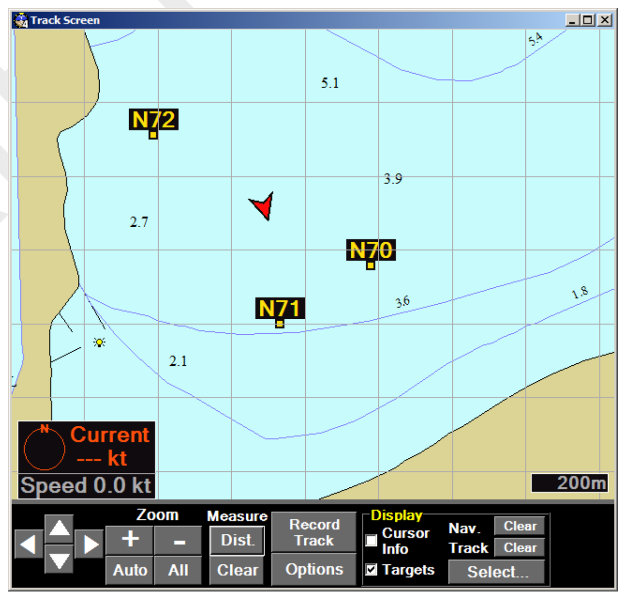


To select which Active Screens are used, the selection is made on the System Setup window. For more information, see section *13.3 Active Screens*. Any number of Active Screens can be turned on (and used simultaneously).

The size of the Primary Screen display and number of secondary displays will depend on the size/resolution of the monitor being used. The image of the primary screen will expand to use the available space of the monitor, although the DiveLog window can be resized by dragging a corner of the window. If the resolution of the monitor permits, up to six active screens can be displayed at once. On the Navigator, two secondary screens will be displayed. When there are more Active Screens than can be displayed, additional secondary screens will be active but hidden. Two buttons will enable the Secondary Screen thumbnails to be cycled to the left or cycled to the right to display the hidden screens (see image, right). Either one of the displayed secondary thumbnails can be toggled to the Primary Screen, while hidden thumbnails will need to by cycled into view before they can be toggled to the Primary Screen.



3.2. Detaching Screens



Any Secondary Screen in DiveLog can be detached from the base window into a separate window. This is useful when using more than one monitor for display. Screens can be detached by right clicking on the Secondary Screen image and select “Yes” to the prompt.

The selected screen will then un-dock from DiveLog into a separate window that can be moved or resized. The Navigation View cannot be detached, as it always remains part of the DiveLog base window.

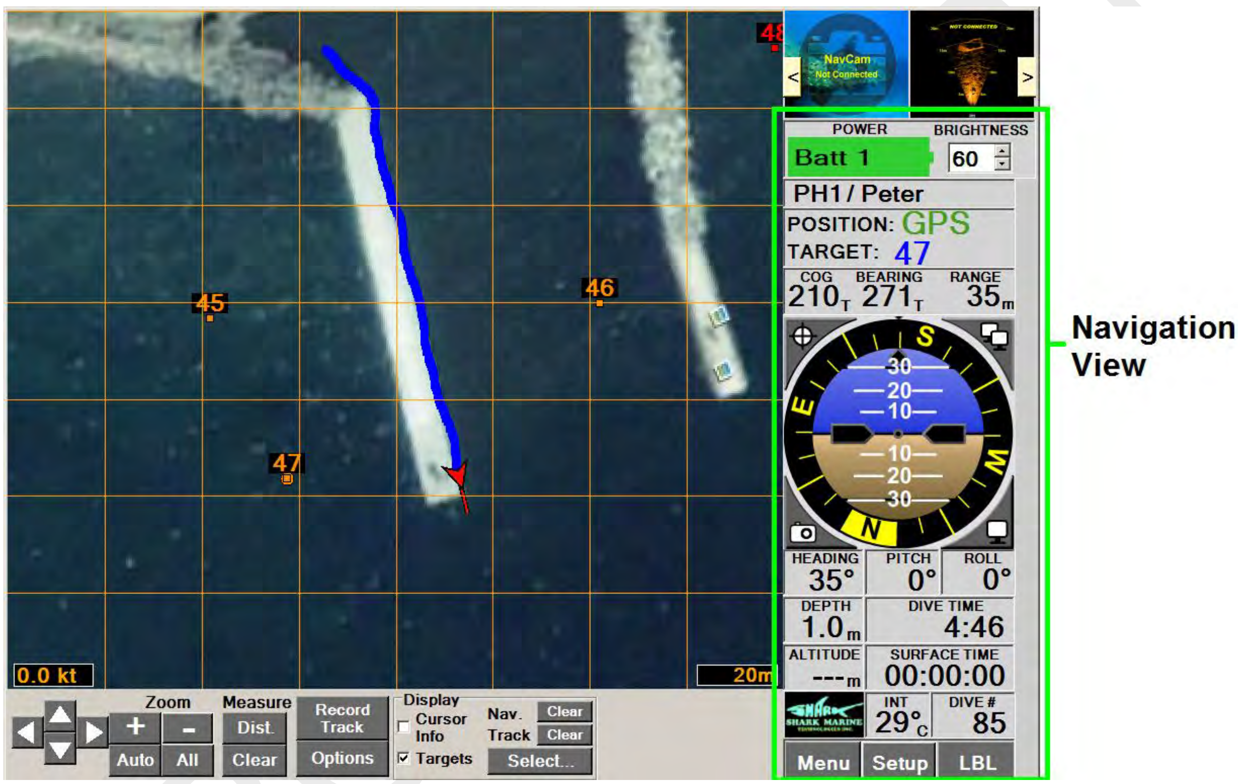
Note that if a detached Active Screen is in playback mode, then its navigation data will not be displayed on the Navigation View unless the Track Screen is the Primary Screen in the base window of DiveLog. See section *3.4.1 Navigation View during Playback* for more information.

3.3. Attaching Screens

A screen that has been previously detached can be reattached in one of two ways; either right click on the Secondary Screen image and choose “Yes” to the prompt, or click the X in the corner of the window. The attached screen will become a Secondary Screen, and can then be clicked to swap to the primary position as normal.

3.4. Navigation View

The Navigation View occupies 1/4 of the screen on the right hand side in DiveLog. In the Navigation View, the Shark Marine logo image will continually flash from yellow to blue to indicate that the program is running normally. To move the position of the DiveLog window on the screen, click and drag the Shark Marine logo.



The Navigation View consists of a large graphical display that shows the heading, pitch, and the roll of the Navigator/vehicle. There is also a vertical bar on the right that indicates the position in the water column if either of the Altimeter or Doppler accessories is installed. The Navigation View in DiveLog also has numeric displays for the following: Course Over Ground (COG), target bearing, target range, heading, pitch, roll, depth, altitude (if the Altimeter or Doppler is installed), dive time, computer clock / surface interval time, temperature (internal or external), dive number, source of the current geodetic position, and the current target number. Not all of these displays are always populated with data, depending on what additional instruments are used. On the Navigator Delta or Dive Tablet, there will also be a battery status indicator and screen brightness control.

3.4.1. Navigation View during Playback

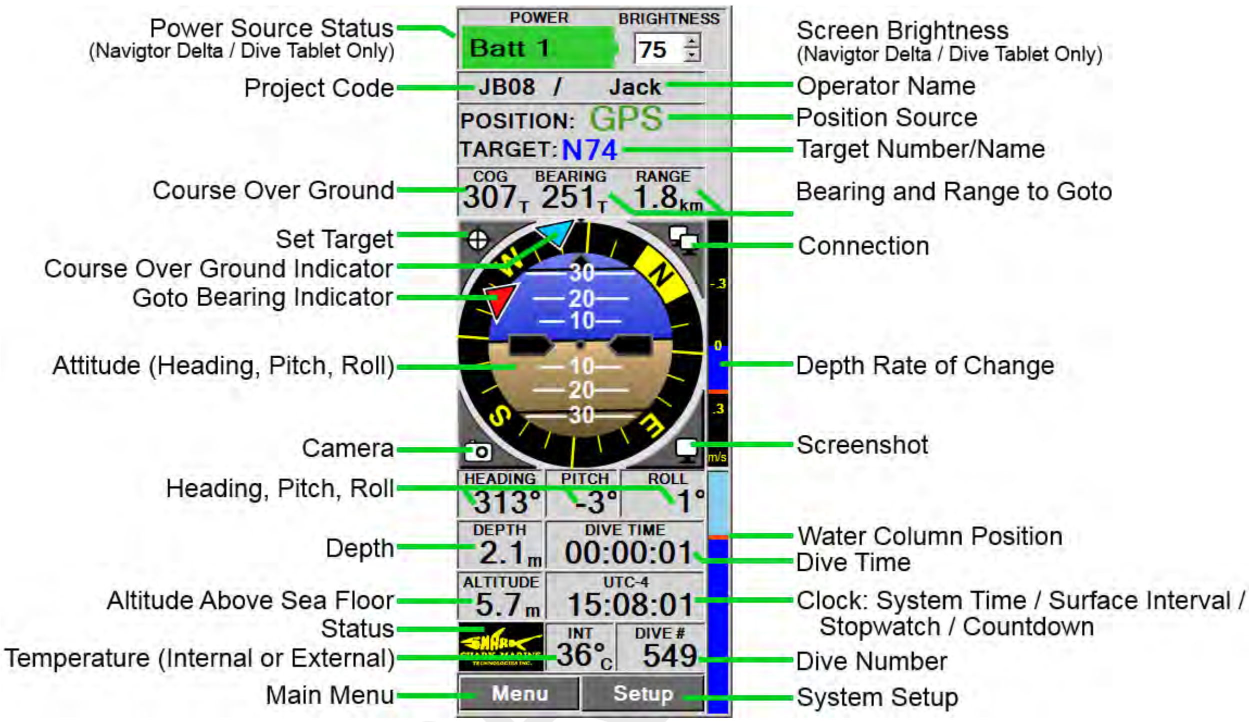
If an Active Screen is in file/playback mode (set on its Options window), the Navigation View will cease to show current/real-time sensor data, and will instead show the data associated with the file that is currently being played back. The flashing shark logo will change to indicate the name of the Active Screen that the Navigation View file data belongs to. As the file for that Active Screen is played, the data in the Navigation view will also play back to indicate the various sensor data at the time that the file was recorded. DiveLog will allow multiple screens to be in playback mode at the same time, but will only allow one screen to be playing at once (other playback files will pause when a file is played).

If the Active Screen is set to a secondary position (thumbnail) or detached, the Navigation view will cease to show the playback data for that file, and will instead show the data associated with the Primary Active Screen that is docked with the Navigation View.

Since the Track Screen shows track data for other Active Screens, when a file such as a sonar file is played back, a track for that file is also played back on the Track Screen. If the Track Screen is toggled to Primary when the sonar file is playing, then the navigation data that corresponds to the sonar file will also be displayed when the sonar screen is Primary, as well as when the Track Screen is Primary. Controls on the Track Screen allow changing whether a different playback file or real-time data is currently showing navigation on the Track Screen. See the section *20.7.4 Track Playback Control Panel*.

3.4.2. Description of Navigation View Fields

The following illustration breaks down the Navigation View:



Power Source Status: (Navigator Delta and Dive Tablet only) Displays the power source that the unit is using (Internal or External battery on the Dive Tablet, and either Batt1, Batt2, Auxiliary, or Internal on the Navigator Delta). The battery graphic will also indicate the approximate drain of the battery.

Click this battery display to open the Screen / Power Settings window. See section *11 Screen and Power Settings* for more information.

On the Dive Tablet, the computer will always run on the internal battery, and it will display “charging” if an external battery is connected.

On the Navigator Delta, the normal power supply is Batt1, which is the standard external Battery. Batt2 is an optional second external battery connection. Auxiliary is the power provided by the “UPLINK” connector on the Navigator (an optional uplink cable may provide power).

Screen Brightness:	(Navigator Delta and Dive Tablet only) This value displays the current screen brightness. This value will adjust the screen brightness (and LED brightness on the Navigator Delta). See section *11 Screen and Power Settings* for more information.
Project Code:	Displays the code for the current project. For details on projects, see section *6 DiveLog Projects*.
Operator Name:	Displays the current diver/operator name. For details, see section *5.2 Diver/Operator Names*.
Position Source:	The position source field indicates where DiveLog is currently getting information for the geodetic position. For more information, see section *3.4.3 Position Sources*.
Target Number/Name:	This will indicate the number or name of the current target, if a target Goto has been selected. A target Goto is used to navigate towards the target geodetic position (bearing and range will be displayed). Also, while the current target is selected, the following operations can be performed: changing the target's position, adding screenshots to a target's associated files, and linking to NavCam images and other recorded files. Clicking the current target text ("TARGET: ") will open the Manage Targets window, where targets can be edited or the Goto target can be changed. See section *12.6 Managing Targets* for more information.
Course Over Ground (COG):	This indicates the course over ground (COG), which is the true direction of movement. The course over ground is calculated from the change in GPS position (as opposed to the direction that the compass is pointing). The time between the current and previous GPS positions used to calculate the COG can be set on the Track Options window (see section *20.4.13 Positioning*). Using a larger time between readings will smooth out changes in the COG value.
Bearing and Range to Goto:	The bearing to the current Goto position in degrees true, and the horizontal distance to the Goto position in metric or imperial units. The Goto position could be a target

or the next point on a route. These fields will continue to update as the geodetic position changes.

Goto Bearing Indicator: When a Goto is used (a target or route), a red triangle will appear on the compass display indicating the bearing to the Goto position. As the geodetic position changes, the Goto Bearing indicator will continuously update to reflect the current bearing to the Goto position. See *12.7 Tracking a Target (Target Goto)* for more information.

Set Target: Click this button to allow marking a target on any Active Screen image. See *3.4.6 Graphical Attitude (Heading, Pitch, Roll) Display* for more information.

Connection: Shows status and opens a window for configuring a Sub-NET or Topside data connection. See *3.4.6 Graphical Attitude (Heading, Pitch, Roll) Display* for more information.

Course Over Ground Indicator: The blue triangle acts as a visual indication of the current course over ground (COG). See *12.7 Tracking a Target (Target Goto)* for more information.

Goto Bearing Indicator: This is a visual indication of the bearing to the Goto (target or route point) position. See *12.7 Tracking a Target (Target Goto)* for more information.

Attitude: This is a visual indicator of the current heading, pitch and roll. See *3.4.6 Graphical Attitude (Heading, Pitch, Roll) Display* for more information.

Depth Rate of Change: This is a visual indicator of the current ascend or descent rate. See *3.4.8 Graphical Depth Change Rate Display* for more information.

Camera: Runs the NavCam digital camera. See *3.4.6 Graphical Attitude (Heading, Pitch, Roll) Display* for more information.

Screenshot: This button captures a screenshot or allows viewing of past screenshots in the project. See *3.4.6 Graphical Attitude (Heading, Pitch, Roll) Display* for more information.

Heading: This is the compass reading, displayed in degrees, from an HPR or MRU sensor. A “magnetic declination” offset is given to the compass reading to adjust the heading from magnetic north to true north. A multi stage calibration routine ensures that the compass heading is as accurate as possible (described in section *14.3 Heading Pitch Roll (HPR) Configuration*) To open up the HPR (heading, pitch, roll) Configuration window, double click the heading, pitch, or roll numeric displays.

Pitch: The pitch angle from an HPR or MRU sensor. The format is degrees, and the range of the reading will depend on the unit mount style and hardware configuration. The zero level will depend on the specified mounting angle (see section *14.3 Heading Pitch Roll (HPR) Configuration*).

Roll: The roll angle from an HPR or MRU sensor. The format is degrees, and the range of the reading will depend on the hardware configuration. An offset can be applied to this reading to set the exact zero position.

Depth: The depth reading is calculated using the data from a pressure transducer. The zero level (the pressure reading at the water surface) can be adjusted on the Depth Configuration from. Double click the depth display to open up this window (see section *14.4 Depth Configuration* for more details).

Water Column Position: This is a visual indicator of the vertical position in the water column. See *3.4.7 Graphical Water Column Display* for more information.

Dive Time: This is the time duration of the current dive. See section *8.3 Dive Time, Dive Number, and "divelog.txt"* for more information.

Altitude above Sea Floor: This is the distance to the sea floor. This information is only available if an external Altimeter or Doppler (Doppler Navigation System) is connected. Double clicking the altitude display will open up the window to allow calibration of the altitude. See section *15.8 Altitude Calibration* for more information.

Clock: System Time / Surface Interval / Stopwatch / Countdown:
This display has the option of showing one of four different time values. By default, the computer clock is shown.

Clicking on the text will bring up the Timer Options window to change the type of timer that is displayed (see section *3.7 Timer Options* for details).

Status: When the Primary Active Screen is in realtime mode, a Shark Marine logo will flash to indicate the software is running. If the Primary Active Screen is in playback mode, then this field will flash “Playback”.

Temperature: The temperature from several different sources may be displayed. Depending on the system, the display will read “INT” or “EXT” to indicate if internal or external temperature is being displayed. “ALT” may also be displayed which indicates the displayed temperature is the water temperature provided by an optional altimeter. Clicking on the temperature value will switch the displayed value between the different sources. This can also be changed from the menu by selecting Setup>Temperature Source.

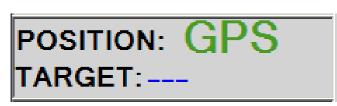
Dive Number: The number of the current dive. See section *8.3 Dive Time, Dive Number, and “divelog.txt”* for more information.

Main Menu: Click this button to bring up the DiveLog main menu. See section *4 DiveLog Main Menu* for more information.

Setup Button: Click this button to bring up the System Setup window. See section *13 System Setup* for more information.

LBL / USBL Button: This button to the right of the Setup button will only appear if the LBL or USBL is set as an Active Port. Click this button to bring up the LBL or USBL Configuration window. See section *15.5.3 LBL Configuration* or *15.10.3 USBL Configuration* for more information.

3.4.3. Position Sources



The position source is displayed as text near the top of the Navigation view. The default text for the position source will be “***”, indicating there is currently no position data to use. To have a valid position, a positioning device must be connected. The possible source indicators are:

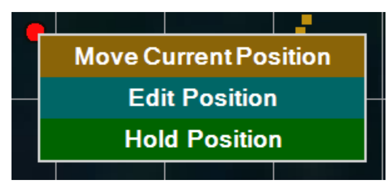
- *** – No active position source
- GPS – Primary GPS
- GPS2 – Secondary GPS

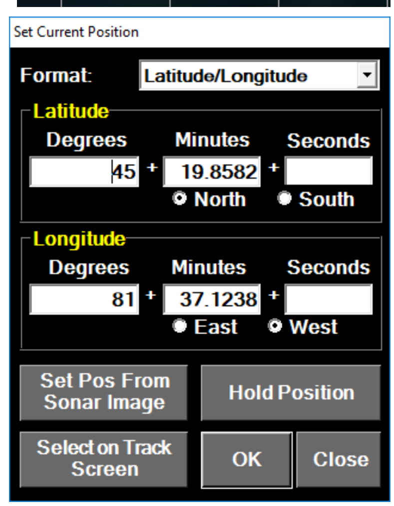
- GPSr – RTK Fixed GPS
- GPS2r – Secondary GPS RTK Fixed
- GPSd – Dual Head GPS (provides heading as well)
- GPSi – Internal GPS (Dive Tablet only)
- LBL – Long Baseline System
- DNS – Doppler Navigation System
- DNS-L – DNS and LBL simultaneously (DNS updates position between LBL fixes)
- SET – The position has been manually entered or set on the Track Screen.
- USBL – Ultra-short Baseline system
- SUR – Position sent from a surface unit
- DR – Dead Reckoning (position estimated from heading and swim speed)
- BOAT – D.A.S. Boat GPS
- BOATr – D.A.S. Boat GPS RTK Fixed
- MPOS – MiniPOSNAV3 inertial navigation system

The color of the text represents the validity of the position. The text for the position source will be **green** if the current position is valid, and **red** if invalid.

If multiple positioning devices are connected simultaneously, DiveLog will primarily use the GPS device if a satellite fix is present. If no satellite fix is present from the GPS, DiveLog will check for position data coming from a Long Baseline Positioning System or the Doppler Navigation System (DNS). If a position is sent from a topside/surface console then that position will temporarily over-ride the position of any of these devices.

3.4.4. Manually Setting the Current Position





A position can also be manually set, which will set a valid position for a short period of time. To set the position, right click the red position icon on the Track Screen and choose Move Current Position to select a position on the Track Screen, or Edit Position to open a window with additional options. Clicking the POSITION text on the Navigation View will also open this window (see image, right). This function can be used to seed the start position for the Doppler Navigation System if no GPS device is connected.

This window allows entering the current position in one of three different formats:

- Latitude/Longitude - The current position can be entered as any combination of degrees, minutes and/or seconds. The minutes or seconds fields do not need to be used if you have degrees with decimals or minutes with decimals.

- UTM – Enter the UTM zone and the easting and northing with decimals.
- MGRS – Enter the MGRS co-ordinate (no decimals).

This window can also be used to convert between these three co-ordinate systems by entering the numbers then selecting a different co-ordinate format.

The “Hold Position” function causes the current position to remain stationary and valid. When position hold is on, the Hold Position button will be red and the stationary position will override incoming position data from any other position source. This is useful to maintain a stable position when collecting data from an unmoving point such as a pole-mounted sonar. Click the button again to turn off position hold and allow normal position updates to occur.

Another option on this window allows setting the current position from the Forward-Looking Sonar image, if a known landmark on the map is visible on the sonar image. To do this, click “Set Pos from Sonar Image”, then click the relevant point on the sonar image, then click the corresponding location on the Track Screen (map).

3.4.5. Hard and Soft Position Sources

Each position source in DiveLog is categorized as either a **hard** or **soft** source.

Hard Position Sources: A position source is hard if it is an absolute position, which does not become less accurate over time. Examples of hard position sources are all GPS sources, LBL, USBL, and manually set positions.

Soft Position Sources: A position source is soft if it is a relative position, which becomes less accurate over time. Each position is calculated based on the previous position. Error is added in each calculation, and thus, these errors will add up over time. Examples of soft position sources are the DNS and dead reckoning.

3.4.6. Graphical Attitude (Heading, Pitch, Roll) Display

DiveLog provides a graphical display for “Orientation at a Glance” navigation. This display provides a quick and accurate means of knowing the orientation of the unit or vessel. The compass dial rotates to show the heading based on the compass input.

The artificial horizon moves up, down, and tilts from side to side, to show the attitude of the unit/vessel.

If a Goto is currently used and the current position is valid, the red Goto Bearing indicator will be shown on the compass ring to represent the bearing to the target's position. A blue indicator represents the course over ground. For more information on using this display, see section *12.7 Tracking a Target (Target Goto).*

There are also four buttons on this display, with functions as follows:

Target Button: The **Target Button** is in the **top-left** of the attitude display. Clicking this button will turn on "Target Marking Mode". In target marking mode the button will turn yellow and the mouse cursor will turn into crosshairs when placed over one of the primary screens. If the user does not desire to set a target, then pressing this button again will turn off target marking mode.

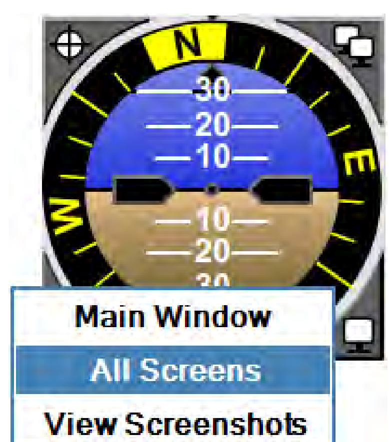
Right click the **Target Button** to activate "Target Linking Mode". In target linking mode, the button will turn blue. Then, when an active screen image is clicked, instead of setting a target position a link between a target and an open file will be created.

If using only the Navigation View (not displaying Primary Screen and Secondary Screens), then pressing this button will create a new target using the current position.

See section *12 Marking and Managing Targets* for more information on targets.

Connection Button: The **Connection Button** is in the **top-right** of the attitude display. This button is only active if DiveLog is set up for a Sub-NET connection or an Ethernet uplink connection to a SeaSAR system. If there is an active link, then this button will flash to indicate that communication is taking place. Clicking this button will bring up a window that shows the connection status and setup. See section *15.15 Sub-NET System* for more information.

Screenshot Button: The **Screenshot button** is in the **bottom-right** of the display. Pressing this button will give options for capturing or viewing screen images. This feature is useful for capturing information on the screen at a specific moment. Choosing either "Main Window" or "All Screens" will either capture either the main Divelog window, or a full image of the screen or both screens in extended

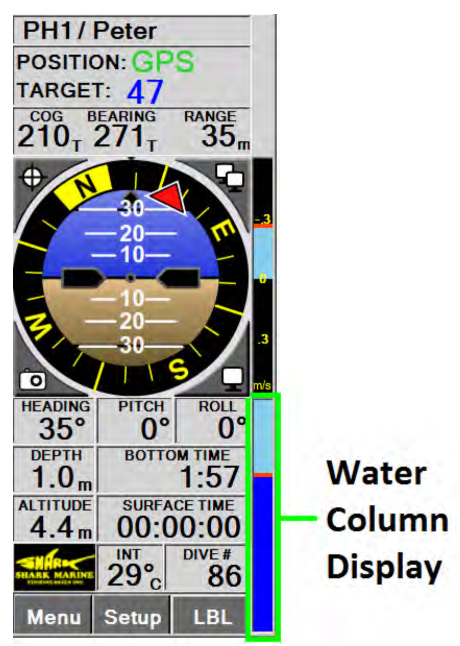


desktop mode, and save the image as a ".jpg" file to the Screenshots folder in the current project. The name of the file created will have the project code, diver/operator name, date and time. If there is a target nearby, the user will be asked if they would like to save the image with the target. If the user chooses yes, then rather than being saved in the "Screenshots" directory, the screen image is saved in the "Associated Files" directory for the current target. If "View Screenshots" is chosen, the "View Screenshots" window will be displayed in order to view previously captured screenshots.

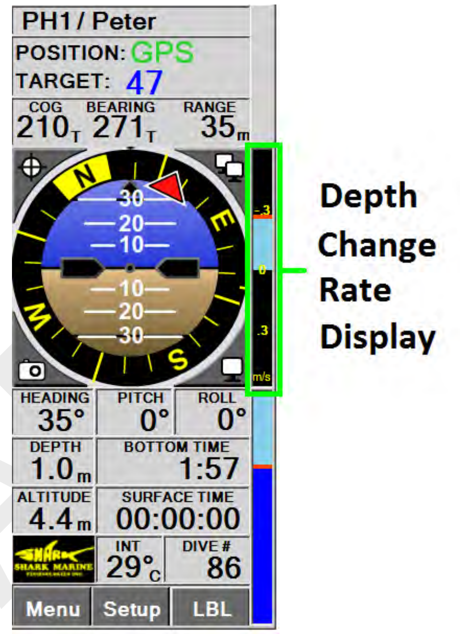
Camera Button: The **Camera button** is in the **bottom-left** of the display. This button will open the NavCam window (the optional NavCam digital camera should be connected). On the Navigator Gamma, clicking this button will open up the NavCam window, or take an image if the NavCam window is already open. On the Navigator Delta, ROV topside, or survey system, clicking this button will turn on the NavCam mode if not already on, and will set the NavCam as the primary mode.
When a NavCam image is taken, the image will be saved to the "NavCam" directory in the current project. If there is a current target being used, the user will be asked if they would like to save the image with the current target. If the user chooses yes, then rather than being saved in the NavCam Images" directory, the screen image is saved in the "Associated Files" directory for the current target.

3.4.7. Graphical Water Column Display

The Water Column Display is the vertical bar on the right side of DiveLog. The Water Column Display is meant as a quick means of showing the vertical position between the surface of the water and the sea floor. The orange bar represents the unit's vertical position. The light blue bar above the orange bar represents the distance to the surface. The dark blue bar below the orange bar represents the distance to the sea floor. This display is useful for divers wishing to keep their depth at a certain ratio of the total depth. For this display to be active, an Altimeter, or Doppler unit must be connected to the system.



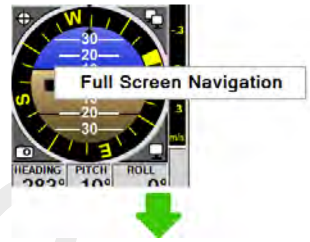
3.4.8. Graphical Depth Change Rate Display



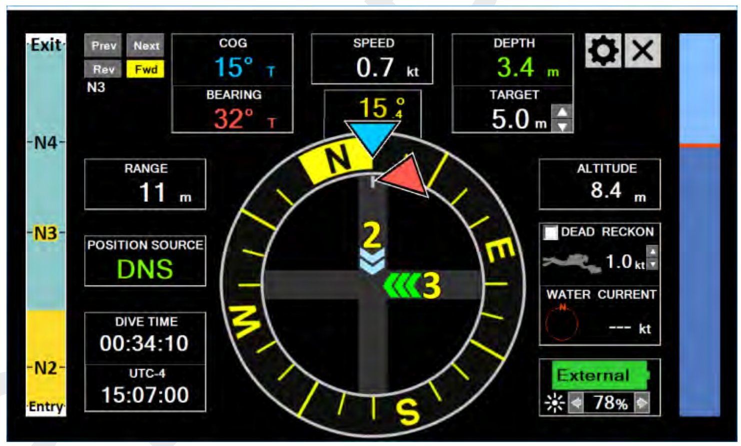
The graphical depth change rate display is the vertical bar above the water column display. It is meant to give a quick indication of the current accent or descent rate in the water column. A blue bar drawn from the vertical midpoint of the display will indicate the direction that the depth is changing, and the size of the bar will reflect the rate of change. The full scale is +/-2ft/s (+/-0.61m/s). If the depth change rate is greater than +/-1ft/s the bar will turn red to indicate a fast accent or descent.

3.5. Full Screen Navigation View

Click on the Heading/Pitch/Roll display on the Navigation View to bring up an option for Full Screen Navigation.



This view is useful when the primary task is navigating on a particular heading, navigating towards a target, or following a route. This view presents a much larger compass graphic with arrows to indicate how far your current position is from the desired position based on the current route.



Like the main screen Navigation View, this view shows triangles on a compass ring to indicate the bearing to the Goto location (red triangle) and the course over ground (blue triangle). Line-up these two triangles to travel on the correct bearing to the target position, since the water current will cause your direction of travel to differ from your heading.

The arrows in the center of the circle indicate the horizontal distance away from the route line and the vertical distance away from the proper depth. These aid the diver by indicating the direction to swim to stay at the intended depth or route. These have the same purpose as the route following bars at the top of the main screen (see section *20.6 Routes*). To adjust the horizontal and vertical distance limits of the crosshair, use the settings on the Manage Routes window (see section *20.6.1 Managing Routes*). These arrows will not appear if not following a route or going to a target.

To use the vertical arrows to maintain a certain depth without using a route, a target depth can be set using the arrows under Target Depth near the top right.

Numeric displays show values for various navigation parameters, similar to the main screen Navigation View (see section *3.4.2 Description of Navigation View Fields*). The water current indicator and dead reckoning controls are also shown (see section *20.8 Dead Reckoning and Water Current*).

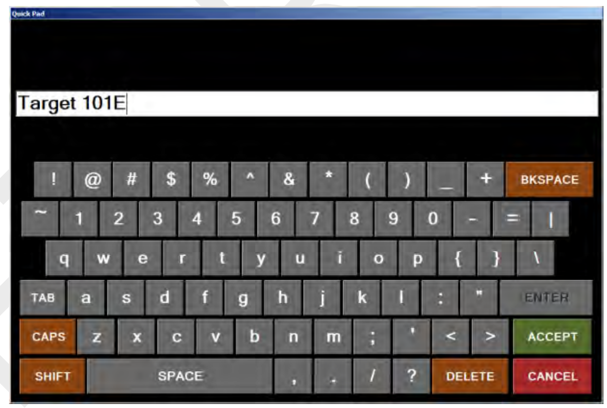
Buttons near the top left allow incrementing/decrementing the route point, and reversing the direction of travel along the route.

The bar along the left side shows the progress along the route or towards the current target. The yellow bar will progress from the bottom to the top as the route is followed.

The bar along the right side represents the current location in the water column. The red bar indicates the vertical position of the diver between the surface and the seabed. Note: an altimeter or doppler velocity log must be installed and receiving valid readings for this bar to be displayed.

The gear button near the top right allows setting a Goto – it provides access to the manage routes window, manage targets window, and an option to cancel the Goto.

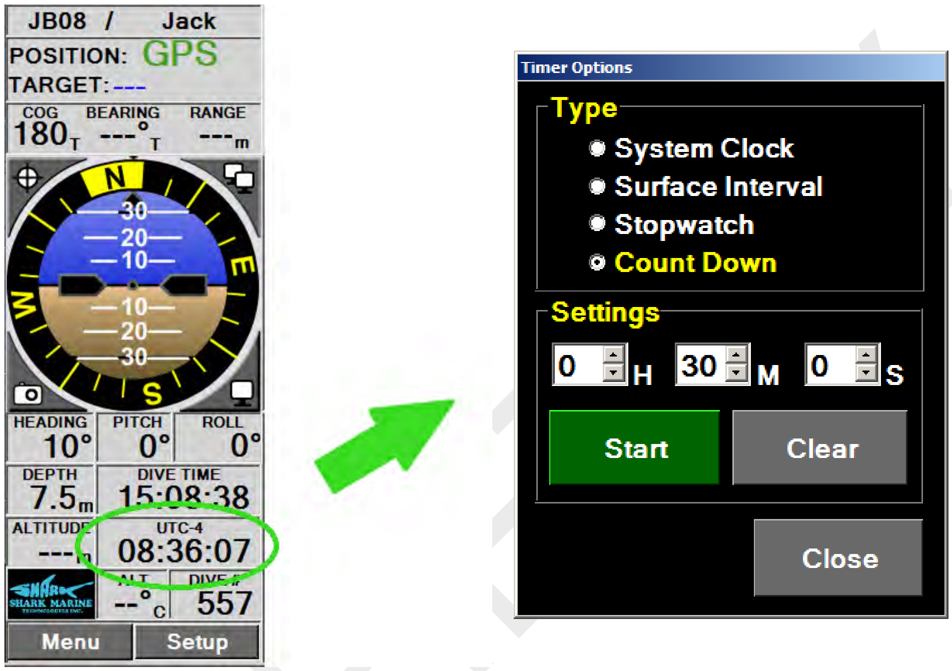
3.6. Quick Pad On-Screen Keyboard



The “Quick Pad” was developed to allow rapid text entry and editing on a touch screen or the Navigator thumb controls. When a text box in DiveLog is clicked, the Quick Pad will automatically come up (if turned on), taking up the majority of the screen real-estate. The Quick Pad will show a duplicate of the text box in a larger format to make the text clearly visible. The text box on the Quick Pad can be clicked to move the caret position or highlighted to delete a portion of it. Once the text entry is complete, click Accept to enter the changes, or Cancel to discard the changes. Once Accept is clicked, the text may be validated depending on the window in DiveLog, and invalid text may be rejected. The Quick Pad can be turned on or off from the main menu, under Setup>On Screen Keyboard.

3.7. Timer Options

The Timer Options window can be reached by clicking on the System Clock / Surface Interval / Stopwatch / Countdown field on the Navigation View of DiveLog.



The type of timer can be selected from four choices:

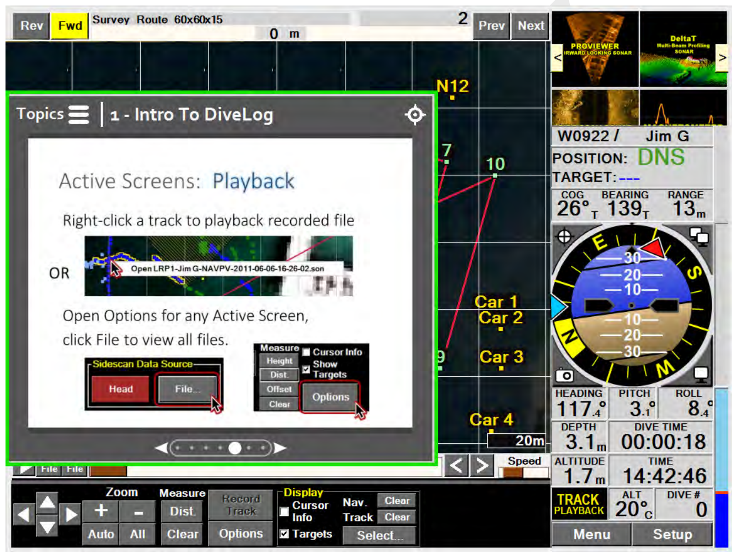
- System Clock: Displays the current computer clock time. It will also display the time zone offset from Coordinated Universal Time (for example, UTC-4 indicates the displayed time is four hours earlier that UTC). During file playback, this will display the time of the current playback data.
- Surface Interval: Displays the interval of time that the system has been on the surface between dives (see section *14.4 Depth Configuration* for more information).
- Stopwatch: Counts up from zero in increments of one second until stopped.
- Count Down: Counts down from the start interval specified as a value in hours, minutes, and seconds and stops when it reaches zero.

To start the stopwatch or countdown timer, press the green Start button. To reset or clear the count, press the Clear/Reset button.

For the Count Down timer, enter the start value in a combination of hours, minutes, or seconds. When the countdown reaches 00:00:00, then the box displaying the value on the Navigation View will flash red until the timer is stopped or cleared.

3.8. Quick Cards

DiveLog Quick Cards are easy to access, instructional images to assist the operator with any number of tasks, determined by the mission planner. They can be used as a lookup for typical DiveLog tasks, specific instructions during missions with little prep time, or as reference images to link to targets. Quick cards are useful in situations where the operator has had limited time for training.



Quick Card topics are made up of one to twelve pages, and can be added or edited easily, at any time, by the mission planner. There can be any number of different Quick Card topics (i.e. sets of Quick Cards). Quick Cards can be any image, usually created by another software program. For example, any image editing software can be used to create Quick Cards, or Microsoft PowerPoint slides can be used as Quick Cards by exporting the slides as images.

Quick Cards can be turned off through by clicking Menu>Setup>QuickCards.

3.8.1. Using Quick Cards

The Quick Cards Window can be opened by moving the mouse over the yellow question mark icon at the far left of the DiveLog window, or pushing the mouse against the left edge of the screen when DiveLog is maximized.

To move between pages, either left/right click the main image (back/forward), or use the arrows in the bottom corners of the window. You can also jump to any page directly by clicking the page marker bar or dragging the page marker at the bottom of the window.

To hide the menu, simply move your mouse off of the Quick Cards window.

To change topics, click the Topics icon in the top-left corner of the window, and select the desired

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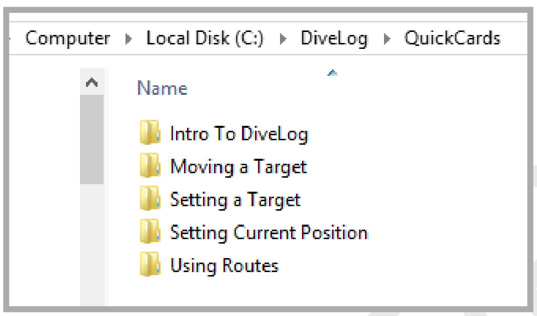
topic from the drop-down menu. The current topic is identified with a checkmark.

3.8.2. Editing Quick Cards

All Quick Card topics are stored in folders in the **QuickCards directory**, which is located in the DiveLog folder (C:\DiveLog\QuickCards) along with the default location of the **Projects** folder. Each topic contains one to twelve images, which will be ordered **alphanumerically** when viewed in the Quick Cards window. Topics can also be put into folders for better organization.

To add a Quick Cards Topic, use the normal Windows file explorer to add a folder to this directory containing the images you wish to display. You may have to add numbers to the start of each image to display them in the order you wish to see the pages in DiveLog (a powerpoint presentation exported as images are generally named in the correct order).



To remove a Quick Cards topic, simply delete the folder with the same name.

The supported Quick Cards image formats include: .bmp | .gif | .jpg | .jpeg | .png | .tif | .tiff

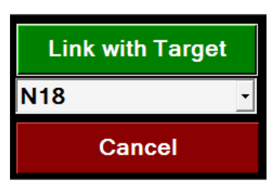
The Quick Card page size is 540 x 420, but any size of image will be proportionally scaled to fit into the window. It is recommended that for fast performance, the size of each image should be kept to a minimum.

The Quick Cards icon will NOT be displayed if no valid folders are found in the Quick Cards directory. If DiveLog is running when the first folder is added, a restart of DiveLog is required.

Note: Editing or removing topics is not possible while that topic is being displayed. To allow editing, select another topic or close DiveLog.

3.8.3. Linking a Quick Card to a Target

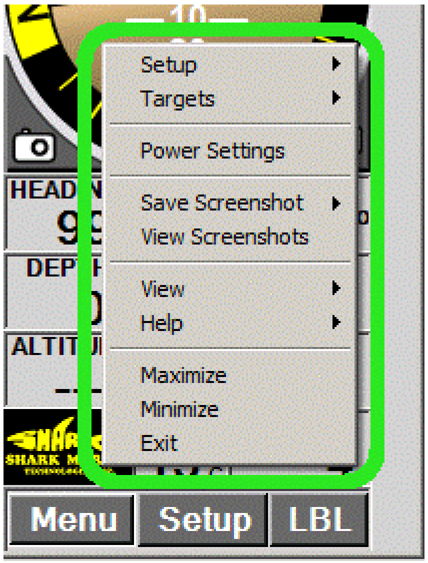
Any Quick Card image can be linked to a target by clicking the Target icon in the top right corner of the Quick Cards window.



The standard target link window (shown right) will be displayed with the closest target, if any, selected. To link the Quick Card image to the target, simply choose the correct target in the drop-down list and click *Link with Target*.

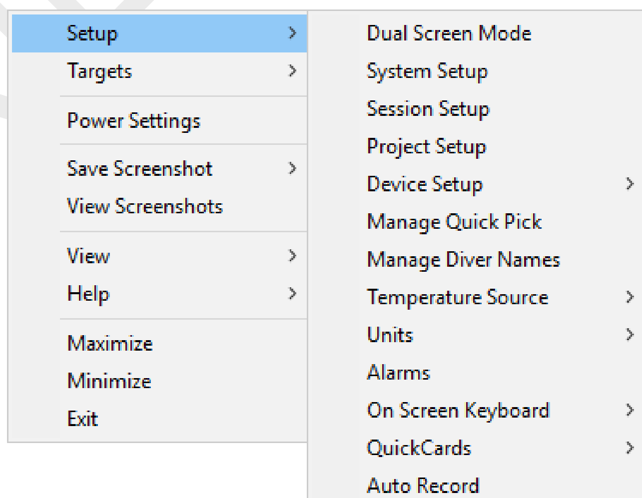
Linked images can be viewed in a target's associated images list (right click any target and select *Associated Files*).

4. DiveLog Main Menu



Clicking the Menu button or right-clicking on the Shark Marine Logo will bring up the main menu, as shown to the left. Many of the settings and forms discussed thus far in the manual can be accessed from this menu. All of the menu items and sub-items are discussed below.

4.1. Setup



The sub-items under Setup provide access to the following:

4.1.1. Dual Screen Mode

(Navigator Delta Only) This opens the "Screen Modes" window for changing the screen mode settings between several single or dual screen options. The Screen Modes window can also be reached from the Power Settings window. See section *11.5 Screen Modes (Navigator Delta)*.

4.1.2. System Setup

This opens the window for setting up COM ports, device configurations, and Active Screens. The System Setup can also be reached by clicking the "Setup" button at the bottom of the Navigation View. See section *13 System Setup* .

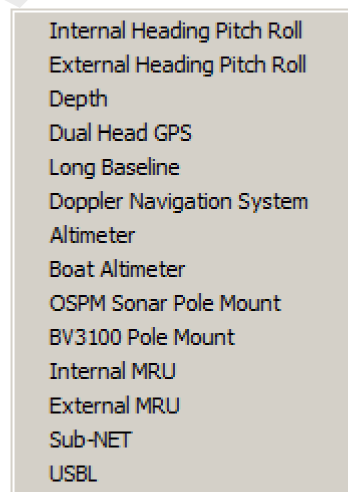
4.1.3. Session Setup

This opens the Session Setup window that opens on start-up. It allows changing of the current diver/operator name, current Project, and current Quick Pick List. The Session Setup can also be reached by clicking the diver/operator name on the Navigation View. See section *5 Setting up the Session*.

4.1.4. Project Setup

This opens the Project Setup window for changing the current project, and other project related functions. The Project Setup can also be reached by clicking the project code displayed on the Navigation View. See section 6.1 *Project Setup*.

4.1.5. Device Setup



Device Setup allows setting the configuration parameters for various built-in and add-on devices. Clicking an item in the list will open up the configuration window for that item. Note that this is the same as clicking the "Config" button for a device in the COM Setup Table (see section *13.1 COM Setup Table*).

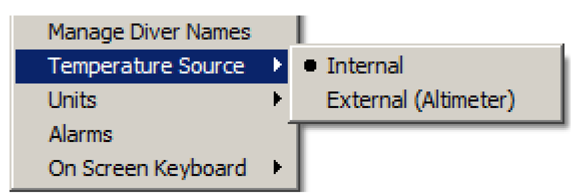
4.1.6. Manage Quick Pick

This opens the window for creating and editing Quick Pick Lists. This can also be reached from the Session Setup. See section *12.11 Managing Quick Pick Lists*.

4.1.7. Manage Operator Names

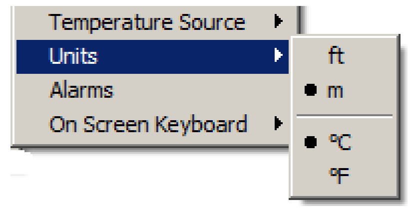
This opens the window for creating and editing Operator Names. This can also be reached from the Session Setup. See section *5.2.1 Managing Diver/Operator* Names.

4.1.8. Temperature Source



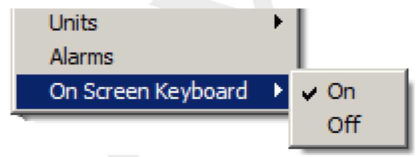
This allows a selection of the source for the displayed temperature. The available temperature sources will depend on which sensors are installed, for example "External (Altimeter)" is only available if an external Altimeter is connected.

4.1.9. Units



This allows a selection of the system units. Choose between feet and meters for distance, and degrees Fahrenheit or Celsius for temperature. This will affect all displayed or entered distance and temperature values in DiveLog.

4.1.10. Alarms

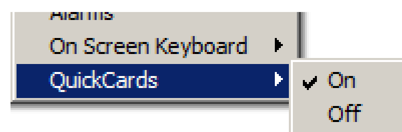


This opens the window for setting up the system alarms. See section *14.1 Alarms*.

4.1.11. On Screen Keyboard

This specifies whether or not the “Quick Pad” on-screen keyboard will pop up when a text box in DiveLog is clicked. The default setting is *on* for the Navigator Delta and Navigator Gamma, and *off* on a PC, but this setting can be overridden by clicking on/off on this menu item. See section *3.6 Quick Pad On-Screen Keyboard* for more information.

4.1.12. QuickCards

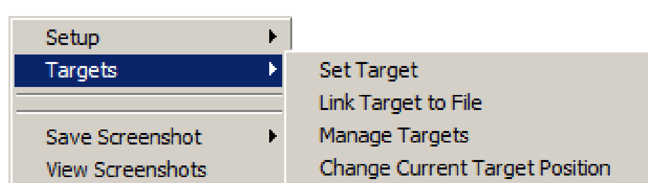


This specifies whether or not the QuickCards feature is turned on. See section *3.8 Quick Cards* for more information.

4.1.13. Auto Record

This option allows automatically recording active screens when a specified depth is reached. See section *4.15 Auto Record* for details.

4.2. Targets



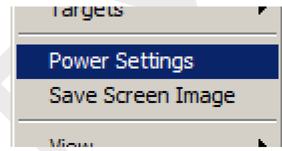
The sub-items under Targets Menu provide access to:

- Set Target: Turn on or off target marking mode, same as pressing the target button on the Attitude graphic.
- Link Target to File: Turn on or off target linking mode, same as right-clicking the target button on the Attitude graphic.

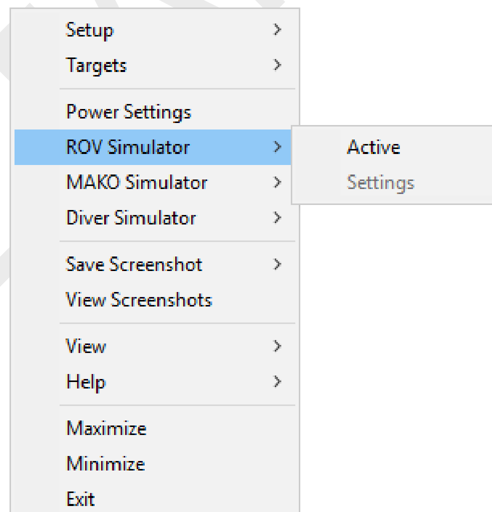
- Manage Targets: Allows viewing and editing of targets, change the current target, and other target related function. The Manage Targets window can also be reached by clicking the text “TARGET:” on the Navigation View.
- Change Current Target Position: If there is a current target set, this allows manually changing the latitude and longitude position of the target.

Both of these topics are covered in section *12 Marking and Managing Targets*.

4.3. Power Settings



(Navigator Delta only) This option will bring up the “Power Settings” window to allow viewing the power sources as well as screen brightness options. For more information, see section *11 Screen and Power Settings.*



4.4. Simulator

If one of the simulators are enabled on the system, then a menu item for ROV Simulator, MAKO Simulator, or Diver Simulator will be available. Clicking Active will start or stop the simulator (DiveLog will restart in simulation mode).

4.5. Save Screenshot

This is the same function as clicking the screenshot icon in the bottom right corner of the attitude graphical display on the Navigation View. The Save Screenshot function is useful for capturing information on the full screen or DiveLog window at a specific moment.

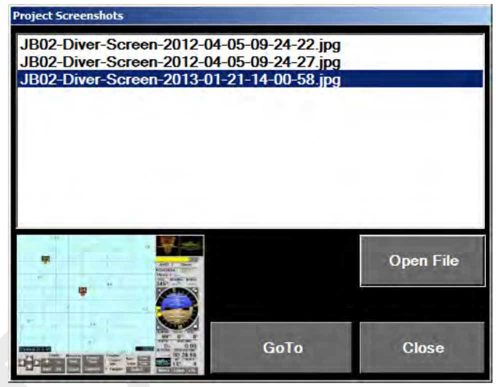
There are two options:

- Capture the main DiveLog window
- Capture a full image of the screen (or both screens if using two monitors with an extended desktop)

The screenshot will be saved as a .jpg file. The name of the file created will have the project code, diver/operator name, date and time.

If there is a target Goto being used, the user will be asked if they would like to save this image with the current target. If the user chooses yes, then the screenshot is saved in the “Associated Files” directory for the current target. Otherwise, the screenshot will be saved to the “Screenshots” folder in the current project.

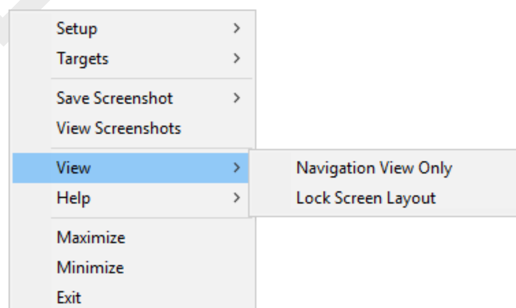
4.6. View Screenshots



If screenshots are captured and not linked to a target, then they will be saved to the “Screenshots” folder in the current project. To view these screenshots, click this menu item. This action will bring up a list of all screenshots, and a thumbnail of each can be viewed (see image, right). Click “Open File” (or double click the file) to view a full resolution image of the screenshot.

Note: if screenshots are linked to a target, then they will not appear in this list; they will only appear in the list of associated files for that target.

4.7. View



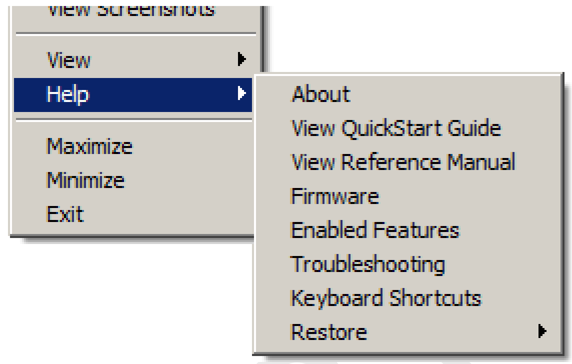
4.7.1. Navigation View Only

Clicking this menu item toggles the view between the Navigation View only and the standard DiveLog view. Navigation View Only hides all of the Primary and Secondary Screens and only the Navigation Display is visible.

4.7.2. Lock Screen Layout

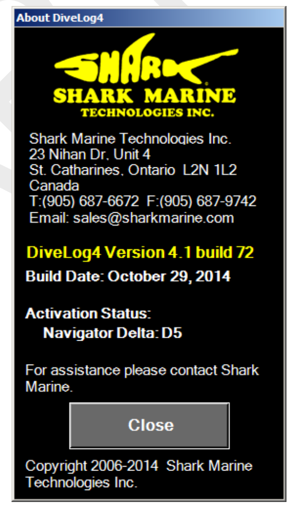
This is useful for ROV or survey systems where a permanent screen layout is desired. To set this up, detach the appropriate active screens (by right-clicking the secondary window thumbnail image), and arrange all windows in the desired layout. Then click the menu item to lock the screen layout. The windows will no longer be able to be moved or resized, but they may still be minimized or maximized. If windows are locked on a secondary monitor, if that monitor is removed, the windows will unlock and snap back to the main screen. They will snap back to their locked locations when the secondary monitor is reconnected. Click the menu item again to unlock the screen layout.

4.8. Help



The Help menu presents several items for obtaining general system information, troubleshooting and access to the manuals. These sub items are described below.

4.8.1. About



The "About" window displays the DiveLog software version number and contact information for Shark Marine Technologies Inc. The "Activation Status" gives information on the DiveLog run mode (such as Navigator Delta, Dive Tablet, or Survey Mode), unit number, and status (it may report "Not Activated" if there was a activation error).

If contacting Shark Marine for technical support, report the version number along with the problem description.

4.8.2. View QuickStart Guide

This option opens the Quick Start Guide for DiveLog, which briefly outlines the basic features of DiveLog. This is a useful guide for anyone new to DiveLog. The document will be opened with the associated PDF reader in Windows.

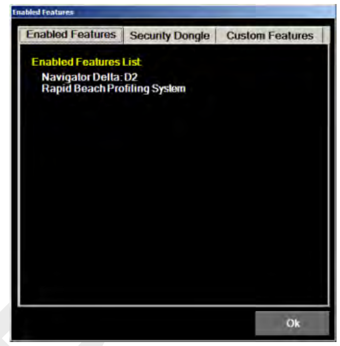
4.8.1. View Manual

This option opens the DiveLog Software Manual (this document). The manual will be opened with the associated PDF reader in Windows.

4.8.2. Firmware

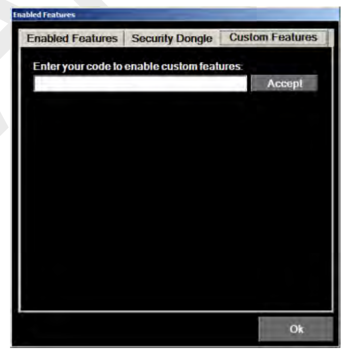
(Navigator Delta only) This option brings up the "Firmware" window. The Firmware window displays the current version numbers of firmware for the Navigator Delta hardware.

4.8.3. *Enabled Features*



This option opens a window that displays the DiveLog run mode (Delta, Gamma, or PC), the unit number, and lists all special enabled features in DiveLog (such as RBPS, SeeTrack Import/Export, et cetera).

The second tab titled “Security Dongle” provides information on a Security Dongle that is currently connected to the machine. Click “Evaluate Security Dongle” to retrieve information such as the list of programs/features enabled by the Security Dongle, the serial number, and the name of the authorized customer.



The third tab enables custom features. The features enabled here are non-standard features that have been requested by a customer for their specific application. Activating these features is done by entering a specific code given to that customer. When the code is entered, pressing Accept will then display controls to configure the custom feature. Once a feature has been enabled, it will be listed as a feature on the “Enabled Features” list on the first tab of this window, and it will remain enabled until specifically disabled using the code.

4.8.4. *Troubleshooting*

Navigator Delta: This option brings up the “Troubleshooting” window. This window does not normally need to be accessed, but is available to display the status of the Navigator Delta internal circuitry. For more information, see section *4.12 Troubleshooting Functions (Navigator Delta)*, or section *4.13 Troubleshooting Functions (Dive Tablet)*.

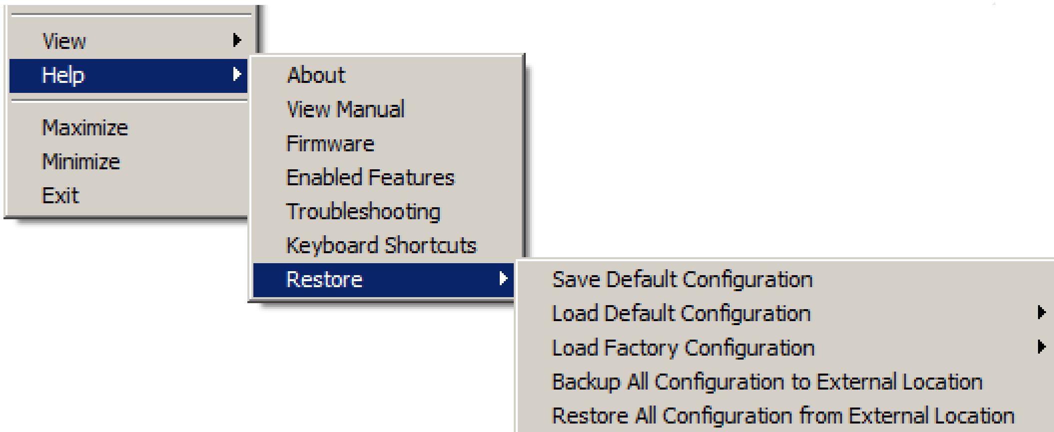
Dive Tablet: This option brings up the “Tablet Troubleshooting” window. This window does not normally need to be accessed, but is available to display the status of various internal Dive Tablet processes and sensors. For more information see section

4.8.5. *Keyboard Shortcuts*

This displays a list of all keyboard shortcuts in DiveLog. See section *4.14 Keyboard Shortcuts*.

4.8.6. Restore

The Restore menu allows the user to reset DiveLog to previously backed-up software configuration settings. This may be used when incorrect configuration settings are causing DiveLog to function improperly.

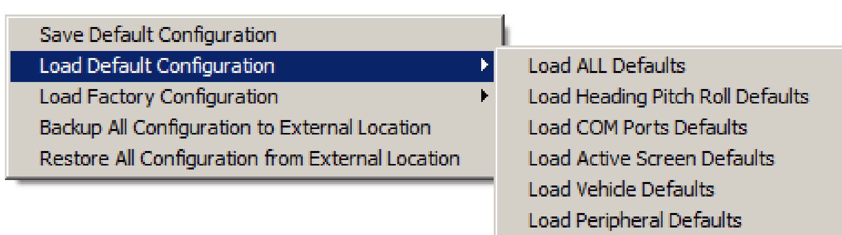


Save Default Configuration

If the DiveLog settings have been recently configured or updated then click “Save Default Configuration to make a copy of all software configuration files. When this option is selected the following configurations are backed up:

- General configuration such as COM port settings and configuration for basic sensors such as depth and altimeter.
- All Heading/Pitch/Roll (HPR) configurations such as all compass calibrations.
- All COM Port settings.
- Track Screen display settings, and all other “Active Screen” settings.
- Vehicle and peripheral settings.

Load Default Configuration

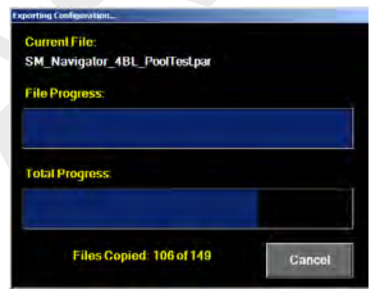


The “Load Default Configuration” allows the user to load each specific region of defaults, or all defaults simultaneously. Clicking any of these options will cause either the specified, or all saved configuration settings to revert to the default values set earlier with the above option “Save Default Configuration”.

Note: The Load Defaults functions will erase and re-set the specified DiveLog default configuration settings.

Load Factory Default Configuration

Clicking “Load Factory Default Configuration” is very similar to “Load Default Configuration” described above, but a different set of configuration files is used for restoring the configuration settings. When the unit is initially fully set up, Shark Marine Technicians will save the Factory Default Settings. Clicking this option will restore the DiveLog software configuration to that initial state. The factory configuration back-up files are separate from the user-set default configuration files, and will not be overwritten by using the “Save Default Configuration” option described above.



Backup All Configuration to External Location

Clicking this option will allow the operator to select any location on the computer hard-drive or external storage location. A folder “DiveLog Backup Config” will be created, and all of DiveLog’s configuration files will be copied to this location. This function is useful for backing up and restoring DiveLog when replacing a hard-drive.

Restore All Configuration from External Location

Clicking this option will allow the operator to select the location that previously backed up configuration files have been saved to (using the function “Backup All Configuration to External Location” described above). DiveLog will close and restart once the restore is completed.

4.9. Maximize

This option resizes the DiveLog main window to take up the full display area of the monitor. DiveLog can subsequently be made smaller by dragging one of the sides or corners of the window.

4.10. Minimize

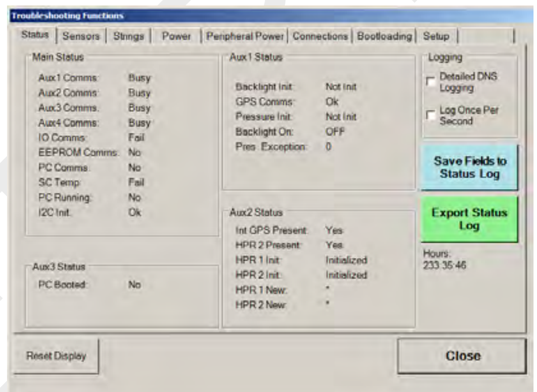
This option minimizes DiveLog to the Task Bar at the bottom of the screen in Windows. This is provided so that the DiveLog window can be temporarily hidden in case the full screen must be used for another program.

4.11. Exit

Saves configuration data and closes the program. DiveLog will prompt the user to verify that they wish to exit. It is not recommended that you close DiveLog while on a mission as the current sensor and status information will stop being recorded.

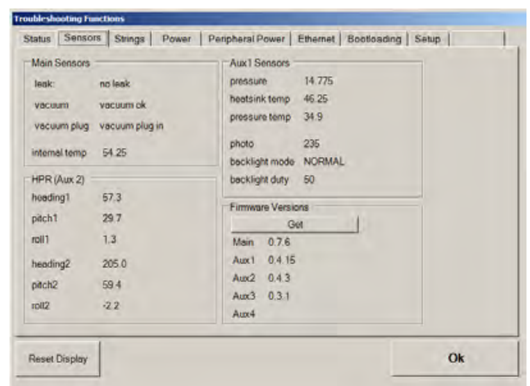
4.12. Troubleshooting Functions (Navigator Delta)

This window can be reached through the Main Menu > Help > Troubleshooting. This will not normally be accessed by the operator, and will be used primarily when troubleshooting problems with assistance from technical help from Shark Marine Technologies Inc. The function of the pages on this window will be briefly outlined.

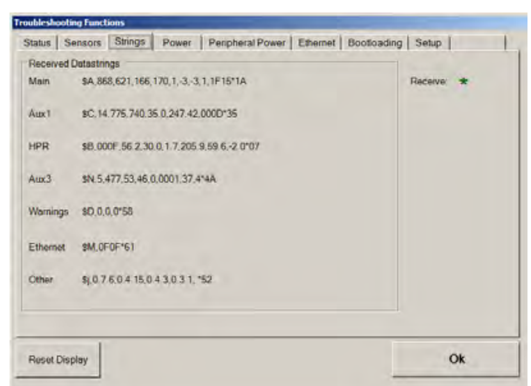


The first tab labelled “Status” displays the current status of various internal communications and devices.

This Tab is also useful for updating a status log file with the current data on this window, and also for exporting the status log file (done with the blue and green buttons, respectively). This would normally only be done at the request of a technician from Shark Marine Technologies to gather troubleshooting information.

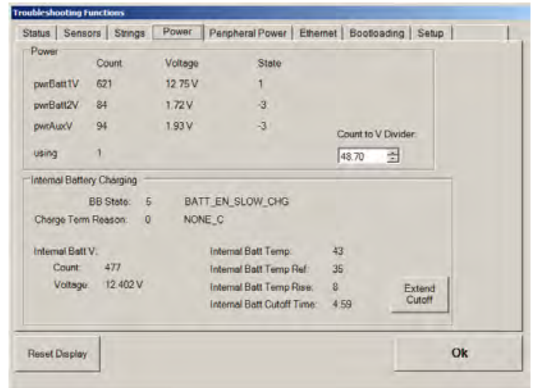


The second tab labelled “Sensors” shows the input reading of various internal sensors.

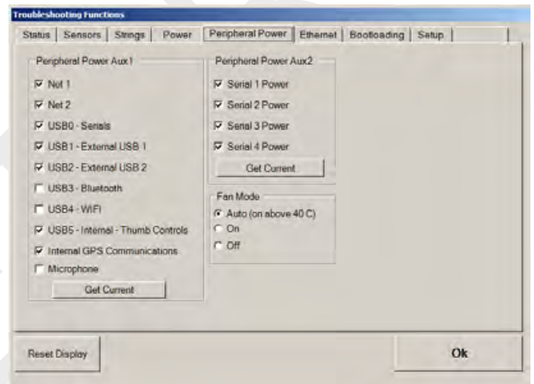


The tab labelled “Strings” shows the raw communication strings that are received by DiveLog from the internal circuitry.

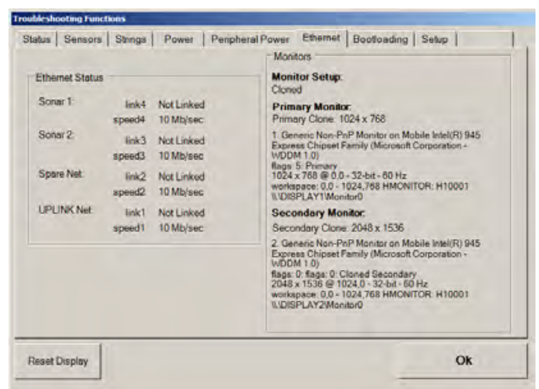
The “Power” tab shows voltage readings for the external sources. It also shows a voltage reading, states, and other information from the internal battery circuit.



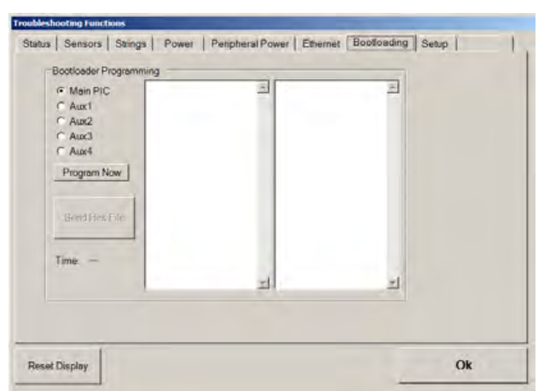
The “Peripheral Power” tab turns on and off power to various peripherals. It is possible to disable the thumb controls here, so be careful not cut out the controls you are using.



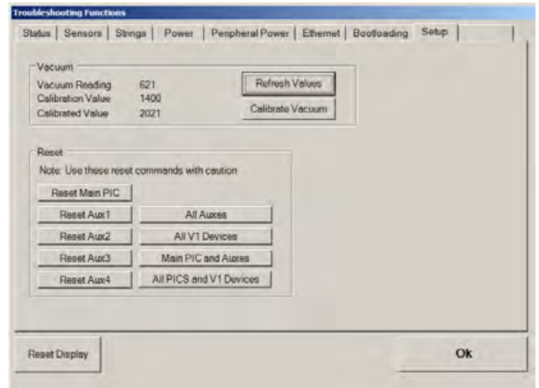
The “Ethernet” tab displays the link and speed status of the ports on the internal Ethernet hub. This page also displays information about the displays enabled on the system.



The “Bootloading” tab allows re-programming of the firmware of the internal microcontrollers which control many hardware functions. Avoid touching these controls unless under direction from a technician at Shark Marine Technologies Inc.



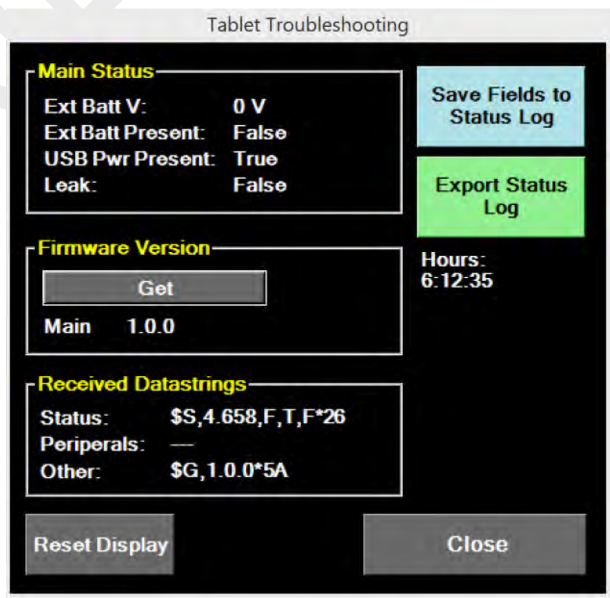
The “Setup” tab will display the reading from the internal vacuum sensor (for detecting presence of a vacuum test on the system). This page also allows resetting of internal devices and microcontrollers. This may cause erratic operation of the system, so avoid using these controls.



4.13. Troubleshooting Functions (Dive Tablet)

The Tablet Troubleshooting window allows the monitoring and querying of internal sensors and parameters. This window should be used primarily when troubleshooting problems with assistance from technical help at Shark Marine Technologies Inc.

The Main Status box shows the status of an external battery or power source, including if one is present and its voltage. It also indicates the presence of USB power and if a leak has been detected.



The Firmware Version box allows the user to obtain the current firmware version of the Dive Tablet internal circuitry.

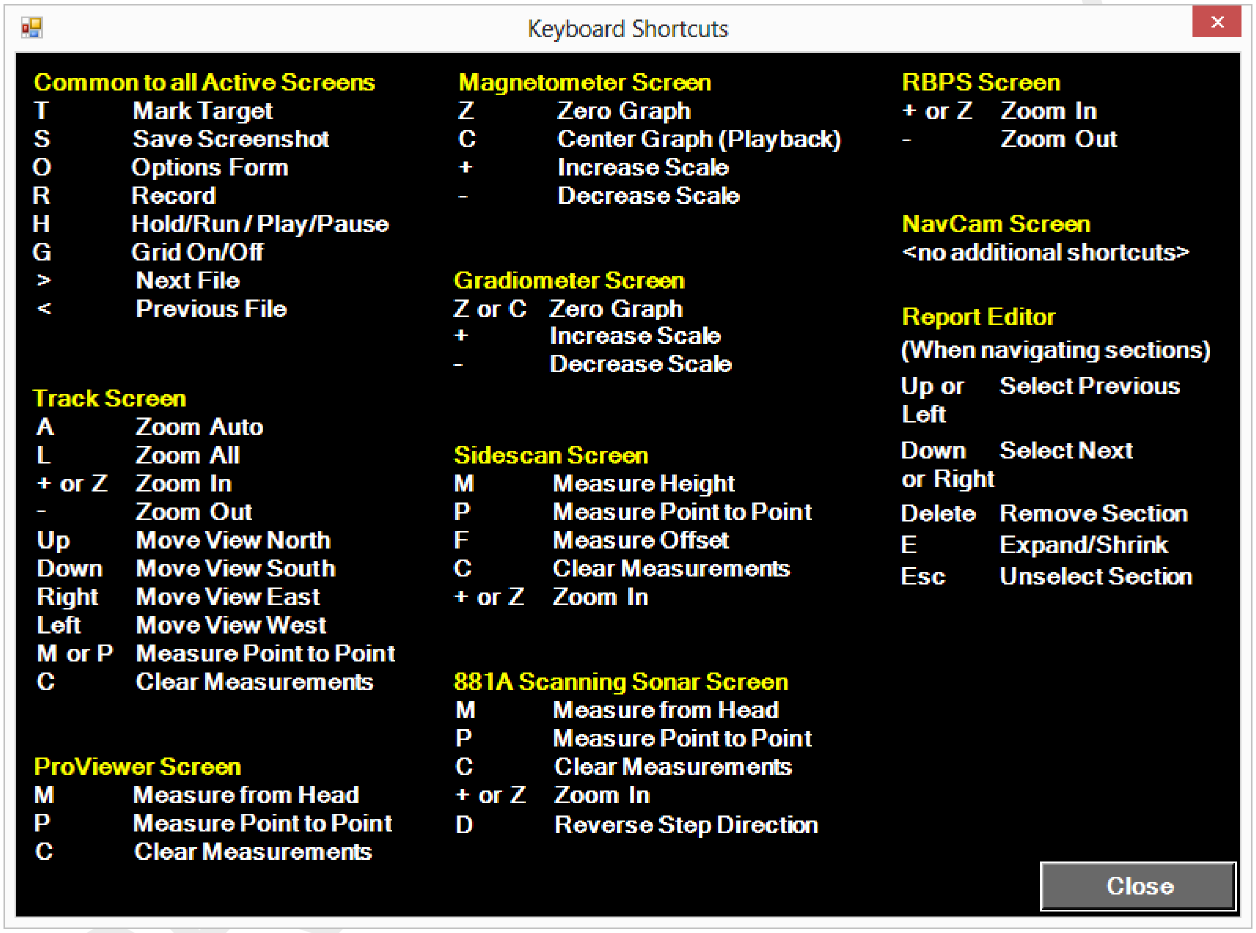
The Received Datastrings box shows status messages sent from the Dive Tablet internal circuitry to DiveLog.

To assist in troubleshooting efforts, the user may be asked to use the Save Fields to Status Log command, shown on the top right of the window. This command saves the current status of the Dive Tablet to the standard status log.

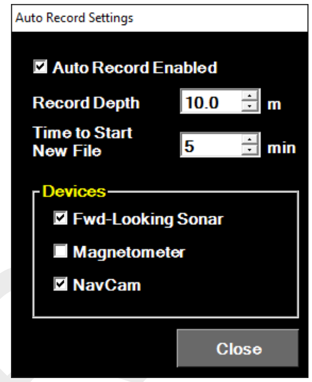
If the status log is required to troubleshoot an issue, the user can export the status log to a location of their choosing, so it can be forwarded to Shark Marine Technologies Inc.

4.14. Keyboard Shortcuts

The keyboard shortcuts are useful for mission planning or analysis and also for survey operations. The list of shortcuts can be viewed in DiveLog by clicking Menu>Help>Keyboard Shortcuts. Some shortcuts are common to all Active Screens. Shortcuts for a particular Active Screen will only work if that Active Screen is in the Primary position.



4.15. Auto Record



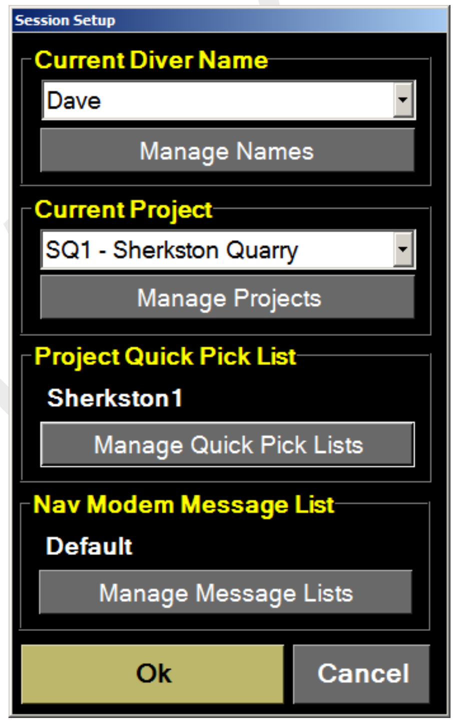
The Auto Record feature turns on running and recording of active screens when the unit descends past a specified depth in the water. Recording will automatically stop when the unit ascends to a point just above the same depth.

To keep files from becoming excessively long, specify the time length for each file; new files will be started at this time interval.

Check the boxes under Devices to select which active screens to record at the specified depth.

5. Setting up the Session

When DiveLog starts each time, the “Setup Session” window will be displayed. This allows the user to specify (or confirm) four important items that will affect how DiveLog is used for the current session.



The first option on the Session Setup window is the diver/operator name. Specifying the name is important because all collected data will be recorded with the diver/operator name in the file name. This allows recorded files to be quickly referenced to the person that performed the dive. The name is selected by choosing an item from the drop-down list. If the current user is unknown, the default account “Diver” or “Boat” can be selected. To add a new name, click the “Manage Names” button and enter a new name (up to eight characters long). See section *5.2 Diver/Operator* Names for more information.

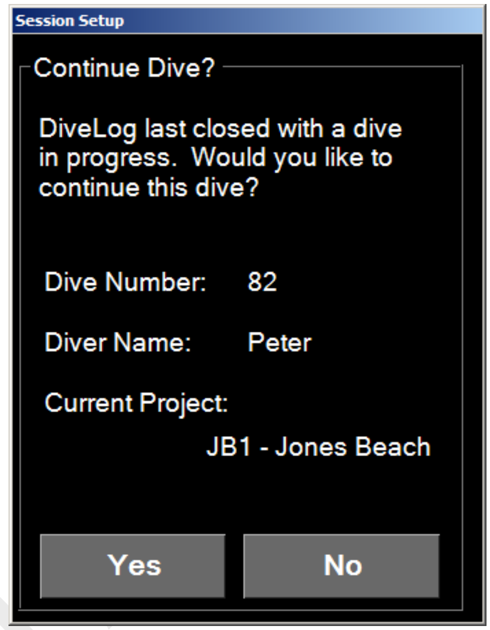
The second item is the current project. The name of the last project will be displayed, and the drop-down list can be used to select a different project. The “Manage Projects” button is provided to open the “Project Setup” window, which allows viewing of project setup information, and provides project related functions. See section *6 DiveLog Projects* for more information. It is important to specify the proper project when the system is used each time since this will determine what data is displayed and accessible, and where all collected data will be stored. To keep data for the current session separate from other data, start a new project with the “Manage Projects” button.

The third item is the current Quick Pick List for the project. This is the multiple-choice style questionnaire that pops up when the operator marks a target; used for entering target details. To change the current or create a new Quick Pick List, click the “Manage Quick Pick Lists” button to open the “Manage Quick Pick Lists” window. See section *12.11 Managing Quick Pick Lists* for details.

The last item is the current Sub-NET Message List for the project. This is a list of pre-set messages to send using the Sub-NET underwater communication system. Click the “Manage Message Lists” button opens the “Manage Sub-NET Message Lists” window.

Click Ok to use the current selections shown in this window, or click Cancel to use the last used settings.

5.1. Continuing a Previous Dive



If DiveLog closes or the computer shuts down when a dive is in progress, DiveLog will suspend the current dive. If DiveLog starts-up again and the system is still at depth, then the prompt to the right will be shown rather than the Session Setup window. This allows the operator to shut down the system (or close DiveLog) and still continue recording data under the same dive number when the DiveLog is running again. When a dive is continued in this fashion, the Diver Log Track will continue with the same file, but other recorded files will need to be started again with a new file name (such as a sonar file).

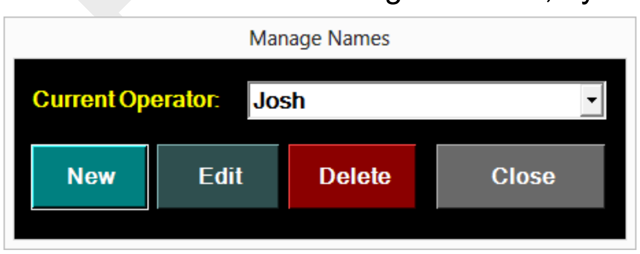
5.2. Diver/Operator Names

The use of diver/operator names allows all recorded data to be easily referenced to the person operating the system at the time that the data was recorded. The diver/operator name will be used in all recorded files, and will be displayed when files are played back. The diver name should be specified when the session is started, but “Diver” may be chosen as a generic name. The name “Boat” may also be used if DiveLog is being used for a surface/boat application, where multiple people may be operating DiveLog. The term “Diver” is used by DiveLog when running on a Navigator, while the term “Operator” is used when DiveLog is running in Survey mode.

See section *6.2.3 File Naming Convention* for more information on how the diver name will appear in filenames.

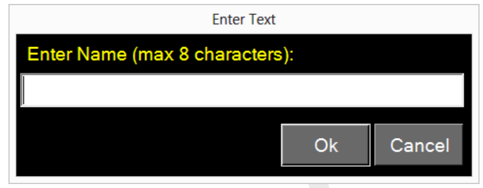
5.2.1. Managing Diver/Operator Names

This window allows adding, editing, and deleting diver/operator names, as well as setting the current diver/operator name. This window can be accessed by clicking on the diver name on the Navigation view, by clicking on Manage Names on the Session Setup window, or by selecting Menu>Setup>Manage Diver/Operator Names.



At the top of the window is a drop-down list of all diver/operators, and the buttons below allow for several different functions.

Click “New” to add a new diver/operator name. A prompt will appear to type in the new name. All names must be eight characters or less.



To change a name, select the name in the drop-down list, and then click “Edit”.

To delete a name, select the name in the drop-down list, and then click “Delete”.

To set the current diver/operator, select the name in the drop-down list and then close the window. After the window is closed, the display on the Navigation Window will then reflect the selected operator name.

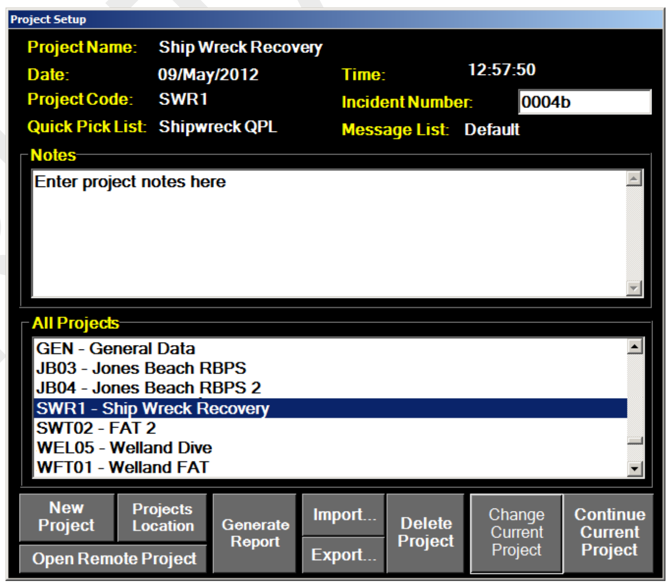
6. DiveLog Projects

All recorded files are saved under the umbrella of a project. In a project, saved files are named automatically in a standardized file and folder structure for organization. Projects are used to keep recorded data separate for different missions. It also provides a means of exporting all data from a mission for later review.

When DiveLog starts, it will automatically load the last project that was used so the operator can continue with it. However, if another project needs to be reviewed or revisited, the Project Name can be selected from the list of past projects on the Project Setup window.

6.1. Project Setup

The Project Setup window can be accessed in by clicking the project code on the main Navigation View, or by selecting Menu>Setup>Project Setup.



Information on the current project is displayed:

- the project name
- the date and time the project was created
- the project code
- the incident number (which may be edited)
- the project Quick Pick List
- user entered notes for the project

Under All Projects on this window, a list of all projects located in the projects folder on the system is shown. Clicking on a different project in the list will display the information listed above for that project, but will not switch to that project.

If no project has been selected or created, the default project will be the GEN - General Data project.

The **Notes** text box is an area that allows the entry of text that can be modified or added to at any time. This text will remain with the project and is a good place to keep general information about the project.

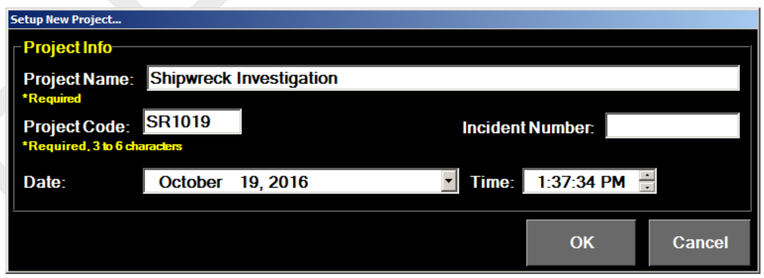
To change the current project, after highlighting a project in the list, click the button **Change Current Project** (or double click the project in the list). When this action is performed, all files/data from the current project will be closed and data from the selected project will be loaded including targets, routes, Track Screen map and track files.

To exit this window and keep using the current project, click **Continue Current Project**.

6.1.1. Creating a New Project

The **New Project** button on the Project Setup window will open the Setup New Project window to allow creation of a new blank project (although data from another project can immediately be imported).

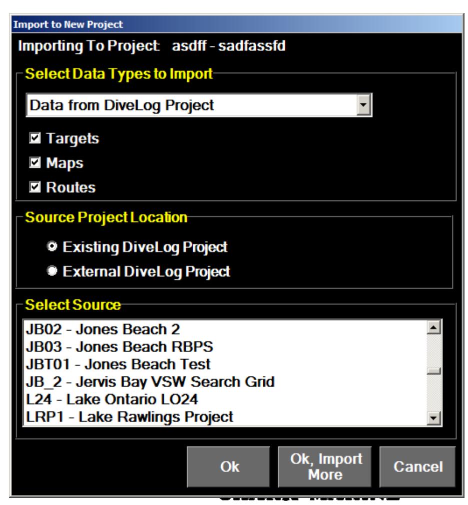
Note: It is highly recommended that a new project be started if activity from a project begins more than 100 kilometres from the previous activity of the same project. This is suggested because the nature of the UTM projection in relation to the curvature of the Earth can cause inaccuracies in positioning over such a span.



There are two requirements to creating a new project: **(1) Project Name** and **(2) Project Code**.

The project name can be any text with the exception of certain reserved characters, since the project name will also be the name of the file folder that contains the project. The new project code must be alpha-numeric and from three to six characters in length.

The date and time fields are the current date and time by default, however they can be changed by clicking on the arrows. There is also an optional incident number field for additional identification purposes.

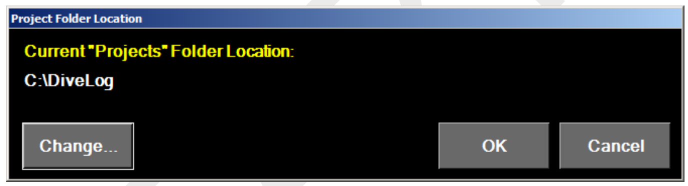


Once the information is entered into these fields, press OK to create the project. Cancel returns to the project setup window without creating a new project.

Once the project is created, the new project will be loaded (set as the current project). The user will then automatically be prompted to import data to the new project with the standard Import Data window (shown right). This window allows importing of data such as maps, targets, and routes from another project or external location. For example, this can be used to copy the maps from another project in the same location. See section ***Error! Reference source not found. Error! Reference source not found.*** for more information. If you do not wish to import data, click cancel on the “Import to New Project” window.

After creating a new project, the **Details** field on the Project Setup window can be used to enter any other information about the project.

6.1.2. Projects Location



The **Projects Location** button on the System Setup window opens a window for viewing and editing the location that the “Projects” directory resides on the Windows file system. The displayed folder path represents the folder that contains a folder called “Projects”, which contains all project folders and project data. Click “Change...” to specify a new location on the file system. If a different projects location has been selected, when the “OK” button is pressed DiveLog will look for a “Projects” folder inside the selected folder and create it if it does not exist. DiveLog will then look for a project called “GEN - General Data” in the new Projects folder and create it if it does not exist (the Projects folder must have a general data project as the default location for saving files if no new project is created). The list of projects on the Project Setup window will then change to show only the projects in the new project folder.

When the projects location changes, a shortcut on the Desktop will be set or updated to point to the new location of the Projects folder.

6.1.3. Open Remote Project

When there is a very large project or archive project that has been exported to a server or external drive, it is useful to still be able to open and add to the remote project, even though it does not exist in the Projects folder. Clicking Open Remote Project will open a browse dialog for selecting the project. The project will be opened and used like any other project, but the data will remain at the remote location rather than in the Projects folder. The name of the remote project will not appear in the All Projects list on the Project Setup window.

6.1.4. Generate Report

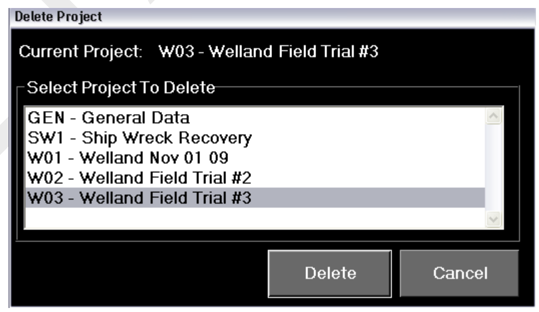
The **Generate Report** opens the *7 Project Report Editor*, which can be used to generate, edit, and export a report summarizing the project and its associated targets as an HTML webpage or printable report. If a project is selected other than the current project, DiveLog will request to change to the selected project before launching the Report Editor.

6.1.5. Importing and Exporting Projects

The **Import…** and **Export…** buttons on the Project Setup window open the Import Data window or the Export Data window, respectively. Any DiveLog project from another computer running DiveLog or a project stored on a memory device (such as USB Drive) can be imported to the current system. Similarly, projects can be exported to any destination on the file system or external drive. A project may be created and set up on a mission planning PC, then be exported to a USB memory device. On the system performing the mission, DiveLog can import the pre-set project to add recorded data. When finished collecting data, the project can be transferred in the same way back to the mission planning PC for post-mission data analysis. See sections *9.2.1 Importing an Entire Project* and *10.2.1 Exporting an Entire Project* for more information.

6.1.6. Deleting a Project

The **Delete Project** button on the Project Setup window opens up the Delete Project Window. This window will then allow a project to be selected. Press the Delete button to delete the project after it has been selected from the list.



Note: You cannot delete the current project (if you want to delete the current project, change projects first). The General Project also cannot be deleted.

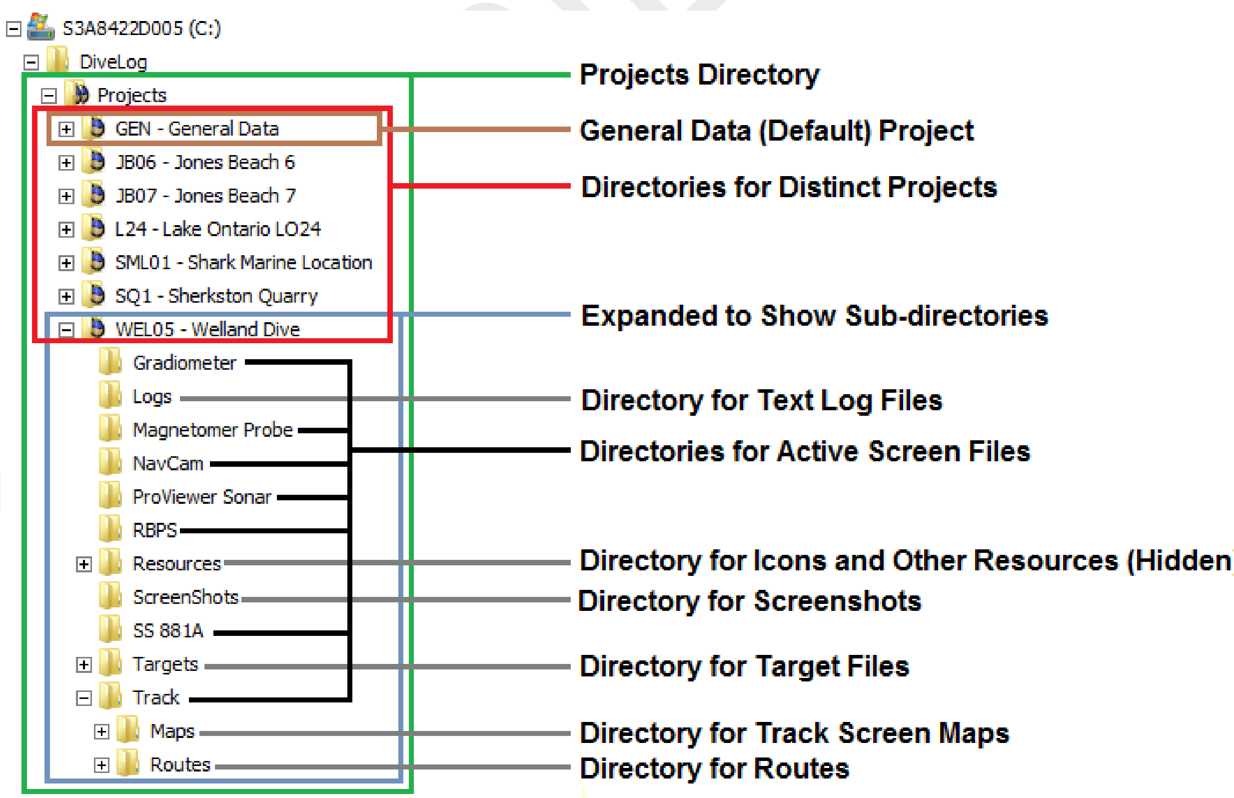
6.2. Project Directory and File Structure

DiveLog will always have a reference to a folder on the system called **Projects**. The projects folder will contain any number of sub folders which are the individual projects. Each project folder contains all of the data associated with a mission, or multiple missions if desired. Any data collected such as targets and recorded files such as sonar files, track files, maps, screenshots, NavCam video/snapshots, et cetera are all saved within the folder for the current project.

A shortcut to the projects directory will be created on the Desktop by DiveLog. This gives a quick way for a user to get copies of files or open files for viewing.
Note: It is **STRONGLY RECOMMENDED** that the contents of the project directory never be altered outside of the DiveLog program itself unless done by someone with a complete understanding of the directory and naming architecture. Changes here could corrupt project data or cause the project to load incorrectly.

To be able to visually identify the main "Projects" folder and individual projects folders, Windows will display a special folder icon to indicate the association with DiveLog.

All projects in DiveLog (regardless of the hardware that DiveLog is running) follow the same directory structure. The following diagram illustrates how a project is organized:



In the diagram above, the green outline illustrates the directory with all DiveLog projects, while the blue outline details the contents of a single project. Each individual project will have multiple folders to organize the data stored within the project. A project contains five main subdirectories (Logs, Resources, Screenshots, Targets, and Track) plus one for each additional Active Screen.

The root directory folder name for a project starts with the project code and is followed by a dash and the project name. Renaming the project folder will prevent DiveLog from opening the project.

6.2.1. The Main Subdirectories in a Project

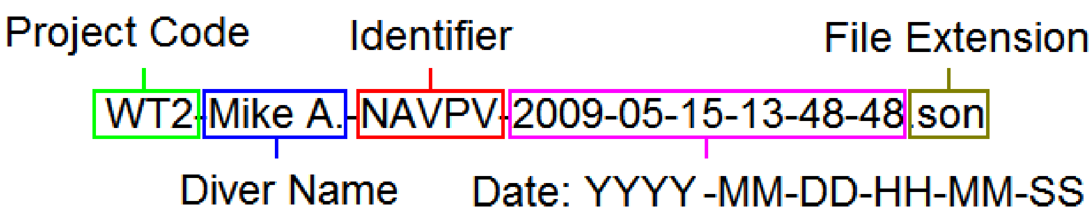
Logs:	Contains text files with daily log data. See section *8 Log Files* for details on the Log files.
Resources:	Contains utility files that DiveLog or Windows uses.
Screenshots:	Any screenshots taken in DiveLog that are not associated with a target will be saved as a ".jpg" file to this directory.
Targets:	All target data relating to the project is stored in this directory. This includes target text files and target associated files such as screenshots. The contents of this folder is described in section *12 Marking and Managing Targets*.
Track:	The Track folder holds all data pertaining to the track screen. This folder contains a configuration file, track files, a Routes folder and a Maps folder. The Maps folder contains any maps that are added to the project, as well as a folder "Deleted Maps" where maps are moved to when deleted in DiveLog. Some types of maps contain multiple files, which are organized within their own folder in the Maps folder. The Routes folder contains text files containing route points and other route data.

6.2.2. The Active Screen Subdirectories in a Project

Additional folders are created in the project directory as needed by an Active Screen. All of the recorded files and other data for an Active Screen will be organized into a folder in the project folder specific for that Active Screen. If there are folders in the project for Active Screens that are not currently active, then those folders and data files will be ignored by DiveLog when a project is loaded.

6.2.3. File Naming Convention

All files in DiveLog follow a standard naming format. All file names in a project begin with the three to five character project code, followed by the diver name, followed by a type identifier (and an additional identifier if is a target screenshot), followed by the date/time and then the file extension.



Project Code: This three to five character user defined string indicates the project that this file belongs to. All files relating to a specific project will have the same project code at the beginning of the file name.

Diver Name: This is the user identifier that is specified on the "Setup Session" window when DiveLog loads. This allows all recorded files to be referenced to the person operating the unit at the time the file was created.

Identifier: There are many possible identifiers to differentiate files. The primary identifiers of DiveLog files are as follows (not an exhaustive list):

NAVPV:	Forward-Looking Sonar recording
NavCam:	Captured image from the NavCam Camera
Screen:	Screenshot image
Track:	Track file
Target-#:	Target File. The # sign in the target will be the number of the target.

Date: The date field corresponds to when the file was created. The date follows the following format: Year-Month-Day-Hour-Minute-Second where the hour is specified in military time (from 0 to 23).

Extension: Files created by DiveLog may have any of the following file extensions (not an exhaustive list):

.son	ProViewer Forward-Looking Sonar file
.trk	Track file
.txt	Information File
.bmp	Bitmap image file (high resolution screenshots)
.jpg	JPEG image file (screenshot, snapshot or thumbnail)
.avi	Windows video file (NavCam recording)
.wmv	Windows media video file (NavCam recording)
.mpeg	MPEG video file (NavCam export)
.mag	Magnetometer file
.grd	Gradiometer file
.xtf	Sidescan sonar file
.872	YellowFin sidescan sonar file
.81A	881A scanning sonar file
.873	DeltaT sonar file
.qpl	DiveLog quick pick list
.nml	Sub-NET message list
.kml	Keyhole Markup language (Google Earth)
.kmz	Keyhold Markup Zipped (Google Earth)

7. Project Report Editor

Although DiveLog allows the best viewing tools for project data, it is useful to package the information in a way anyone can view it. The project Report Editor allows for the creation and customization of a report, summarizing the project, including target information and associated multimedia.

The report is created as an HTML webpage that can be viewed on any computer with a browser, but can also be used as a simple print document. The report displays critical information about the project and its targets, including associated images and videos.

7.1. Opening

The Report Editor can be opened from either the Project Setup window or the Managing Targets window, using the Generate Report button. If you wish to create a report from a project other than the current project, the Project Setup window allows you to change to the selected project before launching the Report Editor. For further details on the Project Setup window and Managing Targets window see sections *6.1 Project Setup* and *12.6 Managing Targets*.

The Report Editor automatically generates a full project report of the project in a user friendly format.

7.2. Views

The report editor has 3 main views that allow you to edit and preview the report.

7.2.1. Report View

The report view shows the full report, as it will be seen when viewed in a web browser.

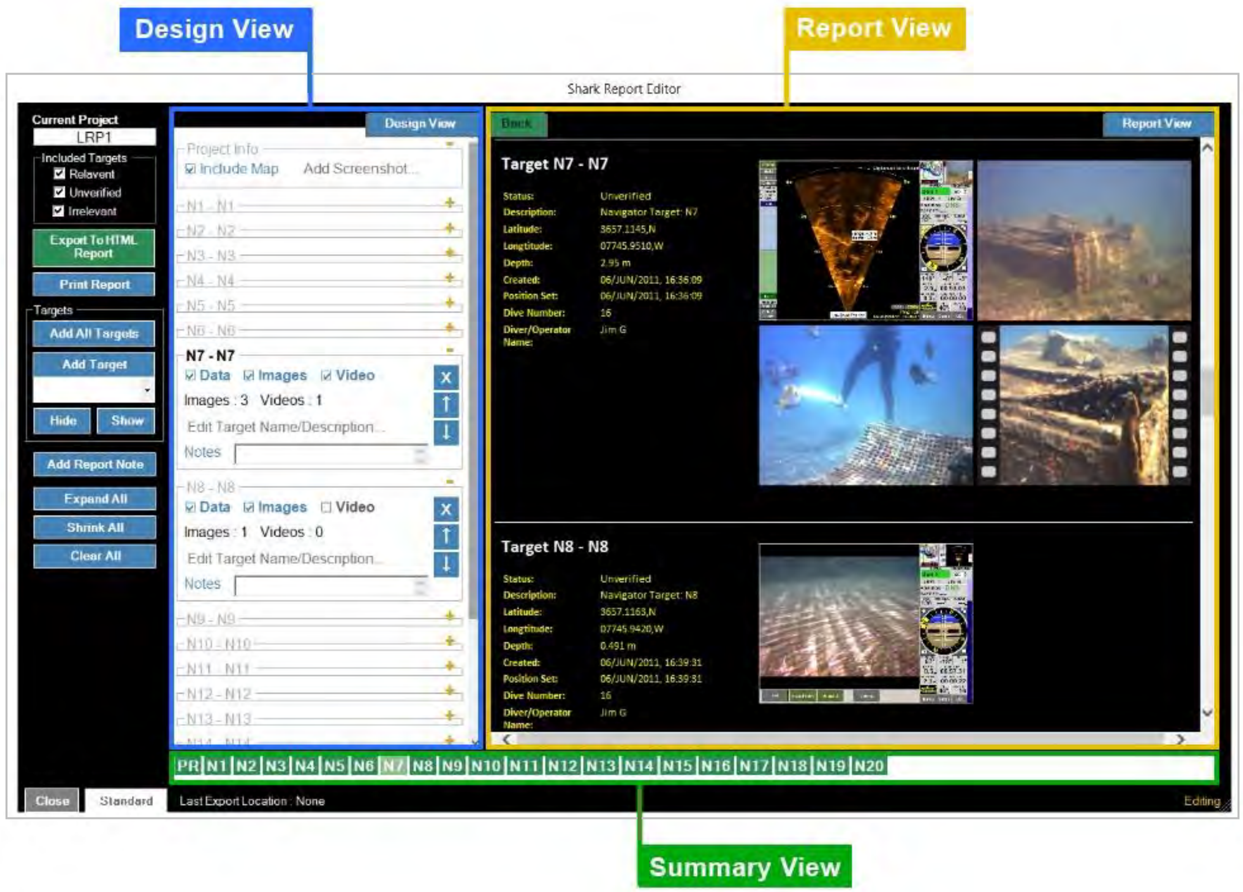
Reports can contain project information, target information and associated images and/or videos. The inclusion or exclusion of any data or multimedia can be configured using the Design View. The report view updates any changes as quickly as possible to reflect any change to the report content.

Clicking on any thumbnail in this view will bring you to either a full size image or launch a video in your default video player, depending on the content. This view can be seen in both Standard and Advanced mode.

7.2.2. Design View

The design view is used to configure each section of the report.

This view displays the current section order, and allows for detailed configuring of each section within the report, using checkboxes to include or remove data. This view also allows the rearranging and even the removal of each section. The currently highlighted section is also indicated by a bold and dark title.



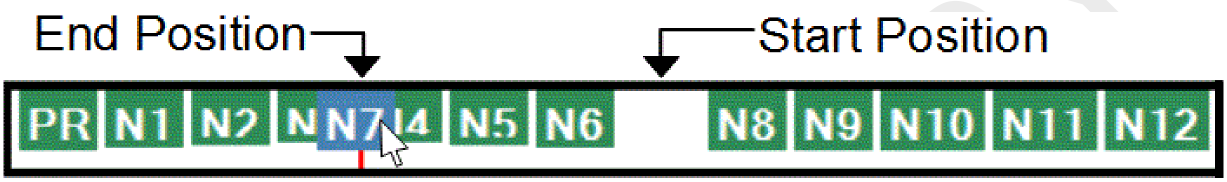
All of these options are only available when a section is maximized, which can be done by clicking the gold +/- in the top right corner of a section, or pressing the E key when a minimized section is highlighted. Both these methods toggle a sections minimized/maximized state. The Expand All or Shrink All buttons maximize or minimize all sections respectively.

This view is only seen in Advanced mode. To toggle between Standard and Advanced mode, click the Standard or Advanced toggle button in the bottom left hand corner.

7.2.3. Summary View

The summary view, located at the bottom of the Report Editor window, is used for quick viewing and high level editing of a report.

Drag and drop positioning is the main function of this view, which allows you to reposition any section by clicking on it and dragging it to the desired location. This view also indicates which section is currently highlighted by showing it with a lighter color. This view can be seen in either Standard or Advanced mode



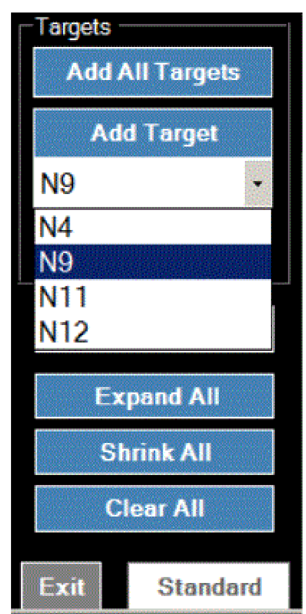
7.3. Managing Sections

7.3.1. Rearranging

Changing the order of section in a report can be accomplished 2 ways.

First, blocks in the Summary View can be dragged and dropped to their desired location, using the red line as a guide. The sections can also be moved one position at a time using the up and down arrow buttons on each section in the Design View.

7.3.2. Adding/Removing



Each type of section is added differently.

- Targets can be added all at once using the Add All Targets button, or added one at a time by using the Add Target button after selecting a target from the drop down menu below it. Targets can also be added and removed by group. Targets from each group can be added or removed by checking or unchecking the checkboxes in the top left corner of the window.

- The project info section is not removable or movable and is added automatically to the report.

- Report notes can be added using the Add Report Note button on the left hand side of the window.

To remove (i.e. delete) a section, use the X button on any section, or press the delete key after highlighting the desired section. To remove all sections, use the Clear All button on the left hand side of the window.

7.3.3. Editing

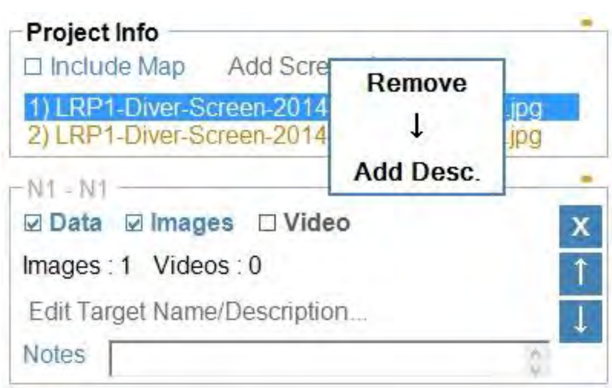
In each section, checking or unchecking each option will either include or remove that information from the report for that section (e.g. unchecking the images box from section N8 will remove images from the N8 target section of the report).

Target sections give the options to include or remove the main info table, images, or video, whereas the Project Info section gives the option to include or remove the project map (an auto-generated map containing all targets included in the report).

To hide or show data, images, or videos from all target sections, you can use the Hide and Show buttons on the left hand side of the window. When either of these buttons are clicked, a drop down menu allows you to select which option you would like to hide or show, as seen in the image to the right.

Notes in either a target section or a report note section, can be edited by clicking on the text region of the section and typing.

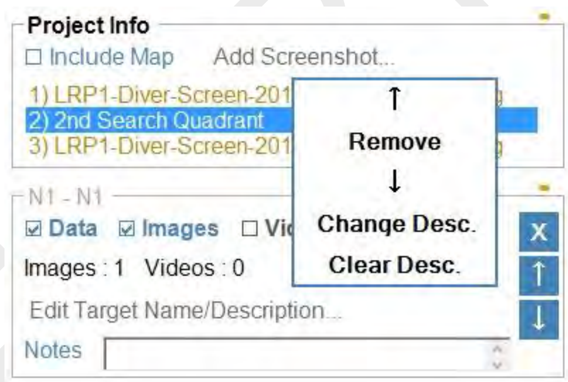
Adding Screenshots



In addition to the auto-generated map, additional screenshots included in the project, but not associated with a target, can be added to the top of the report. In Advanced mode, expand the Project Info section and click the “Add Screenshot…” button. This will bring up the Divelog screenshot selection screen. Selecting a screenshot will add it to the report, under the main map (if visible).Each screenshot may only be added once.

The Project Info section will show a numbered list of each additional screenshot added. Clicking on an item of this list will display a menu of options available for each screenshot. Options include moving the screenshot up or down in the display order, removing the screenshot, or adding, changing, or clearing a description of the screenshot.

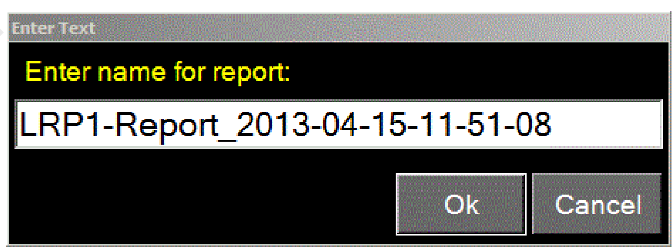
Screenshots are added with no description, and are identified only by their file name in the Project Info section and under the image in the report. When the "Add Desc." option is chosen from the drop down menu, you will be prompted for a description, which will be displayed below the screenshot, along with the filename, in the report. If the "Clear Desc." option is chosen, this description will be removed from the report. The "Change Desc." button option allows the description to be altered after setting it.



7.4. Finishing a Report

7.4.1. Exporting

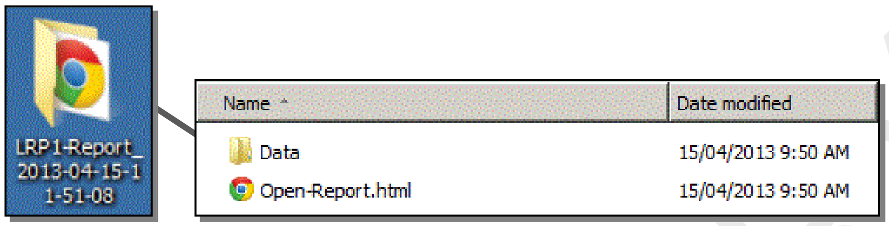
Once a report is finished, it can be exported by clicking the Export to HTML Report button located in the top left corner of the window. The report exports as a folder, whose name and location will be given by the user when requested.



Note: This export is not a saving function, as the report cannot be edited after it is exported. If an update to the report is needed, exporting again to the same name and location will overwrite the previous export. The last export location is displayed at the bottom of the window. The report folder should not be altered in order for it to remain viewable.

7.4.2. Viewing and Sending

To view the report, open the report folder and double click the file named “Open-Report.html”. This file should launch the report in your default web browser.



Transferring the report to another computer can be done it two ways. The easiest is to copy the entire folder to a thumb drive and move it to the other computer manually. Optionally, the report can be changed to a compressed zip file and emailed.

7.4.3. Printing

To print a hard copy of the report, press the Print Report button on the left of the window and following the general print dialogs. The printed report will not include videos or full size images. Be sure to preview the report to ensure that all required data is included before printing.

8. Log Files

DiveLog records data into several different log files. The first is the log file, which is always recording and logs data at five second intervals while DiveLog is running. The second is a track, recorded when an operation is underway. The third is divelog.txt, which contains a summary of each dive made with DiveLog.

8.1. Log File

DiveLog is logging pertinent data every five seconds to a daily log file, stored in the folder "Logs" in the DiveLog directory. DiveLog creates a daily log file automatically for each new day that the system is used. For each log entry, a set of data will appear on a single line with commas separating each value. If any of this information is not available, "---" will be placed in its field. The log file is a standard ASCII text file, which can be viewed with any text editor. A separate file is created for each day. The default name of each text file:

PC- Log- UnitNumber-YYYY-MM-DD.txt.

Where:

PC is the project code,
Log is the file identifier to indicate that it is a log file,
UnitNumber is the number that identifies the unit, such as "D2" or "G2",
YYYY-MM-DD is the date that the log file was created.

The format of each line in the file is a comma-delimited string of values, logged at five second intervals. The data (and format) contained in each line is as follows:

- Diver/Operator Name (current operator name, up to eight characters),
- Date (DD/MMM/YYYY),
- Time (HH:MM:SS),
- Depth (numeric value),
- Depth Units (ft or m),
- Heading (degrees),
- Temperature (value in degrees),
- Temperature Units (C or F),
- Latitude (DDMM.MMMM),
- Latitude Hemisphere (N or S),
- Longitude (DDDMM.MMMM),
- Longitude Hemisphere (E or W),
- Altitude (numeric value),
- Altitude Units (ft or m),
- Pitch (value in degrees),

- o Roll (value in degrees),
- o Doppler Transverse Velocity (value in mm/sec),
- o Doppler Longitudinal Velocity (value in mm/sec),
- o Doppler Normal Velocity (value in mm/sec),
- o Doppler Velocity Valid (Yes or No),
- o Doppler Altitude (value in metres),
- o Doppler Altitude Valid (Yes or No),
- o GPS Source (NONE, GPS, LBL <long baseline>, DNS <Doppler Navigation System>, SURFACE <topside connection>, et cetera)

8.2. Track

The track is essentially a log of each dive or operation. The track file will always be recording when a dive is underway (when the depth is greater than the Dive Start Time). For surface applications, a track can also be recorded by clicking “Record Track” on the Track Screen control panel. The track records information from all main sensors and all information displayed on the Navigation View panel on the main screen of DiveLog. Tracks are stored in the “Track” directory, in the current project. See section *20.7.2 Track* for more information.

8.3. Dive Time, Dive Number, and “divelog.txt”

Each dive is logged to a file called “divelog.txt”, contained in the same location as the configuration data (C:\ProgramData\Shark Marine\DiveLog4). This single text document will contain a record of every dive that DiveLog has recorded; each line in the file representing a separate dive. A line in divelog.txt will contain the following comma delimited values in this format:

- Dive Number (incremental integer value),
- Start Date (MM/DD/YYYY),
- Start Time (HH:MM:SS),
- Dive Duration (MMM:SS),
- Maximum Depth (numeric value with units ft or m),
- Project Code (3 to 5 characters),
- Diver /Operator Name (up to 8 characters)

A dive is started when the depth of the unit exceeds the “Start Dive Depth”. A dive will not be logged if the unit is used on the surface, or at depths less than this set value. See section *14.4 Depth Configuration* for more information on the start dive depth.

When a dive is started, the track automatically starts to record. Also, the dive time display will start to count and the surface interval will reset to zero. The surface interval may or may not be displayed, depending on the selection of the time display; see section *3.7 Timer Options*. The dive time will continue to count as long as the depth stays below this threshold. When returning to a depth of less than this threshold, the dive will be paused. The dive time will cease to count, the surface interval will start to count again, and the track automatically stops recording.

If the unit returns to a depth greater than the threshold within ten minutes while the dive is paused, the dive will then resume. In this case the surface interval will be added to the dive time and the dive time will continue to count, and the track will continue to record to the same file. If the unit stays on the surface for more than ten minutes then the dive is considered over: the dive number will increment, and the track file will be closed (a different track file will be started when the next dive is started). Since the dive is complete, at this point the dive will be logged in the “divelog.txt” file.

Note: When using the DNS as a position source, the dive will not pause immediately when returning to the surface. The track will continue to record for a short while, as it waits for a GPS fix (up to thirty seconds, or longer if the DNS position is still valid). This allows DNS track correction in post processing with a known GPS track end point.

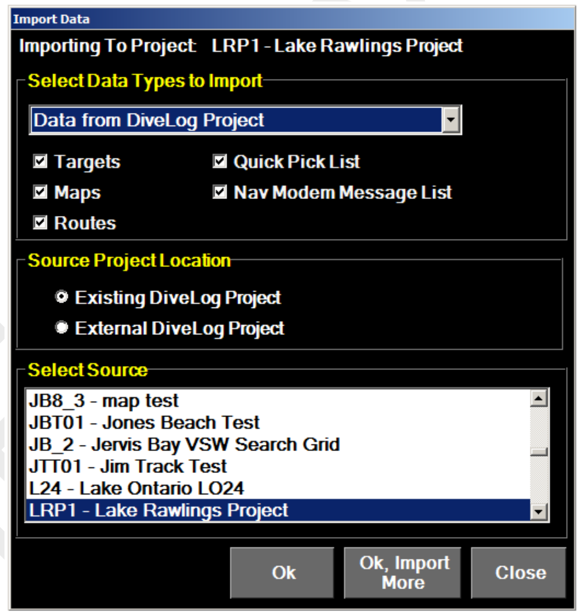
9. Importing Data

9.1. Importing Overview

Importing of data into DiveLog is performed with the “Import Data” window. This window can be reached from the Project Setup window. Data will always be imported to the current project in DiveLog, unless importing an entire project.

There are many different import methods, including:

- Entire Project
- Entire Project – Merge with Current
- Data from DiveLog project
- Data in DiveLog format
- Map from disk
- Comma delimited target file
- Quick Pick List
- Sub-NET Message List
- Data from SeeTrack™ Mission Plan (optional)
- Data from MINTACS™ XML (optional)
- Data from Hypack
- Point Cloud Data
- Targets from COIN



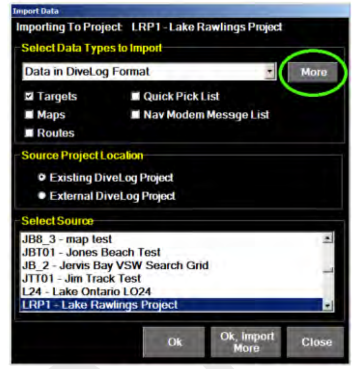
Selecting one of these methods will adjust the window to provide the appropriate options. Depending on the type, there will be checkboxes enabled for importing targets, maps, routes, quick pick lists, and Sub-NET message lists. Select any combination of these data types to import that data using the selected import method.

When importing data from another DiveLog project, the import source project can be selected from a list of all projects. When importing data from a location on the file system other than DiveLog’s projects folder (such as a USB flash drive or a network location), the “Browse…” button will open a dialog to select the file or folder. If there are any removable drives connected to the system, a button will appear allowing selection of one of these drives as a shortcut to select this location.

On the Import Data window, the “Ok” button performs the import based on the settings and import file/folder selected, and then closes the window.

The “Ok, Import More” button will perform the import as with the “Ok” button, but the window will remain open so that additional imports can be performed.

When the Import Data window is opened from a location other than the Project Setup window (such as the Manage Targets window), it will be configured to import only that specific data type and other data types and import methods will be hidden or deselected. Clicking the “More” button in the top right corner will show the options for other types if desired.



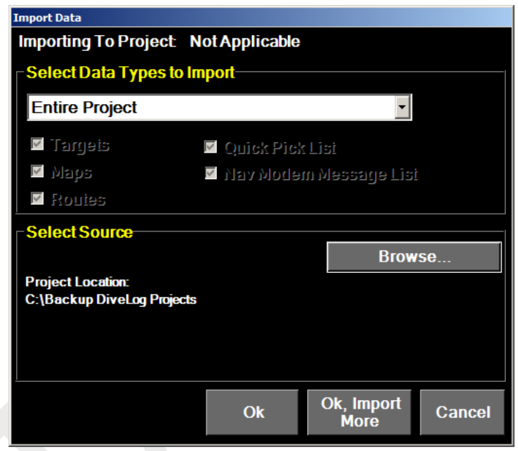
The following table indicates which import methods support which types of data. Details of each data type (columns) and import method (rows) can be found in the next sections.

Type of Data / Import Method	Recorded Files	Targets	Maps	Routes	Quick Pick Lists	Sub-NET Message Lists	Point Cloud Data
Entire Project	✓	✓	✓	✓	✓	✓	
Merge Projects	✓	✓	✓	✓	✓	✓	
Data from Project		✓	✓	✓	✓	✓	
Data in Project Format		✓	✓	✓	✓	✓	
Map from Disk			✓				
Comma-Delimited Target File		✓					
Quick Pick List					✓		
Sub-NET Message List						✓	
SeeTrack™		✓		✓			
MINTACS™		✓		✓			
Hypack™		✓		✓			
COIN™		✓					
Point Cloud Data							✓

9.2. Import Methods

9.2.1. Importing an Entire Project

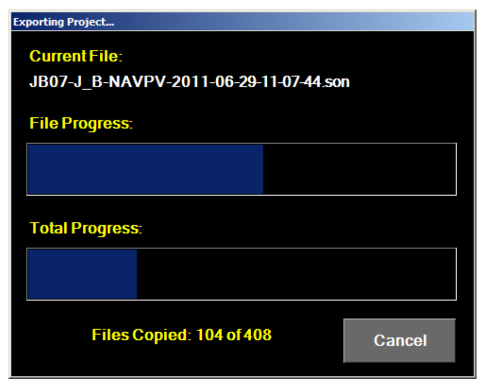
The Import Entire Project feature is used when there is a DiveLog project on the file system somewhere other than the current DiveLog projects location. It may be a project created on another computer that you wish to add as a project in DiveLog to view/edit the data or collecting more data into the project.



Targets, Maps, and Routes data type choices will be disabled since all data in the project will be imported, including these types.

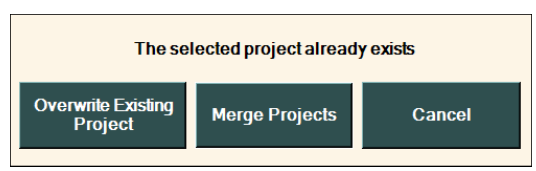
Click the "Browse…" to select the root directory of the project that you wish to import to DiveLog. DiveLog will check the structure of the importing project to make sure that it is a valid DiveLog project. If this check fails, then make sure that the root folder of a DiveLog project was selected. It should have the format "PCODE - Project Name", where PCODE is the project code.

A progress dialog will be displayed to show the progress for each file as well as the whole project. Once the import is complete, the list on the Project Setup window will be updated to include the newly imported project.



If a project with the same code and name already exists in the current Projects directory, then DiveLog will prompt the user with two options:

- Overwrite Existing Project: Completely erases the project with that code and name that exists in the current Projects directory. The external project will then be imported as normal.
- Merge Projects: Combine projects that have been modified or added to separately and the user wishes to bring all data back together into the same project. See section *9.2.3 Project Merging* for details.

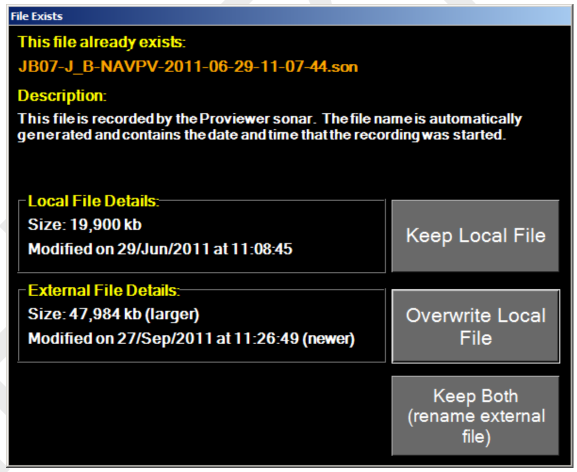


9.2.2. Importing an Entire Project - Merge with Current

This option allows the importing of all data from an existing project into the current project. The source project may be pre-existing in the projects folder, or a project external to the system. This option will perform a "Merge" as the project data is imported. See section *9.2.3 Project Merging* for details.

9.2.3. Project Merging

When importing or exporting an entire project, there is the option to merge (combine) projects. During merging of projects, different actions will occur depending on the type of file in the project.

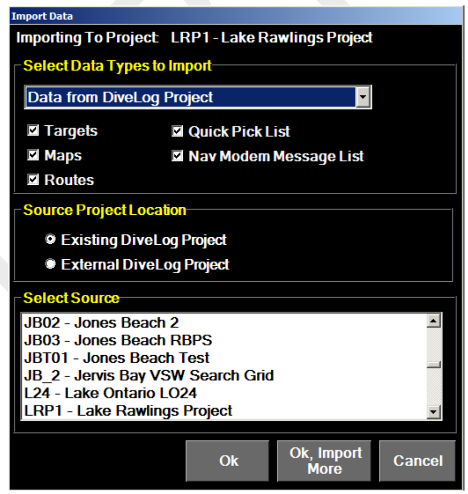


Below is a description of how file types are merged:

- Information Files: The data will be combined. For example, for the project "Details" (text entered on the Project Setup window), new text will be appended the previously existing text. If the project incident number has changed, then the user will be prompted to select the correct one.
- Recorded Files: Any new files that exist in the source project but not the destination project will be added. If a file has the same name and size, then no action will be taken for that file (it is assumed the file is the same in both projects). If a file from the source project has the same name, but a different size, then the user will be prompted to choose which file to keep.
- Log Files: For log files that exist in the source project but not in the destination project, will be copied. If a log file with the same name in the source project has more data than the log in the destination project, then the log file with more data will overwrite the one with less data. The Unit Number will be included in the name, meaning that log files from different units (but the same date) can co-exist in the same log folder and the unit that they were recorded on can be identified.
- Routes: Route files that do not exist at the destination will be copied. If a route does exist and the route is different in each of the two projects, then one of the routes will be renamed, with a number added to the end of the route name.
- Targets: All targets will be run through an intelligent routine that looks for duplicate targets. If duplicate targets are found, then any additional information or files associated with those targets will be added to the existing targets. If there are conflicting target identifiers, then the conflicting targets will be renumbered to

the next available target numbers in the list. If a duplicate target is found during merging that has a different position, then DiveLog will keep the position information from the target that most recently had its position set. If the target description text is different between the two targets, then the new portion of the description will be appended to the other target. Any other conflicts that can't be settled automatically (such as different names between the same target in the two projects), then the user will be prompted to choose which information should be used.

9.2.4. Importing Data from a DiveLog Project

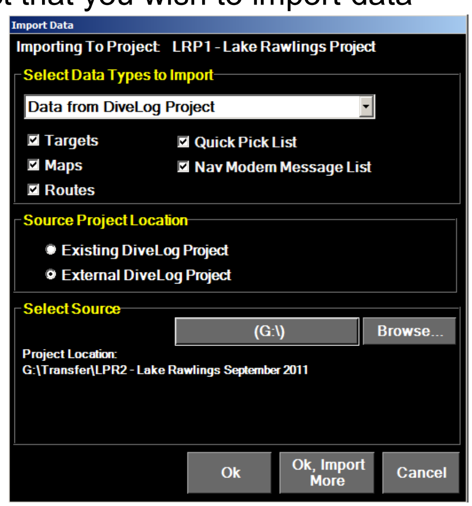


The import "Data from DiveLog Project" feature is used when there is data that exists in another project that you would like to use in the current project. This feature is useful for setting up a fresh project that is in the same location as another project.

Under "Source Project Location" there are two choices. If the desired import location is a project already in DiveLog (in the current "Projects" directory), then select "Existing DiveLog Project". If the desired import location is a DiveLog project elsewhere on the file system, select "External DiveLog Project".

If selected "Existing DiveLog Project", then there will be a list of all DiveLog projects. Select the source project from the list.
If selected "External DiveLog Project", then there will be a Browse button to select the project location (see image, right).

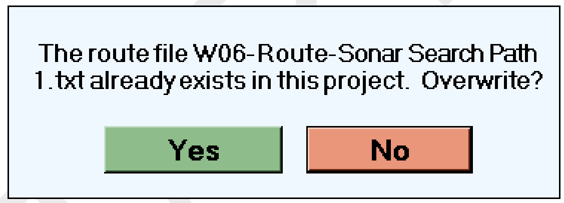
Click "Browse…" to select the root directory of the project that you wish to import data from. The selected folder must have the format standard project directory naming format "PCODE - Project Name". DiveLog will check the structure of the importing project to make sure that it is a valid DiveLog project. If the root directory of the project was not selected then this check will fail.



When importing targets, all targets will be transferred to the project. For each target, associated files such as thumbnails and screenshots will be copied to the project, but linked files such as sonar recordings will not be imported. Targets will be run through an intelligent routine which looks for duplicate targets. If duplicate targets are found, any additional information or files associated with those targets will be added to the existing targets. If there are conflicting target identifiers, then the conflicting incoming targets will be renumbered to the next available target numbers in the list.

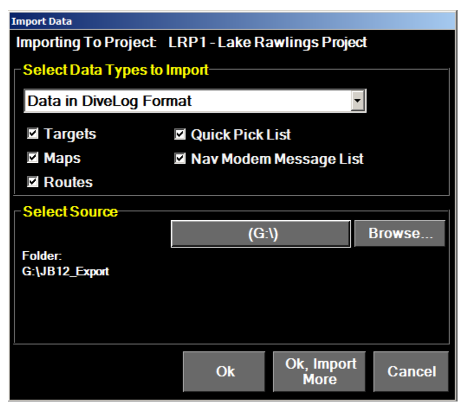
When importing maps from another DiveLog project, all map/chart files will be copied to the new project. If there is already a map or chart with the same name in the project, then the user will be prompted with a choice to overwrite it or keep the current one. If replacing, the old map in the project will be moved into the "Deleted Maps" folder (rather than deleted), and replaced with the new map.

When importing routes from another DiveLog project, "Waypoint Routes", "Target Routes" and "Survey Routes" will retain all formatting and information. The name of the route will be preserved but the file name for the route will be changed to reflect the new project code. If a route with the same name already exists in the project, then the user will be prompted if they would like to overwrite the route in the current project (see image, right). If not, then that route will not be imported.



9.2.5. Importing Data in DiveLog Format

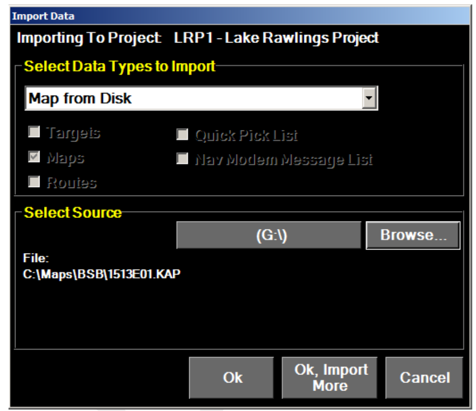
Importing "Data in DiveLog Format" is used when you have previously exported "Data in DiveLog format" for transferring to another system. This would be done to transfer targets, routes, maps, quick pick lists, and/or Sub-NET Message Lists from a project, but without transferring the rest of the data in the project such as recorded files. From the exported data, there will be a folder with the format "PCODE_Export", where PCODE is the project code. Inside that folder there may be folders for "Targets", "Maps", and "Routes", depending on whether these data types were exported.



Under "Select Data Types to Import", choose "Data in DiveLog Format". The targets, routes, and maps choices will be enabled, allowing the selection of any or all of these data types. Click the "Browse…" button to select the folder in the format "PCODE_Export" (or if only importing one of the three data types, you can select the "Targets", "Maps", or "Routes" folder, respectively).

When importing targets, maps, and routes, they will be imported with the same methodology as importing from another DiveLog project. See *9.2.4 Importing Data from a DiveLog Project* for details.

9.2.6. Importing a Map from Disk



The “Map from Disk” import function is for importing a map or chart from a location external to DiveLog. The choices for targets, maps, and routes will be locked to only allow import of maps.

The browse dialog will allow the selection of any of the supported map types (see section *9.2.7 Supported Map Types* for more information). If the chart consists of multiple files, select the main file and the other supporting files will also be copied into the project.

If a map with the same name already exists in the project, then the user will be prompted if they would like to replace the map in the current project. If replacing, the map in the current project will be moved into the “Deleted Maps” folder (rather than deleted), and replaced with the new map. If not replacing, then the map will not be imported.

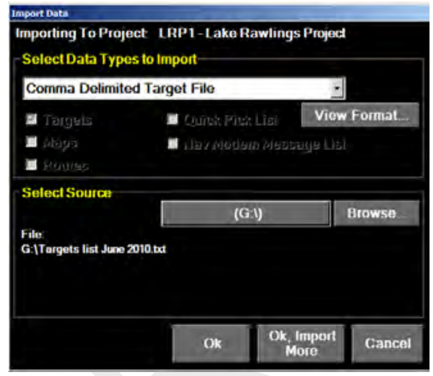
9.2.7. Supported Map Types

Currently supported map types are as follows:

- S57 Electronic Navigation Charts (ENC) with extension .000 (vector chart).
- S63 encrypted charts with extension.000 (vector chart). A permit file is required to use these charts.
- BSB charts with extension .KAP (raster chart).
- Admiralty Raster Chart Service charts with extension .HDR (additional required files and folder structure is all copied when importing).
- ESRI Shapefiles with the extension .shp (with additional supporting files of other extensions). Shapefiles will be drawn as an overlay on top of the base map.
- GeoTiff maps (geo-referenced raster image) with the extension .tif or .tiff, and optional geo-reference file .tfw or .tifw.
- Drawing Exchange Format drawings, with extension .dxf. Note that the drawing must exist at the proper UTM co-ordinates with a metric coordinate system, or Lat/Lon co-ordinates with an imperial coordinate system (inches = degrees). Colour will be displayed, however line widths and text may be altered when imported.
- The Shark Marine Technologies map file type “Shark Map” with extension .smp (used for user-calibrated images).
- KML and KMZ, with extension .kml or .kmz (Google Earth mapping format)

If other map types are required for your application, please contact Shark Marine. For more information on maps in DiveLog, see section *20.5 Managing Maps.*

9.2.8. Importing Comma Delimited Target File



Importing a comma delimited target file is used to import a list of targets from a single text file. This file may have been generated by DiveLog, other software, or manually using a text editor.

Clicking the button "View Format…" will display the expected format of the text file (this information is also in section *9.2.9 Format for Comma-Delimited Target Import/Export File*). Each line of the text file must have a minimum of the first five fields (number and geodetic position).

Supported file types: **.txt**

Note: Only target data from the text file will be imported this way; no associated files such as images will be imported.

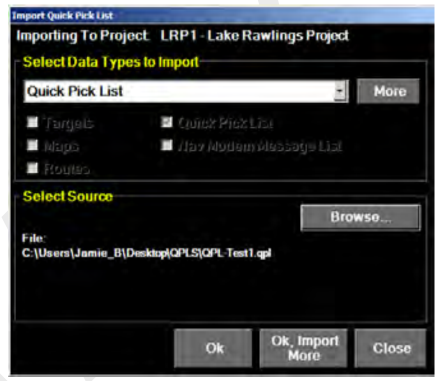
9.2.9. Format for Comma-Delimited Target Import/Export File

The comma-delimited import/export file for targets is a plain text file with one line of text for each target. Unknown fields may be left blank, but blank fields will include the comma if there are subsequent non-blank fields. The format of each line is the following fields separated by commas:

- Target Number (should be ascending integer values),
- Latitude (ddmm.mmmm),
- Latitude hemisphere (N/S),
- Longitude (dddmm.mmmm),
- Longitude hemisphere (E/W),
- Depth (decimal value),
- Depth units (feet/meters),
- Name (up to thirty characters long),
- Target Group,
- Date Set (dd/mmm/yyyy, date when target position/depth was last changed),
- Time Set (hh:mm:ss, time (military format) when target position/depth was last changed),
- Date Created (dd/mmm/yyyy) , date when target was first),
- Time Created (hh:mm:ss, time (military format) when target was first created),
- Dive Number (integer),
- Diver/Operator Name (up to eight characters),
- Unit number (such as "D2" or "G2"),
- Reserved,

- Reserved,
- Reserved,
- Reserved,
- Reserved,
- Reserved,
- Description (text of any length, lines may be separated by semicolon space ("; "))

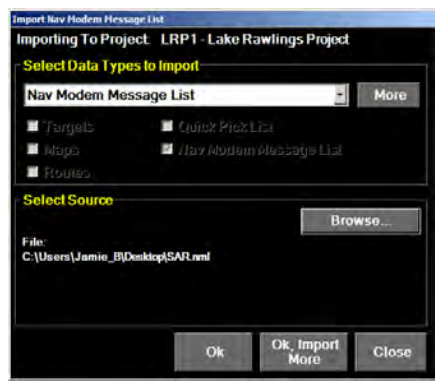
9.2.10. Importing Quick Pick List



The "Quick Pick List" import function is for importing a quick pick list from a location external to DiveLog.

Supported file types: **.qpl, .txt**

9.2.11. Importing a Sub-NET Message List

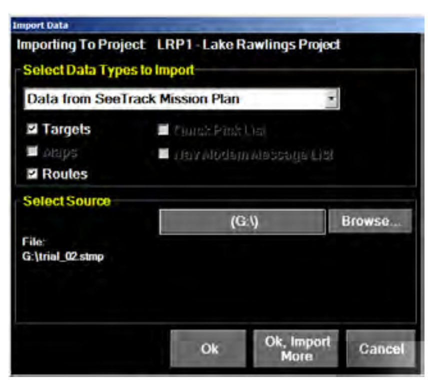


The "Sub-NET Message List" import function is for importing a Sub-NET message list from a location external to DiveLog.

The external Sub-NET message list will be saved as the message list for the active project, overwriting the old list.

Supported file types: **.nml**

9.2.12. Importing Data from a SeeTrack™ Mission Plan



Note: This function is an extra feature that must be enabled in DiveLog

The "Data from SeeTrack Mission Plan" import feature is used to import targets and/or routes from a .STMP file created with SeeTrack™ software.

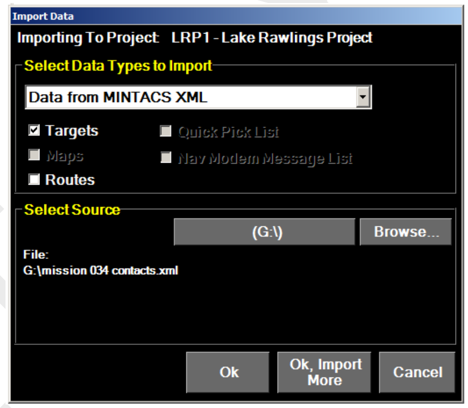
If importing targets, both "Markers" and "Objects" from the mission plan will be imported as targets.

When importing routes from a SeeTrack™ Mission Plan, “Lawnmower”, “Diver Lawnmower”, and a series of “Points” from SeeTrack will be imported as separate “Waypoint Routes” in DiveLog.

Supported file types: **.STMP**

9.2.13. Importing Data from MINTACS™ XML

Note: This function is an extra feature that must be enabled in DiveLog

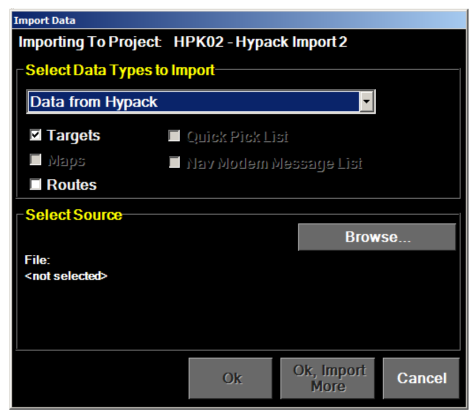


The “Data from MINTACS XML” import feature is used to import targets and/or routes from an .xml file created with MINTACS™ software.

“Contacts” in the xml file will be imported as standard targets in DiveLog. “QRoutes” in the xml file will be saved as “Waypoint Routes” in the DiveLog project.

Supported file types: **.xml**

9.2.14. Importing Data from Hypack



The “Data from Hypack” import feature is used to import targets and/or routes from a Hypack .tgt or .lnw file, respectively.

Since targets and routes (lines in Hypack) are in separate files, only either “Targets” or “Routes” can be selected at once. If you would like to import both types of data, after selecting one file click “Ok, Import More” and then another file can be selected for import.

“Lines” from the .lnw file will be saved as “Waypoint Routes” when importing routes. The imported routes can be viewed in the Manage Routes list. Note: Hypack line/route files are in a UTM format, but do not contain the UTM zone. When imported into DiveLog, they will be imported using the current UTM zone that the DiveLog project is using. If no UTM zone is set in the DiveLog project (i.e., no maps have been added and no previous geodetic locations have been set), then the user will be prompted to specify a zone when importing Hypack line files.

Supported file types: **.tgt, .lnw**

9.2.15. Importing Targets from COIN™ XML

Note: This function is an extra feature that must be enabled in DiveLog

The "Targets from COIN" import feature is used to import targets from an .xml file created with the COIN™ software. With this import source, only targets will be imported.

"Contacts" in the .xml file will be imported as standard targets in DiveLog. Contact name, position, depth, date/time detected, shape, size and additional details will be imported. All images will also be imported and added to the target associated files list.

Supported file types: **.xml**

9.2.16. Importing Point Cloud Data

This option allows for loading an XYZ file (in ASCII format), which may have been previously exported by DiveLog or from another software. Once imported, the "Export Data as XYZ" window will open. This window allows for processing the data to export it in the same format or as a KML file. See section *10.3 Exporting Point Cloud Data* for details.

Supported file types: **.xyz**

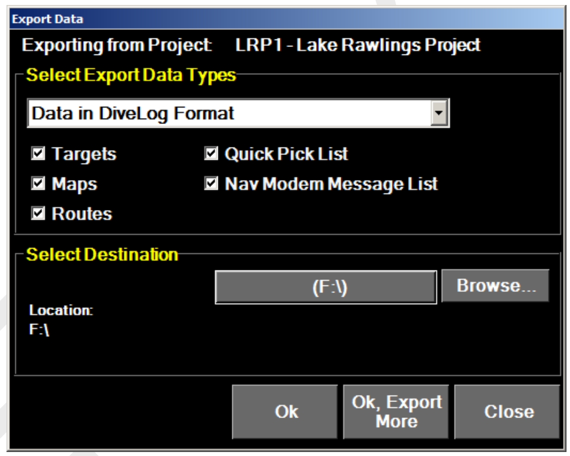
10. Exporting Data

10.1. Exporting Overview

Exporting of data into DiveLog is performed with the “Export Data” window, which can be reached from the Project Setup window. Data will always be exported from the current project in DiveLog, unless exporting an entire project.

There are many different export methods:

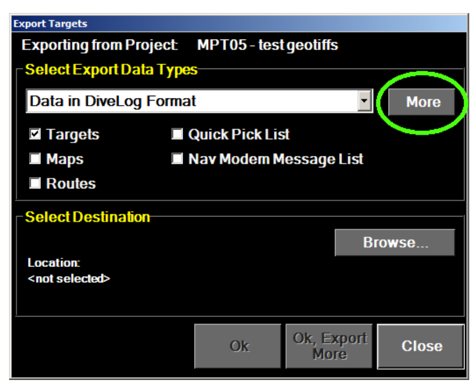
- Entire project
- Data in DiveLog format
- Comma delimited text file
- Hydrographic Data
- Quick Pick List
- Sub-NET Message List
- Data for SeeTrack™
- Data for Hypack™
- Shapefile
- KML (Google Earth)



Selecting one of these methods will reconfigure the window to provide the appropriate options. Depending on the method selected, there may be checkboxes enabled for exporting several data types: targets, maps, routes, quick pick list, and Sub-NET message list. Select any combination of these checkboxes to export these with the selected method.

For all export types, the “Browse…” button will open a dialog to select the location of the export file/folder. If there are one or more removable drives detected, a button or pull-down box will appear allowing selection of one of these drives as a shortcut to select this location.

On the Export Data window, the “Ok” button performs the export based on the settings and export file/folder selected, and then closes the window.



The “Ok, Export More” button will perform the export as with the “Ok” button, but the window will remain open so that additional exports can be performed.

When the Export Data window is opened from a location other than the Project Setup window (such as the Manage Targets window), it will be configured to export only that specific data type and other export types will be hidden or deselected. Clicking the “More” button in the top right corner will show the options for other types if desired.

The following table indicates which export methods support specific types of data. Details of each data type (columns) and import method (rows) can be found in the next sections.

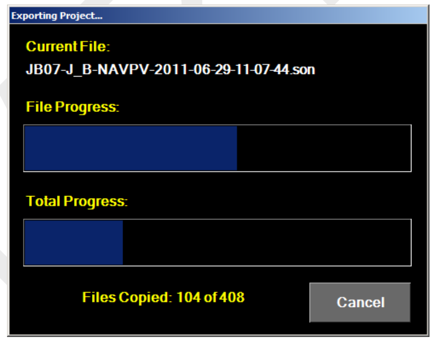
Type of Data / Export Method	Recorded Files	Recorded Tracks	Targets	Routes	Maps	Quick Pick Lists	Sub-NET Message Lists
Entire Project	✓	✓	✓	✓	✓	✓	✓
Data in Project Format			✓	✓	✓	✓	✓
Comma-Delimited Text File			✓	✓			
Hydrographic Data		✓					
Quick Pick List						✓	
Sub-NET Message List							✓
SeeTrack™		✓	✓				
Hypack™			✓	✓			
Shapefile			✓	✓			
KML (Google Earth)		✓	✓	✓			

10.2. Export Methods

10.2.1. Exporting an Entire Project

The Export Entire Project feature is used to copy the entire project to a location external to DiveLog's "Projects" directory. This can be used for transferring it to another system, or backing up the project.

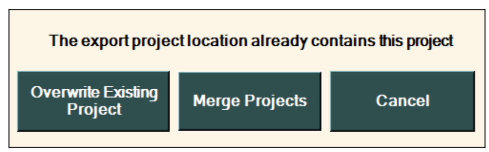
Click the "Browse…" to select the directory that you wish the project folder to be exported to.



Click "Ok" (or "Ok, Export More), and the entire project folder and all contents will then be copied to the export destination directory. A progress dialog will be displayed to show the progress for each file as well as the whole project (see image, right).

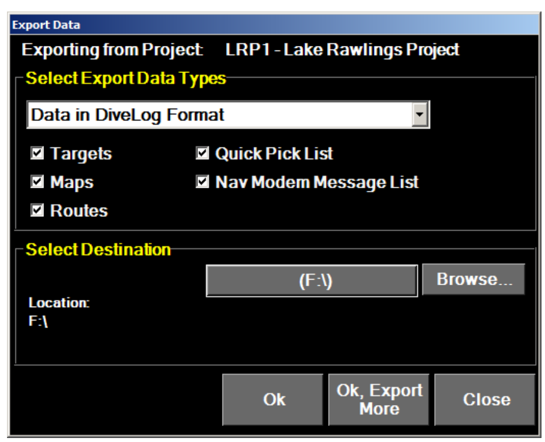
If a project with the same code and name already exists in the export directory, then DiveLog will prompt the user with two options:

- Overwrite Existing Project: This option will completely erase the project that exists at the export location. The project will then be exported as normal.
- Merge Projects: Combines the two projects. See section *9.2.3 Project Merging*.



10.2.2. Exporting Data in DiveLog Format

Exporting in "DiveLog Format" is used to export project data, but not the recorded files. A folder will be created with the format "PCODE_Export", where PCODE is the project code. Inside that folder there will be a "Targets", "Maps", and "Routes" folder depending on whether these data types were selected (check-marked). Although the export folder will use some project formatting it is not considered a project, but it can be imported to a DiveLog project by selecting "Data in DiveLog Format" on the Import Data window.

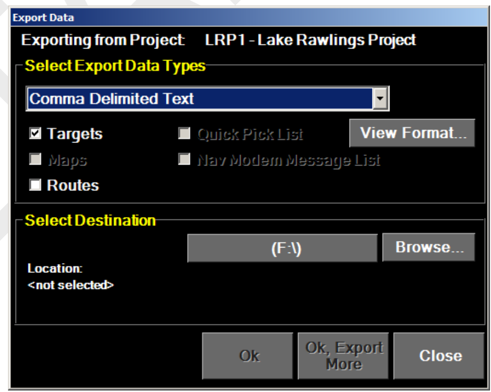


If the targets checkbox is selected, all targets in the current project will be saved to the "Targets" folder at the export location in DiveLog's target file format. Note that files that are linked to the target such as recorded sonar files will not be exported, but files that are not linked such as target thumbnails and screenshots will be exported.

If the maps checkbox is selected, all maps in the current project will be saved to the “Maps” folder at the export location, retaining DiveLog’s project file structure. Since DiveLog’s project file structure retains the native format of the maps and charts, the map files may be imported into other software. Maps that only have a single file will be right in the “Maps” folder, whereas maps with multiple files may be in their own sub-folder.

If the routes checkbox is selected, all routes in the current project will be saved to the “Routes” folder at the export location, retaining DiveLog’s project formatting.

10.2.3. Exporting Data to a Comma Delimited Text File



Exporting to a comma delimited text file is used for data to be analysed or imported by another program. For example, comma delimited text files can be opened by spreadsheet software such as Excel™ to display the data in a table format.

If exporting targets, clicking the button “View Format…” will display the format of the target export file. This information is also in section *9.2.9 Format for Comma-Delimited Target Import/Export File*. When selecting the file location, the file name will be pre-set with the project code, date and time (but it can be changed).

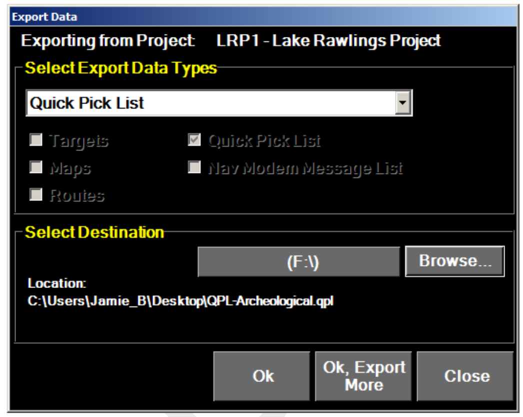
Note: No associated files such as images or sonar file recordings will be exported with this method.

If exporting route data, the routes will each be saved to a separate text file in the same format that DiveLog uses to save routes in the project. The file format will depend on the type of the route:

- The file for a waypoint route will contain a list of geodetic lat/long positions.
- The file for a survey route will contain an optional entry and exit point (in lat/long co-ordinates), and the survey grid will be described by a starting point (in lat/long co-ordinates) and as list of parameters describing the size of the grid.
- The file for a target route will contain an optional entry and exit point (in lat/long co-ordinates), and a list of lat/long co-ordinates for each route point along with a reference to the target including the target name, number, and index.

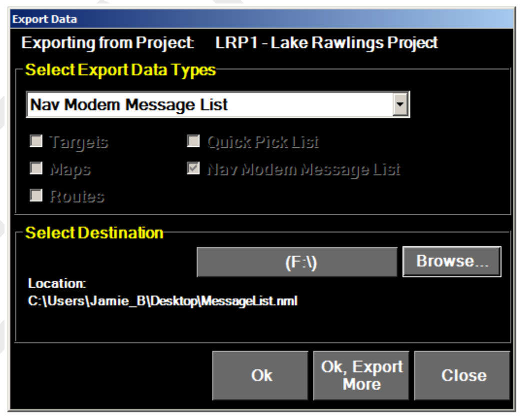
10.2.4. Exporting Quick Pick List

Exporting a quick pick list allows you to share quick pick lists between instances of DiveLog without having to export or merge an entire project. The data is saved in a text format with file extension ".qpl".



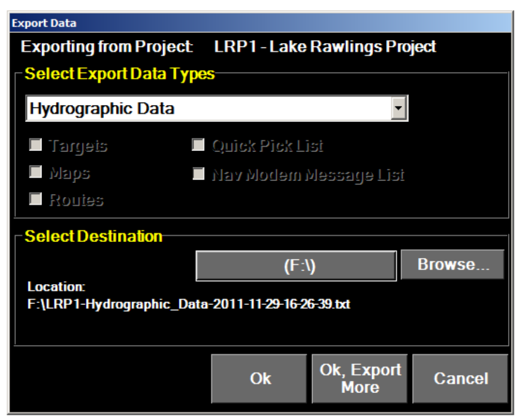
10.2.5. Exporting Sub-NET Message List

Exporting a Sub-NET message list allows you to share Sub-NET message lists between instances of DiveLog without having to export or merge an entire project. The data is saved in a text format with file extension ".nml".



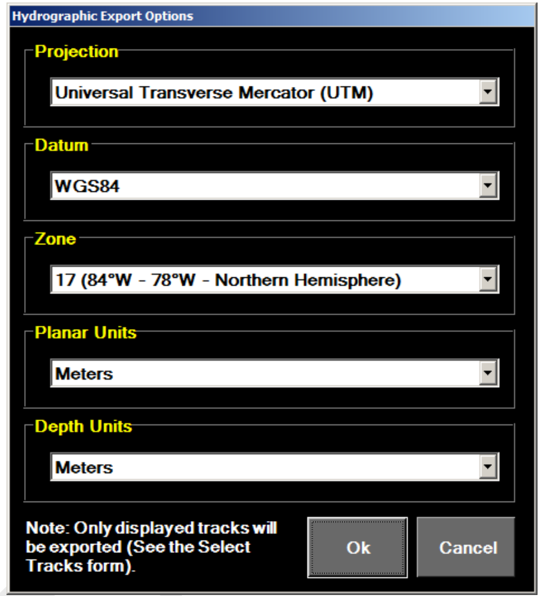
10.2.6. Exporting Hydrographic Data

The Export Hydrographic Data feature is used to create a single file containing depths and positions from the recorded tracks in the DiveLog project. The data is saved in a comma delimited text format and may be opened by other software.



When "Ok", (or "Ok, Export More") is clicked, a dialog will prompt the user to specify the projection and datum used for the exported data. The default projection is UTM, and the default datum is WGS84. If a different projection is selected then the Datum and Zone drop-down lists will be regenerated to show the available datum and zone options for the selected projection.

The Planar Units drop-down list specifies the horizontal units used for the X and Y in the export file. The Depth Units drop-down list specifies the units used for the depth values in the export file.
Click Ok to perform the data export. Hydrographic data will then be extracted from all track files and saved in the selected text file.



The saved file will have a header listing the following:

- The title “Navigator Hydrographic Data Export”
- The project code and project name that the data was exported from
- The name of the projection
- The name of the datum
- The name of the zone (only applicable for some projections)
- The planar units
- The depth units
- A note about how the total depth is calculated: since this feature is meant to be used with data recorded by the Navigator, the value for total depth will have the distance between the altitude sensor and the depth sensor taken into account.

Below the header is the hydrographic data, with each line representing one data point. Data points will generally be recorded once per second. The format of each line of data is as follows:

- Date (mm/dd/yyyy),
- Time (hh:mm:ss),
- Latitude (decimal degrees),
- Longitude (decimal degrees),
- X (or Easting) (using planar units specified in the header),
- Y (or Northing) (using planar units specified in the header),
- Depth from surface (using depth units specified in the header),
- Altitude (using depth units specified in the header),
- Total depth (using depth units specified in the header),
- GPS altitude above mean sea level (using depth units specified in the header)

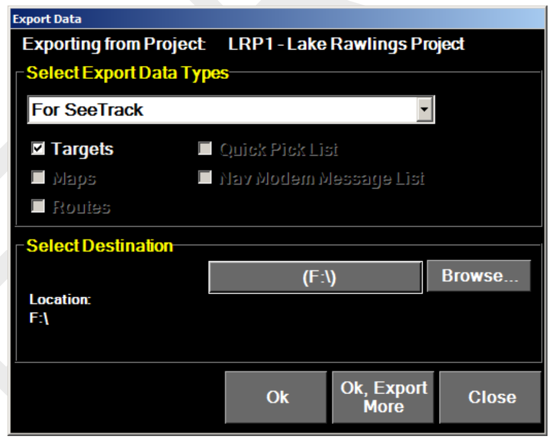
Example line of data:
06/06/2011,15:40:57,36.95190533,-77.765668255,253740.063,4093111.581, 1.91, 0.60, 2.72, 93.85

Note: Only tracks currently set to be displayed in DiveLog will be exported in the Hydrographic Data Export file. To set which tracks will be exported, when the Track Screen is the Primary Screen in DiveLog, click the “Select” button at the bottom to open the Select Tracks window. If ALL is selected (beside “Track”) then all tracks will be exported. If SELECTED is selected (beside “Track”) then the tracks with a checkmark beside them will be exported. Only tracks of type “Track” may be exported (as opposed to tracks that correspond to recorded files such as sonar files).

10.2.7. Exporting Data for SeeTrack™

Note: This function is an extra feature that must be enabled in DiveLog.

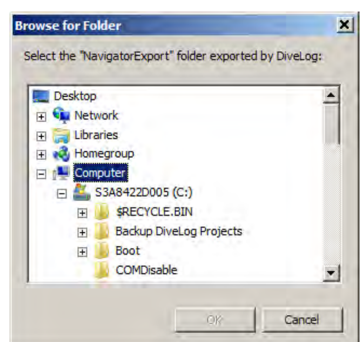
The Export Data for SeeTrack™ feature is used to send targets and tracks to the SeeTrack mission planning software. The exported data will be a folder of files that can be imported by SeeTrack. The Navigator plug-in for SeeTrack must be installed for SeeTrack to import the data exported from DiveLog.



Under “Select Export Data Types”, choose “For SeeTrack”. With this export type only targets and track data can be exported, so maps and routes selections will be disabled.

DiveLog will create a folder in the chosen location with the required files. The folder name will have the format “NavigatorExport-YYYY-MM-DD-HH-MM-SS”. This entire folder and contents will need to be moved to the computer that is running SeeTrack.

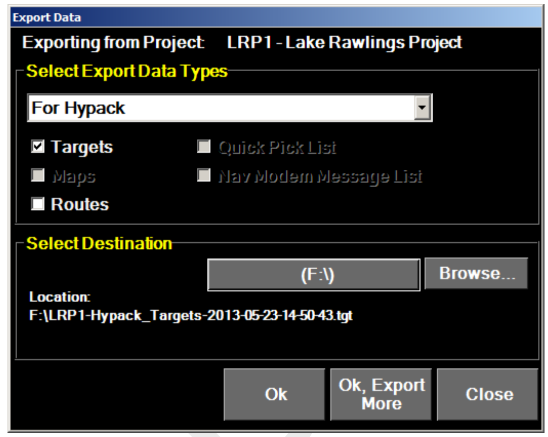
SeeTrack must have the “Navigator” plug-in installed. Execute the Navigator import in SeeTrack, and when prompted to “Browse for Folder” (see image, right), select the folder with the name “NavigatorExport-YYYY-MM-DD-HH-MM-SS” that has been exported by DiveLog.



10.2.8. Exporting Data for Hypack

The “For Hypack” export feature is used to transfer targets and/or routes to Hypack by creating a .tgt or .lnw file (respectively) that can be imported in Hypack.

Since targets and routes (lines in Hypack) are in separate files, only “Targets” or “Routes” can be selected at once. All targets in the project or all routes in the project will be saved to the export file.

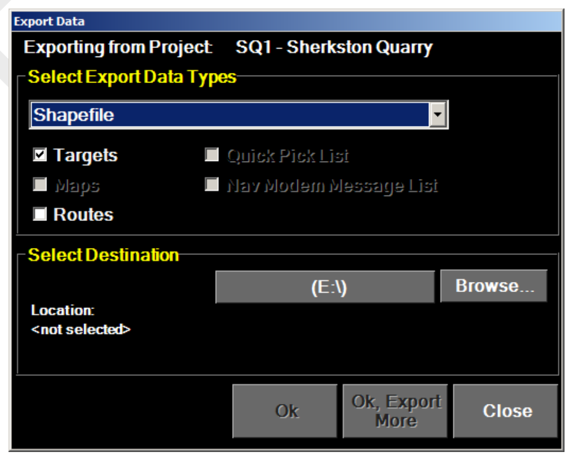


Note 1: **Target associated files will not be exported since Hypack does not support additional files with the .tgt file format.**

Note 2: **Hypack route/line (.lnw) files are in a UTM format, but do not contain the UTM zone. When importing into Hypack, be sure that Hypack is set to use the proper UTM zone.**

10.2.9. Exporting Shapefiles

The Shapefile export feature is used to transfer targets and/or routes to other software by creating a shapefile, which is a group of files with the same name but different extension (extensions .dbf, .prj, .shp, .shx). Since targets and routes are created as separate shapefiles, targets and routes must be exported separately.

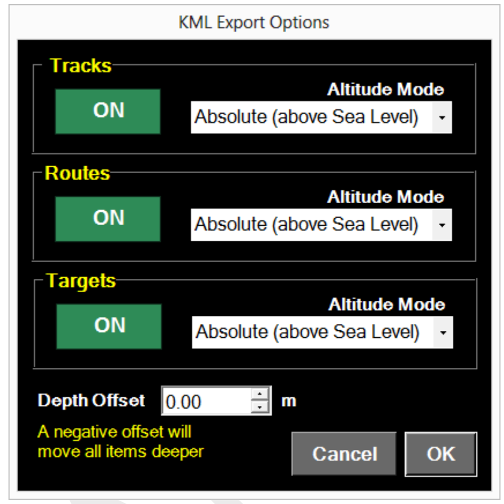


All targets in the project will be saved in one shapefile.

If there are multiple routes in the project, each route will be saved as a separate shapefile with the name of the route used as the filename for the shapefile. Clicking “Browse…” with “Routes” selected will open up a browser to the select folder path. Shapefiles of all routes will be exported to the selected folder.

Note: **Target associated files will not be exported along with the shapefile; only the positions and names of targets will be exported.**

10.2.10. *Exporting KML Files*



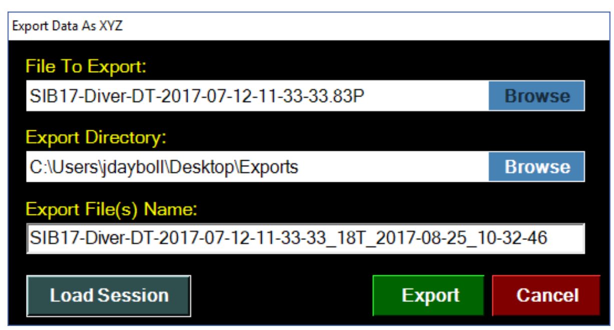
The KML export feature allows you to view DiveLog tracks, routes, and targets in Google Earth. For tracks and routes, only those set as visible on the track screen will be exported to the KML file.

The KML Export Options window gives the option to include or exclude tracks, routes, and/or targets. It also allows you to change the altitude mode of each feature, which alters how the depth/altitude of each feature will be interpreted in Google Earth.

10.3. Exporting Point Cloud Data

Note: Exporting Point Cloud Data is not done from the Export Data window; it is reached from the options window for the Active Screen that you wish to export point cloud data from. This is currently available for the Delta T, Scanning Sonar, Magnetometer, and Track active screens.

Devices such as scanning sonars, multi-beams sonars, and altimeters are capable of collecting data to produce three-dimensional representations of submerged surfaces and/or objects. These scans produce a large number of 3D points, which when viewed as a whole, are an accurate copy of the scanned region. These data sets are referred to as **point clouds**. These clouds are often more useful once processed and transformed into a more easily interpreted format, such as a KML or DXF file.



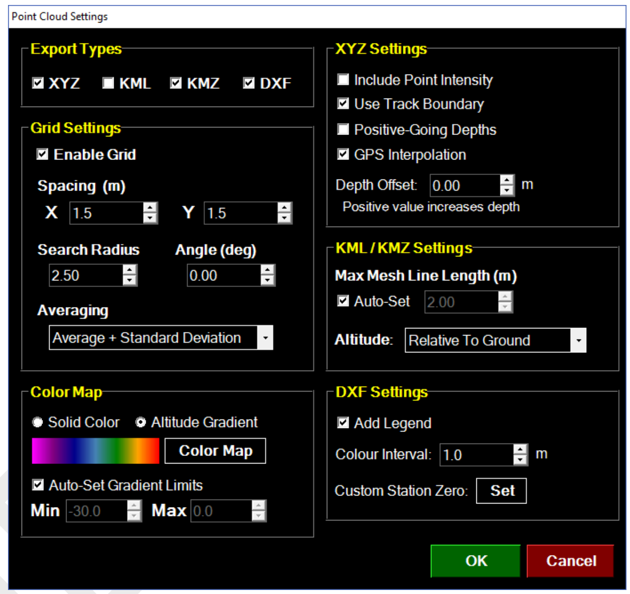
On any supported active screen options window, select Export to XYZ to start the export process. The user can select a directory to export to and the name for any exported files (each file will have a different extension). Once all fields are filled, click Export to continue to the Point Cloud Settings window.

A previous export session may also be loaded from this window. Export sessions contain all the settings and processed data of a previous export, and can be loaded to avoid having to reprocess data, saving time and effort. A change to the colour map, depth offset, or export type may only require a small fraction of the full export time, so export session saving is recommended for longer term projects.

10.3.1. Point Cloud Settings Window

Export Types

To generate the correct processing step, the desired export types need to be chosen. The output formats are:



XYZ: Simple list of 3D points, with option of additional intensity information.

KML: Coloured mesh surface, displayable in Google Earth.

KMZ: Same as KML, but compressed.

DXF: Vector graphics format, which displays as a grid of colored depth markers.

The choice of export types configures the settings shown in this window. These settings can also be changed during a pause in the export, or after the export.

XYZ Settings

These settings alter the raw data point positioning and apply to all export types.

Include Point Intensity:	Include the point intensities if we are exporting an XYZ file, if intensities are available in the source data.
Use Track Boundary:	Include points that fall inside of the Track Search Boundary (see section 20.4.5 Search Boundary).
Positive-Going Depths:	Export depth values as positive (increasing downward), instead of negative (decreasing downward).
GPS Interpolation:	If the data collection rate is faster than the position update rate, data points may fall on the same position. If supported for the data source, this will calculate intermediate positions between these points to improve data position accuracy.
Depth Offset:	Shift the depth of each value by the amount selected. A positive offset will *increase* the depth of each data point.

Grid Settings

The Grid settings determine how the data will be cleaned and smoothed, which is useful for fixing noisy data sets, removing bad points, and/or reducing cloud size. Gridding works by reducing the number of points to create a grid of evenly spaced points at the given Spacing setting over the data coverage area.

Enable Grid: Sets whether or not point gridding should be performed (required for KML, KMZ, and DXF export types).

Spacing: The distance between grid points.

Search Radius: Data points within this distance from each grid point will be considered in that grid point depth average.

Angle: The angle (with 0° as north) of the grid.

Averaging: The method used to calculate the final grid point depth, using the points within the Search Radius.

To increase the smoothness of a cloud, increase the Search Radius and decrease the Spacing. However, decreasing the spacing too much might cause holes to form in the cloud, due to lack of data within certain grid locations. Using the Averaging + Standard Deviation mode is the only averaging mode that completely removes outlying points from the final depth, thus providing the cleanest output.

Color Map

These settings control how KML, KMZ, and DXF files will colour each data point, based on it’s depth value.

Solid Color: Select this to choose a solid colour for all points, regardless of depth.

Altitude Gradient: Select this to choose a color map, that will apply to each point based on it’s depth.

Auto Set Gradient Limits: Sets the range of depths the colour gradient will span. Depths below and above this region will be pinned to the min and max colors. Selecting auto set (recommended) will set the range to the full range of data, otherwise, the range can be set manually.

KML / KMZ Settings

These settings apply to the KML or KMZ export types:

Max Mesh Line Length: Determines how long each mesh triangle edge may be, with larger values allowing larger gaps to be filled. Setting this value too high may cause sharp peaks in the final export data. It is recommended to use the Auto Set.

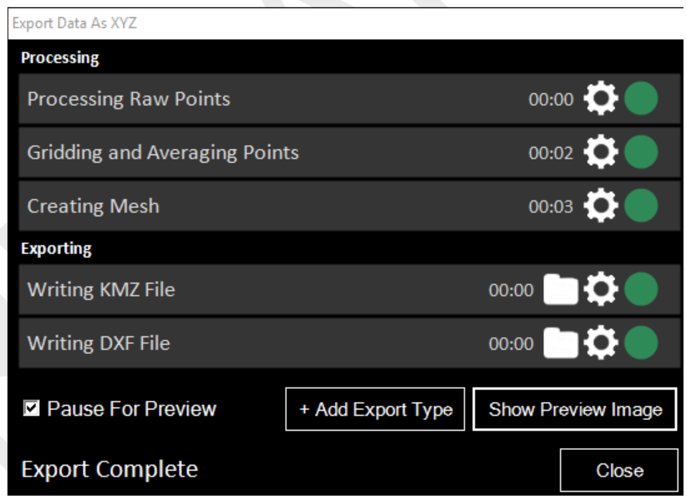
Altitude: The KML altitude mode, which alters how the depth/altitude of each point will be interpreted in Google Earth.

DXF Settings

These settings apply to the DXF export type:

Add Legend:	Select to add a color map legend to the DXF file.
Color Interval:	Determines the step size between depth colors. To allow contrast between depth regions, we recommended this be set to provide a reasonable amount of depth grid steps.
Custom Station Zero:	Set this field to override the default station zero (minimum X and Y position of the data set).

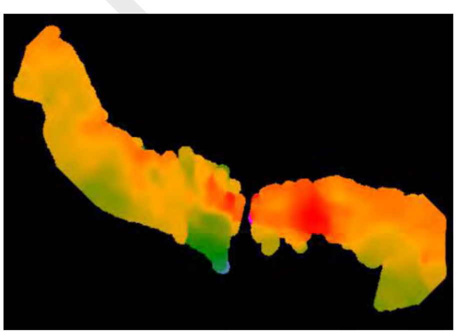
10.3.2. Export Process



Once the settings are chosen, the export window will show each step of the process, in order. The first section contains Processing Steps, which transform the raw data into cleaned and prepared points, grids, and meshes. The second section contains the Export Steps, which perform the output file writing. Each section will run automatically, with some steps pausing before or after running.

If the export is not running, either do to a pause, or the export finishing, any of the above Point Cloud Settings can be changed by clicking the gear beside the step associated with the desired setting. Once a setting is changed, any steps that setting influences will show a reprocess icon. Click the icon to reprocess these steps.

In this paused state, export types can also be added or removed. To add a type, click the Add Export Type button and select a type from the drop-down, and to remove a type, click the “X” icon on the desired type.

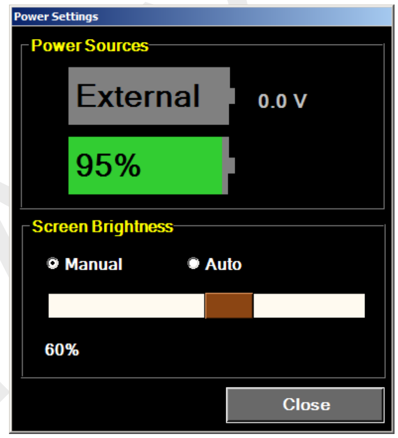


Once the gridding step has completed (if required), a preview image is created to allow the user to confirm the XYZ, grid, and color map settings are correct before continuing the export. Since steps like Meshing may take a long time with a large data set or a tight grid, it’s important to check the preview, and do any settings adjustments, before starting these steps.

11. Screen and Power Settings

On the Navigator Delta and the Dive Tablet, DiveLog will set the screen brightness as well as display the battery status. On the Navigator Delta, there is also an option for setting the mode for multiple screens. This window is opened by clicking on the battery on the Navigation View, or through the main menu.

11.1. Power Sources (Dive Tablet)

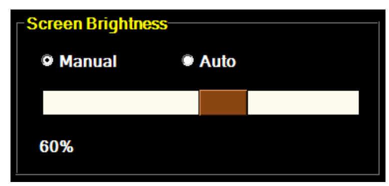


This section of the window displays the status of each of the two possible power sources for the Dive Tablet.

The external battery will indicate the voltage, and the relative charge level of the battery. If the battery indicator is fully gray, then the external battery is not plugged in, or is fully depleted, and has been switched off.

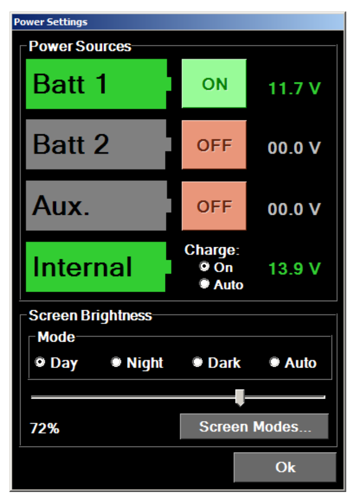
The internal battery indicates the percent charge remaining, and will also indicate if it is currently charging.

11.2. Screen Brightness (Dive Tablet)



The screen brightness may be set to either manual control or automatic control. Under manual control, use the slider bar to change the setting to the desired brightness. Under automatic control, DiveLog will use the ambient light sensor on the tablet to determine a good screen brightness value. For information on configuring the automatic screen brightness, see section *13.5 Internal Sensors (Dive Tablet Only)*.

11.3. Power Sources (Navigator Delta)



This window can be reached by clicking the battery image on the navigation display, or through the main menu. This window shows the status of the Navigator power sources, allows changing of the current power source, enables charging of the internal battery, and also allows changing of the brightness settings.

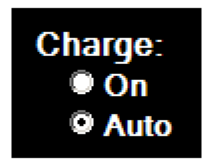
Four different battery icons are shown here, representing the four possible power sources for the Navigator. “Batt 1” is the source connected to the main battery lanyard on the

Navigator. "Batt 2" is an optional second source (a second battery lanyard is required). "Aux." is the power source connected to the "UPLINK" port on the Navigator (i.e. a Topside connection may provide power to the Navigator). "Internal" is the internal backup battery built into the Navigator Delta.

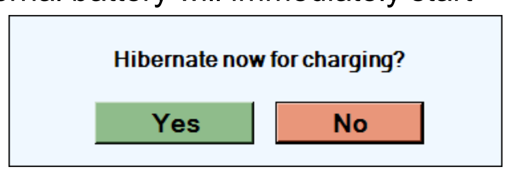
Beside each of the external sources (Batt 1, Batt 2, and Aux) is a button labelled ON or OFF. The "on" or "off" setting sets/displays which battery is currently selected as the primary power source. If multiple external sources are connected, clicking a battery that is currently off will switch the primary source to that power source, and the label will change to "ON". If only using one power source, then switching will be done automatically.

Note: when multiple power sources are connected, the Auxiliary (UPLINK) source will be the preferred source and will be used first. Also note that a small amount of power will always be drawn from the sources that are considered "off".

To the right of each battery image, the current voltage of that power source is displayed.

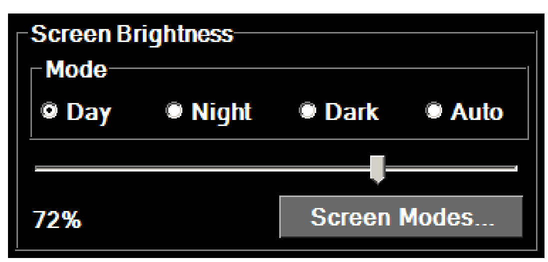


Beside the internal battery image are charging options. The default on the Navigator (reset each time the Navigator is started) will be "Auto". In this mode, the internal battery will start to charge in a slow charge mode if the Navigator is running, and the internal battery voltage drops too low. When the internal battery is being charged, red "Charging" text will be displayed on the internal battery graphic.



Clicking "On" will give the user a choice to keep running, or turn off for a deep charge cycle. If "No" is selected on the dialog, then the internal battery will immediately start charging in slow charge mode regardless of the internal battery level (and the Navigator will keep running). If "Yes" is selected on the dialog, then the Navigator will immediately hibernate and go into a fast (deep) charging mode. As more current will be drawn from the power source in this mode, the Navigator should be connected to a charger with external battery connected (The charger is then used to charge both the internal and external batteries).

11.4. Screen Brightness (Navigator Delta)



The Power Settings window also contains options for setting the screen brightness and screen brightness mode.

There are four possible modes for the Screen Brightness:

Day: Allows a brightness setting from 30% to 100%. Used for Day-time viewing.

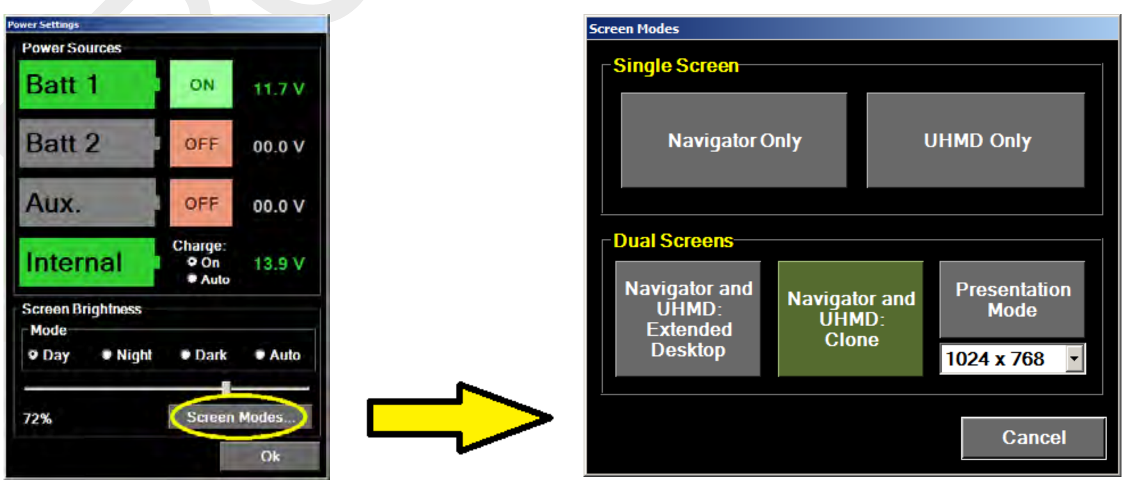
Night: Allows a brightness setting from 1% to 29%. The night mode brightness percent will be saved so that the brightness will go down to a pre-defined level for night-time viewing. If the percent is below a certain value, the user will be asked to confirm the setting.

Dark: Turns off the main screen backlight and status LEDs. This mode can be used if an Underwater Head-mounted Display (UHMD) is connected and the user wants to emit as little light as possible for dark operations (the only light source will then be the backlight of the UHMD). The user will be asked to confirm this setting since the main screen will no longer be visible. When the system starts up in this mode, a count-down dialog will be displayed, and the screen will turn on after 30 seconds unless the dialog is confirmed. When Dark Mode is turned on, the screen mode will be changed to UHMD Only mode, unless the screen setting is already in a dual screen mode. See section *11.5 Screen Modes (Navigator Delta)*.

Auto: Uses the built-in light sensor to determine a good brightness level that maximizes both visibility and power savings.

11.5. Screen Modes (Navigator Delta)

The “Screen Modes...” button on the Power Settings window brings up the Screen Modes window. This allows changing of the Windows Screen settings between the different monitor modes. This is primarily used for turning on and off the screen for the Underwater Head-Mounted Display (UHMD).



The Screen Modes window allows selecting between one of five screen modes. The current screen mode will be highlighted green. If no button is highlighted in green, then this is an indication the screen settings are different than one of these normal five modes. The choices are as follows:

Navigator Only: Sets the Navigator's built-in display as the only active monitor and sets the proper resolution (1024 by 768 pixels).

UHMD Only: Disables the main display on the Navigator, and turns on the UHMD, making the UHMD the primary monitor (i.e, the UHMD will show the Windows Start Bar as the bottom). The resolution of the UHMD will be 800 by 600 pixels. Note that the main display may still show Windows start-up and log-off screens. To keep the main display from showing any image, turn down the brightness or turn on Dark Mode. See section *11.4 Screen Brightness (Navigator Delta)*.

Navigator and UHMD Extended Desktop:
Sets the screen settings to use Navigator's built-in display as the main display, and the UHMD as an extended desktop (secondary) display. The image on the UHMD will be an extension of the Windows Desktop, directly to the right of the Windows Desktop on the main display. Different DiveLog screens may be shown on each display (it may be useful to detach an Active Screen and drag it over to the other screen, see section *3.2 Detaching Screens*). The resolution of the main display will be 1024 by 768 pixels, and the resolution of the UHMD will be 800 by 600 pixels.

Navigator and UHMD Clone:
Sets the screen settings to use both the Navigator's built-in display and the UHMD simultaneously, but duplicate the same image on both screens. In clone mode, the resolution of the displayed image must be the same on each monitor, so both screens will display an image of 800 by 600 pixels (Note: the 800 by 600 pixel image will stretch to fill the main display of the Navigator Delta, which has a native resolution of 1024 by 768). If desired, after turning on the clone setting, the Dark mode can be used to extinguish the other light sources (the main screen backlight and LEDs), see section *11.4 Screen Brightness (Navigator Delta)*.

Presentation Mode: Similar to “Navigator and UHMD” mode, this mode sets the built-in display as the primary screen, and the UHMD output as the extended desktop (secondary) display. This option differs from the Navigator and UHMD Extended Desktop setting by allowing the user to specify the resolution of the UHMD output from a variety of different resolution choices. This allows for using a secondary monitor (connected to the UHMD port) with a greater resolution. Note that the UHMD will only work if the resolution is set to 800 by 600, so if using the UHMD select one of the UHMD modes.

12. Marking and Managing Targets

12.1. Targets Overview

The purpose of a target is to record a geodetic location of interest, along with associated data, images, and references (links) to recorded files. The location of targets will be drawn on images for Active Screens, such as the Track Screen image and the Forward-Looking Sonar image. All targets marked in a DiveLog project are common across all Active Screens. For example, a target marked on the Track Screen will show up on the Forward-Looking Sonar screen. The first target set in a project will be given the identifier “N1”, any additional targets marked will be given an incremental number. Targets can be edited at any time and additional details or associated files can be added at any time.

12.2. Target Files and Directories

Each time a target is created, a text file for the target data and a directory for the target’s associated files are created. These will be created in the “Targets” directory for the project.

The target text file name will contain the project code, the operator name, the target number, and the date and time that the target position was set. This text file stores information about the target as well as the notes added by the user.

The name for the associated files directory will contain the same information as the target text file (operator name, target number, date and time). Associated files such as screenshots are saved in the associated files directory for each target (although most associated files are linked, and stored in the folder for their Active Screen).

The text file for each target follows the following format:

- Target Number: <N#> or <S#>
- Name: <text>
- Latitude: <ddmm.mmmm N/S>
- Longitude: <dddmm.mmmm E/W>
- Position Valid: <Yes/No>
- Depth: <# ft/m or Invalid>
- Date Created: <DD/MMM/YYYY>
- Time Created: <HH:MM:SS>
- Date Position Last Set: <DD/MMM/YYYY>
- Time Position Last Set: <HH:MM:SS>
- Relevant: <Unverified/Yes/No>
- Dive Number: <#>

- Diver/Operator Name: <text>
- Unit Number: <D#/G#/S#>
- Target Type: <integer value>
- Thumbnail: <filename>
- Number of Files: <#>
- Associated Files: <filenames>
- Description: <description text >

Description of the fields:

- Target Number: The target number (integer) and source (N for Navigator, S for survey system),
- Name: The user-defined target name, up to 30 characters,
- Latitude: The latitude of the target in the format ddmm.mmmm N/S,
- Longitude: The longitude of the target in the format dddmm.mmmm E/W,
- Position Valid: Indicates if the target has a valid position,
- Depth: The depth of the target (depth may not be available depending on how the target was set)
- Date Created: The date when the target was initially created, in the format DD/MMM/YYYY,
- Time Created: The time that the target was initially created, in the format HH:MM:SS,
- Date Position Last Set: The date when the target position/depth was set, in the format DD/MMM/YYYY,
- Time Position Last Set: The time that the target position/depth was set, in the format HH:MM:SS,
- Relevant: The relevance of the target set by the user (displayed in DiveLog as the target group),
- Dive Number: The dive number when the target was set,
- Diver/Operator Name: The diver/operator name when the target was set,
- Unit Number: The D, G, or S number, indicating a Navigator Delta, Navigator Gamma, or survey system, respectively. This identifies the unit on which the target position/depth was last set.
- Type: Reserved for future use.
- Number of Files: The number of associated files saved for this target. If there are one or more files saved, then the file names will be on the following lines.
- Associated Files: List of associated files either in the associated files directory or in a directory for an Active Screen. There may be multiple fields separated by the vertical bar |, denoting the filename, relative path within the project, exists in the associated files directory or not, the active screen to open the file, number of times the target is linked within the file, and date and time for the link in the file.
- Description: Any following lines are for the text description of the target, entered by the user. Answers for the Quick Pick List questions will appear in the description text.

Do not change the name of any target text files or target directories. If manually editing the data in these text files, take care to follow the formatting as outlined above, and DiveLog should not be running at the time to avoid the chance that DiveLog could overwrite the changes.

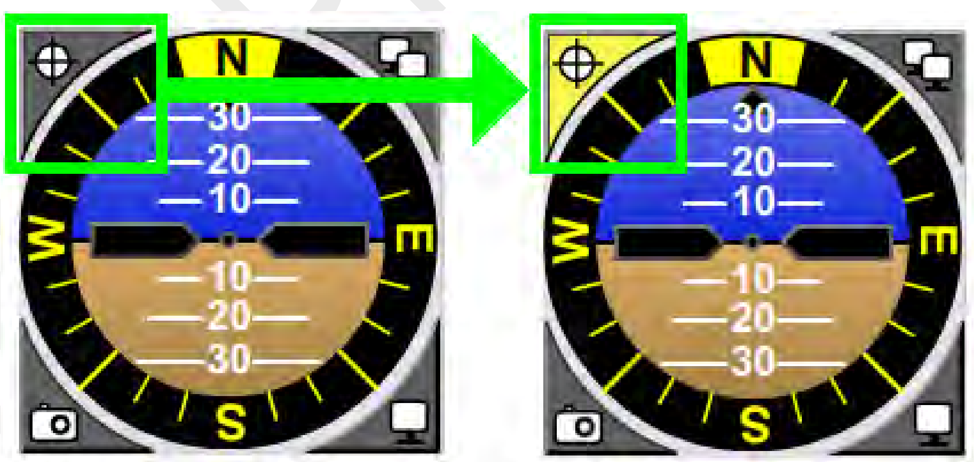
12.2.1. Target Associated Files Directory

Each target can have multiple files associated with it. These files are all put in the associated files directory for that target, as described in section *12.2 Target Files and Directories*. Normally a screenshot is saved with each target, and placed in the associated files directory. Other files associated with the target (or containing additional target data) can be manually placed in the associated files directory for easy reference and organization. Target associated files are opened through the Target Associated Files list (refer to section *12.6.3 Target Associated Files*).

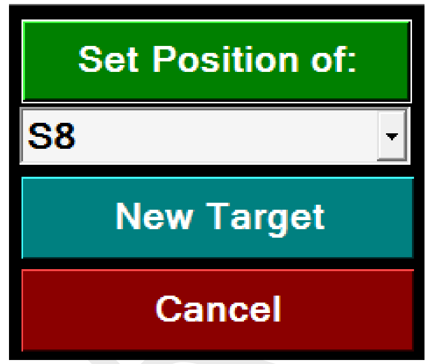
When a target is deleted, any associated files in the associated files directory will be moved into the “Deleted Associated Files” directory in the Targets directory for the project. Any files and directories in the “Deleted Associated Files” can be manually deleted if desired by the operator to free up disk space.

12.3. Marking a Target

Marking targets in DiveLog is done the same way regardless of which screen is the Primary Screen. The targets are also marked the same way in real time or in playback mode.



To mark a target, click the target button. The button will turn yellow indicating you have activated target marking mode. When in target marking mode, the cursor will become a high contrast black and white crosshair on the primary image. After clicking the Target button to activate target mode, just click on the object of interest on the primary image (i.e. the Forward-Looking Sonar screen image or Track Screen image) to mark the object as a target.

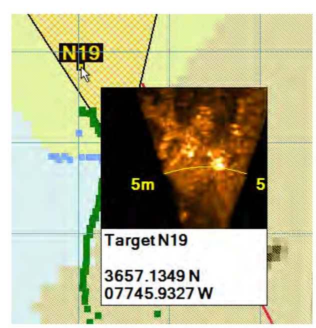


If the active screen image does not have a valid position at the time that the target is selected, then the target data will be saved, but no position will be given to the target.

If there is an existing target close to the position of the newly marked target (within 15 metres / 50 feet), a dialog will come up as shown to the right. This dialog allows updating the position of an existing target rather than marking a new target. Click "New Target" on the dialog to just create a new Target at the selected position. Click "Set Position of:" to update the position of the target displayed in the box (the closest nearby target). The drop-down box can be used to update the position of a different target in the Project.

Depending on the Active Screen, there may also be the option to set a target at the current position. When Target Marking mode is entered, a button "Use Current Position" may appear at the bottom of the Active Screen (see image, right). Clicking this button will set a target at the current realtime or playback position (depending on whether the data source of the Active Screen is set to realtime or playback).

If DiveLog is running on a Navigator, a new target will be given an identifier in the window "N#", where # is an integer that is 1 higher from the highest target number. If DiveLog is running on a survey system (PC), then the new target will be given an identifier in the form "S#". "N" targets and "S" targets behave identically, and the "N" and "S" serve to indicate on what type of system the target was created. For example, a mission planning computer can export "S" targets to a Navigator and the Navigator can then add additional information to the "S" targets just as if they were "N" targets.



Each time a target is marked (or a target position is changed), two images will be saved into the associated files directory for the target:

- A thumbnail image for the target, which will be a small region of the screen image around the target location. The target overlay will not appear in the thumbnail so that the underlying image is not obscured. This image will appear on the cursor tooltip for the target (see image, right). If a thumbnail was previously set for the target, then a new thumbnail will be saved, but the older thumbnail will remain as the currently used thumbnail.

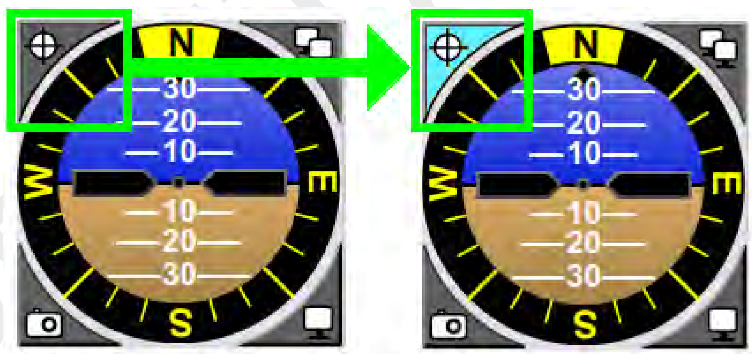
- A full screenshot will be saved with the target. This serves as a record of all data on the screen at the time the target was set. The indicator/overlay for the new target will appear in the screenshot. If an extended desktop setting is used for two monitors, the screenshot will contain both screens.

If a Quick Pick List is currently active when a target position is set, then the operator will be presented with a series of questions to specify target details. See section *12.10 Using a Quick Pick* List for more information.

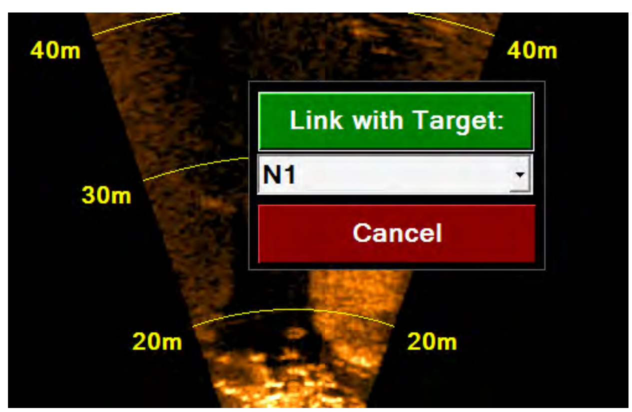
12.4. Creating a Target File Link

Creating a link between a target and a recorded file is useful because it allows a quick way to open a file and jump to the target's position in the file by using the Target Associated Files window (see section *12.8 Target Associated Files Window*).

To add a target link, there should be a file playing or recording on an Active Screen, and a previously existing target should visible. Right click on the target button in the top left corner of the HPR display. The button will highlight blue to indicate that target linking mode is active. Then click the spot on the image where the target is.

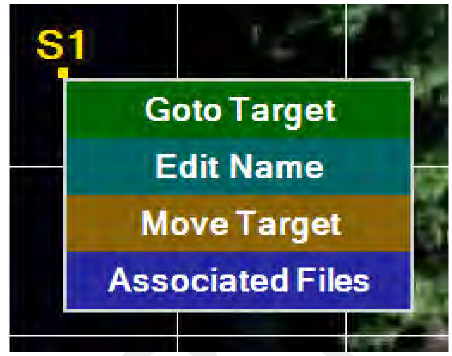


A dialog will be shown that allows confirming and changing the target that will be linked to the file (see image, right).



The filename and time of the link will be saved in the target file. The current playing/recording file can now be opened from the associated file list for that target.

12.5. Target Drop Down Menu



Most major target tasks can be accomplished through the Target Drop Down Menu. By right clicking a target icon, on **any active screen**, opens a menu containing the options seen in the image to the right. If the selected target is already the current Goto, then the menu with also contain a Cancel Goto option.

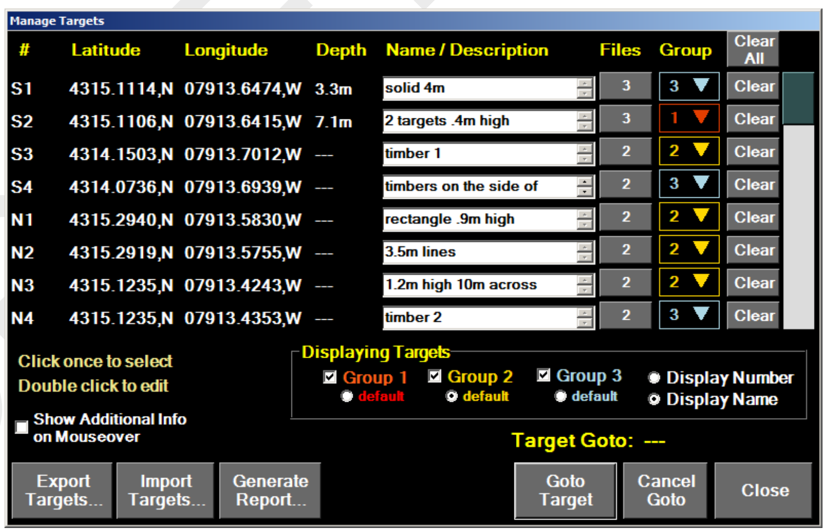
12.6. Managing Targets

To open up the Manage Targets window, click the “TARGET” label on the Navigation View, or select Target>Manage Targets from the main menu.

This window gives a listing of all targets in the current project, along with information on each. Each field, except for target number, can be edited.

Each target displays:

- Number
- Position
- Depth
- Name and Description
- Associated Files
- Target Group



A target can be added on this window manually by entering information on the next available row. To do this, double click the blank position or name/description field, or change the target group.

The number of each new target will increment from the highest existing target number. The letter preceding the number indicates the source of the target. “N” indicates the target was created on the Navigator, and “S” indicates the target was created on a survey system or surface PC.

To set or change a position of a target, double click the target position. See section *12.6.6 Manually Entering a Target Position* for information on entering a target position.

The depth value is the calculated depth of the target when the position was set.

The Group column allows the mission planner or operator to organize targets within three possible groups. The color of the targets on each image will correspond to its group. New targets will be added to the “default” group, which is specified in the “Displaying Targets” box. See section *12.6.1 Target Display Configuration* for more information.

Additional target information can be displayed (on this window only) by checking the box beside “Show Additional Info on Mouseover”.

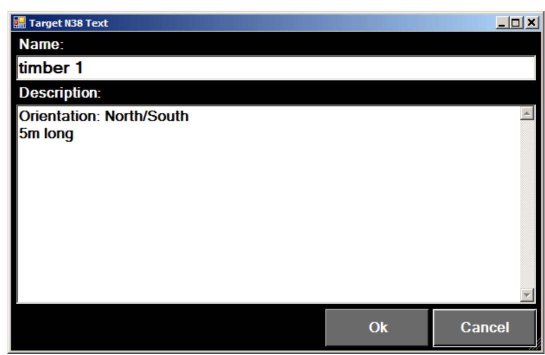
12.6.1. Target Display Configuration

The Displaying Targets box allows the operator to choose which groups of targets are displayed on the Track Screen and other Active Screens.

The operator can also choose between displaying the target name or number. This selection applies to targets displayed on the Navigation View, the Track Screen, and other Active Screens.

12.6.2. Target Description and Name

The target name and description can be edited by choosing the “Edit Name” option from the Target Drop Down Menu. This will open the pop-up window seen on the right. If the Quick Pad is on, the Quick Pad on-screen keyboard will pop up for text entry with the thumb controls.



This option can also be accessed by double clicking on the name/description text on the Manage Targets window.

On the Manage Targets window, the first line displayed in the Name/Description column in the name of the target entered by the user. Clicking the down arrow beside the name will cycle through the lines of test of the description. If a Quick Pick is used to set the target description, then the name will be auto-generated using the answer to the first question of the quick pick list. The target name may be up to thirty characters, but the Navigation view and Active Screens will only display the first twelve characters.

12.6.3. *Target Associated Files*

To open the target Associated Files window, choose the “Associated Files” option from the Target Drop Down Menu. See section *12.8 Target Associated Files Window*.

The Files column on the Manage Targets window indicates how many files are associated with the target. Clicking on the button in the Files column will also open the list of the target associated files.

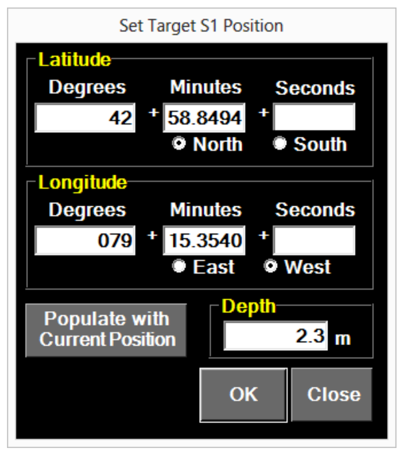
12.6.4. *Clearing a Target*

The “Clear” button in each row will delete the target. This action will delete the saved target text file as well as files associated with the target that are not linked, such as screenshots and thumbnails. Associated files that are linked to the target such as sonar recordings will **not** be deleted.

12.6.5. *Moving a Target Position*

To move a target, choose “Move Target” from that target’s Drop-Down Menu and choose it’s new position by clicking on any active screen. The position can also be set by setting a new target in the region surrounding the target you wish to move and choosing the “Set Position Of:” option, ensuring that target is selected.

12.6.6. *Manually Entering a Target Position*



This is used to set or clear the geodetic position for a target. The geodetic position can be entered in several different formats, using the Quick Pad on-screen keyboard or by using an external keyboard. If the values for latitude and longitude are known in degrees only (with decimals of degrees), then enter that number in the “Degrees” box, for each of Latitude and Longitude, and leave the minutes and seconds boxes blank. If you know the position in degrees and minutes (with decimals of minutes), then enter the degrees in the “Degrees” box and the minutes (with the decimals) in the “Minutes” box, and leave the seconds box blank. If you know a position in degrees, minutes and seconds, then enter each of those three values in the three appropriate boxes. To use the current position, click “Fill with Current Position”.

You may also enter or alter the target depth by entering a numeric value into the "Depth" box. If the target depth is unknown, then leave this box empty.

12.6.7. Setting the Target Goto

To make the target the current Goto, choose the "Goto Target" option from the Target Drop-Down Menu.

To cancel a Goto Target, choose the "Cancel Goto" option from that target's Drop Down Menu, or, right click the Route Crosstrack bar at the top of the screen, and choose "Cancel Goto" from the drop down menu.

This can also be accomplished by clicking the target in the list on the Manage Targets window to highlight it, and then click "Goto Target". See section *12.7 Tracking a Target* for more information on using the target Goto.

12.6.8. Importing and Exporting Targets

The "Export Targets…" button will open up the Export Data window and provide options for exporting targets. See section ***Error! Reference source not found. Error! Reference source not found.*** for more information.

The "Import Targets…" button will open up the Import Data window and provide options for importing targets. See section ***Error! Reference source not found. Error! Reference source not found.*** more information.

12.6.9. Generating Report

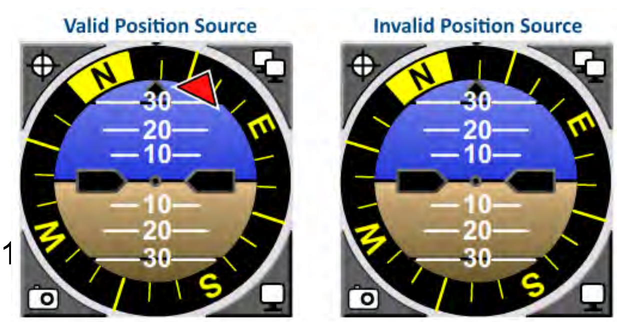
The "Generate Report" button opens the Report Generator window. See section *7 Project Report Editor* for details.

12.7. Tracking a Target (Target Goto)

To track a target, specify that target as the Goto target. This can be done in two ways:

- Right click a target displayed on an Active Screen, and click Goto Target
- Highlight the target in the list on the Manage Targets window and selecting "Goto Target"

When a target Goto is set, the number of the target will be shown on the Navigation View on the main screen of DiveLog. The bearing to the target Goto will show up as a red triangle on the compass ring. The bearing indicator on the compass display



will be continuously updated depending on the change in position to always reflect the current bearing to the target. This allows the operator to know at a glance the bearing to the target of interest. If the position source goes invalid, the red Goto bearing indicator will blink to indicate the last known bearing to the target until the position is updated again. After twenty seconds of invalid position, the Goto bearing indicator will disappear since the Goto bearing cannot be determined without a known position.

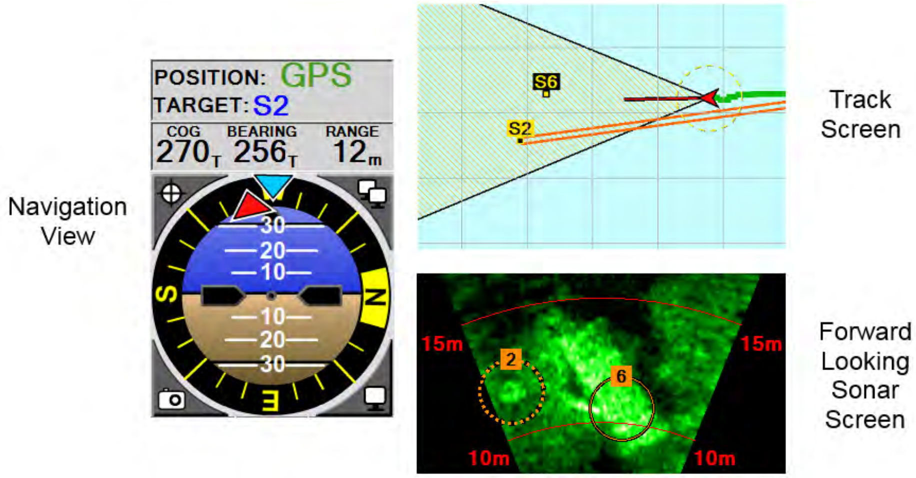
When a Goto is set, a blue triangle will also be shown on the compass ring, which indicates the course over ground (COG). If the speed is too low to determine an accurate course over ground, then the blue triangle will disappear.

With a water current, following the red got bearing triangle alone would not be the most efficient path to the target. The path travelled to the target will follow an arc as the water current will constantly be pushing off course. This problem is solved by using the blue triangle, which is the true direction of travel regardless of the heading. When heading towards a Goto position, line up the blue COG indicator with the red Goto bearing indicator. When the two are lined up, then the true direction of travel is the same as the direction to the target. This will allow the diver/operator to travel in a straight line to the Goto even when a water current is causing the direction of travel to differ from the compass heading.

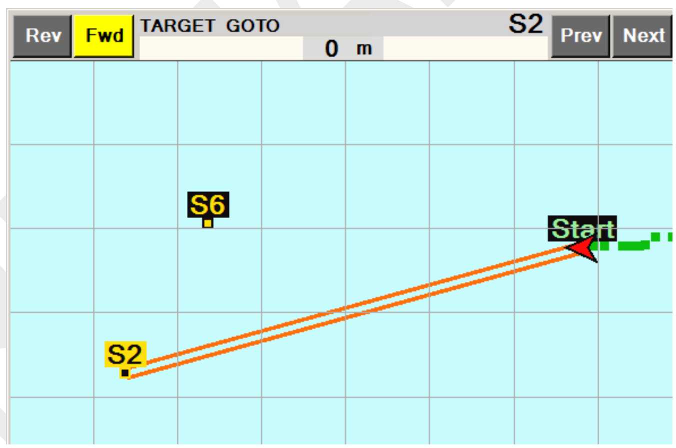
The bearing and range to the Goto are also displayed numerically above the graphical compass display on the Navigation View (see image below). The target Goto will also be highlighted if that target is visible on the Track Screen, the Forward-Looking Sonar screen, and other Active Screens.

To stop tracking the target, use one of the following methods:

- Right click the target of interest and select “Cancel Goto” from the drop-down menu.
- Select “Cancel Goto” on the Manage Targets window



If there is a valid position when the target Goto is set, a temporary route will be displayed between the current position and the target position (see image, right). The Route Crosstrack bar will appear at the top of the screen to display the crosstrack error on the path to the target. This shows the operator if they are following the most direct course to the target and if they are drifting off to either side. For more information on the Route Crosstrack bar, see section *20.6 Routes*.



12.8. Target Associated Files Window

To open the Target Associated Files window, either click the Files button on the Manage Targets window, or right click on any target shown on an Active Screen Image and select Associated Files.

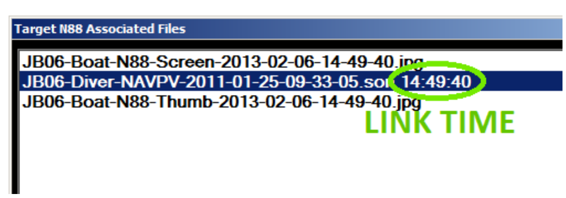
The Target Associated Files window displays the list of associated files, and provides functions for opening files, adding/removing files, changing some target properties, and setting the target as the Goto.

Generally, when a target is set, a screenshot and a thumbnail image are saved as associated files. If the target was set on an Active Screen that has a file currently being recorded or a file currently being played back, then that file will be linked to the target and the file name will appear in this list.

Additional associated files can be added to the list in several ways:

- Changing a target's position will save another screenshot and thumbnail for the target.
- Additional screenshots can be saved with each target by pressing the screenshot button on the Navigation View in DiveLog. After taking the screenshot, a dialog will allow the user to save it with a target.
- If a NavCam is used, recording NavCam video or snapshots will display a prompt to link the file to a target.
- In a file being recorded or played with an Active Screen, right clicking the Target button (to activate target linking) and then clicking the target on the image will link the target to the current file. This action will also create another screenshot and thumbnail for the target.

When opening linked files through this list, DiveLog will open and play the file with the proper Active Screen. If the file is a type that DiveLog cannot open with an Active Screen, then DiveLog will allow Windows to open the file with the file's default program. For example, screenshots will be opened in the standard Windows Picture Viewer.

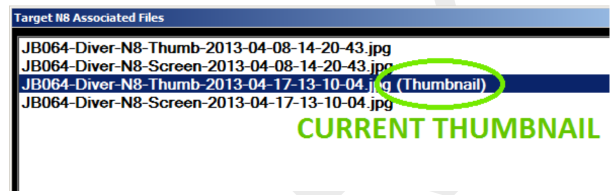


For linked files, such as a sonar file, there will also be a link time listed beside the file name (see image, right). The link time indicates the time within the recorded file that the target was set or linked. When the file is opened from this window, playback will jump to a point slightly before this time in the file so that the target is immediately in view in the playing file.

12.8.1. *Edit File Controls*

There are three buttons that allow modifying the file list:

- Set as Thumbnail: Any image file in the list can be used as the current thumbnail for the target, which will be used in the cursor tooltip on Active Screens. Click the "Set as Thumbnail" button to set the highlighted file as the current thumbnail.



- Add File: This button allows adding a file from an external location on the Windows file system. Browse and select the file. It will then be copied to the target associated files folder in the project and will appear in the files list for this target.
- Delete File/Link: If the highlighted file is contained in the associated files directory (such as a screenshot or thumbnail), then the file will be permanently deleted when the delete button is pressed. If the highlighted file is a linked file (such as a sonar file), then only the link to the target will be deleted.

12.8.2. *Edit Target Controls*

There are two controls for editing the target:

- Edit Target Name / Description: This button opens the standard window for modifying either the name of the target, or its description.
- Target Group: This drop-down specifies which group the target belongs to. The group determines how the target will be displayed on Active Screens.

12.9. Target Quick Pick List

The "quick pick list" is a method for the operator to quickly specify the description that is saved with a new target position. If a quick pick list is assigned to the project, when a new target position is set, the operator will be given a series of multiple choice style questions. The operator selects answers by clicking the appropriate answer from the options given. The questions and their answers will be added to the description text for that target and the text can later be viewed or edited on the "Manage Targets" window.

Each project may contain one quick pick list. Quick pick lists can also be saved to a common area on the computer, which makes them available to be used in any project. A saved quick pick list can be copied to a project at any time to set it as the list used for that project. Any project list may be changed or deleted without affecting any other project quick pick list or any saved quick pick list.

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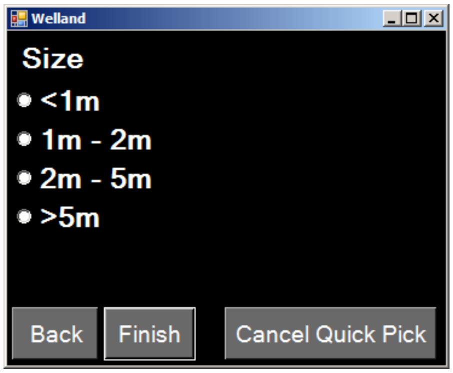
12.10. Using a Quick Pick List

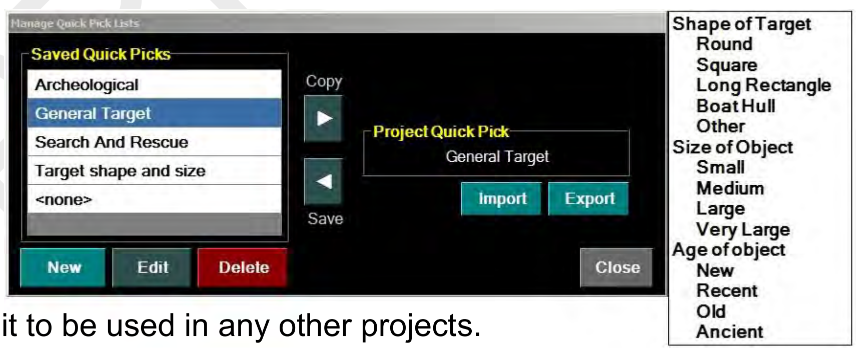


When a quick pick list is set as the project quick pick list (see below for more information), then the operator will be immediately presented with the questions after a target is marked.

The operator simply needs to click on the appropriate answer to move onto the next question. If an answer is unknown, the operator can click “Next” to skip that question. If the operator wants to change an answer then the “Back” button can be used and a different answer selected. The button “Cancel Quick Pick” will close the questions and answers window and the quick pick information will not be used in the description text for that target.

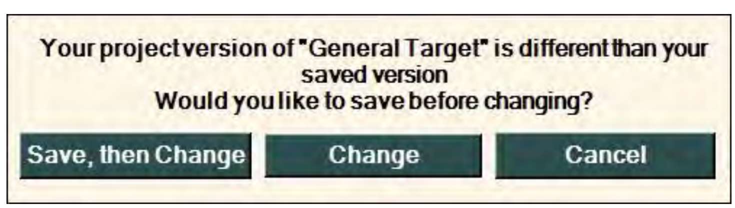
12.11. Managing Quick Pick Lists

The “Manage Quick Pick Lists” window can be reached from the “Session Setup” window, or from the main menu (Setup>Manage Quick Pick). The Manage Quick Pick Lists window allows for setting the current project quick pick list, as well as creating, editing, or deleting saved quick pick lists.



The project quick pick list is listed on the right side of the window. This list is independent of the saved lists, and won’t be altered if any saved list is changed. The project quick pick list is stored in the current project and must be saved in order for it to be used in any other projects.

A summary of the quick pick list in displayed to the right of the window when the cursor passes over a saved list or the project list.

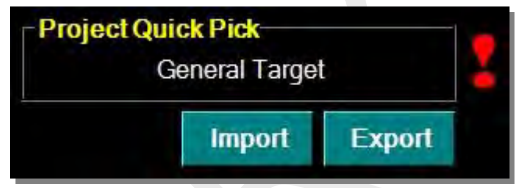


To change the current project list, simply click to highlight a saved list on the left of the window and click the Copy button (right facing triangle). If the list is different than a saved list with the same name, or is not listed in your saved lists, you will be prompted with the option to save your current project list before the change.

To save a current project list, click the Save button (left facing triangle). If your project list shares its name with a saved list, but is not identical to that list, you will be prompted with the choice to overwrite that saved list or to save your project list under a new name.

Unsaved lists cannot be edited. If you need to edit a project list, first save it, then make the changes using the Edit button, and copy it back to the project.

If your current project list has the same name as a saved list but is not identical to it, a red exclamation mark will be shown next to the Project List box. This indicates that in order to keep this list for future use, you will need to save it before either clearing it from the project or changing the current project list.



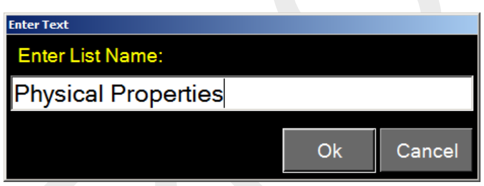
To create a new quick pick list, click "New" and follow the prompts listed in *12.11.1 Creating a New Quick Pick List*.

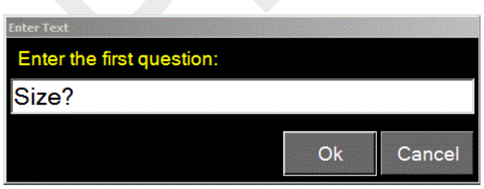
To edit a saved list, click "Edit" and follow the prompts.

To delete a saved list, click "Delete" under the Saved Lists box. If you would like to not use a quick pick list for the project, select "<none>" from the Save Lists box and Copy to the project quick pick.

To import or export a quick pick list, to or from the project, click "Import" or "Export" to bring up the "Import Data" or "Export Data" forms, detailed in sections *9 Importing Data* and *10 Exporting Data*

12.11.1. Creating a New Quick Pick List



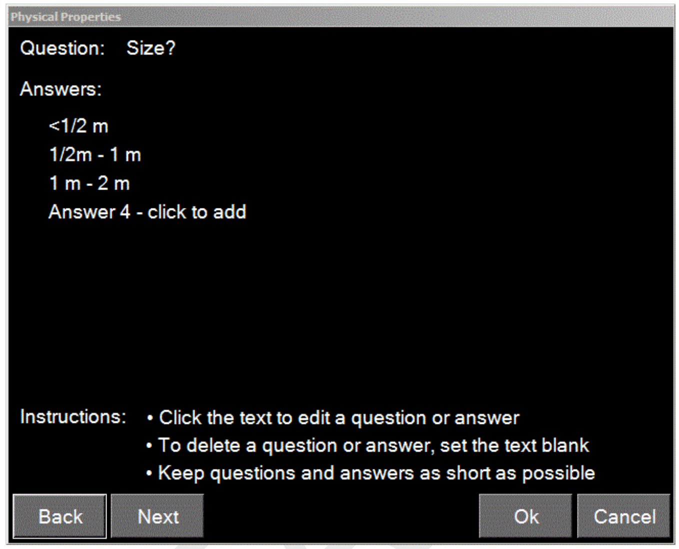


Click the "New" button to create a new list of questions and answers. You will be prompted to enter the name of the quick pick list.

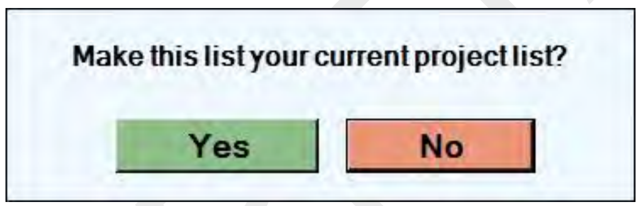
Once the name is entered, you will be prompted to enter the first question. Keep the question short; you cannot enter multiple lines.

The list window will then be displayed where the question with the answers are shown. You may add up to ten answers. Click the text "Answer 1 – click to add" to enter the first question. Keep each answer as short as possible for ease of use by the operator. To add more answers, click the next "click to add" text.

While adding questions and answers, the “Back” and “Next” buttons can be used to review and edit previously entered questions and answers. Hit “Ok” when done to save changes or “Cancel” to discard changes.

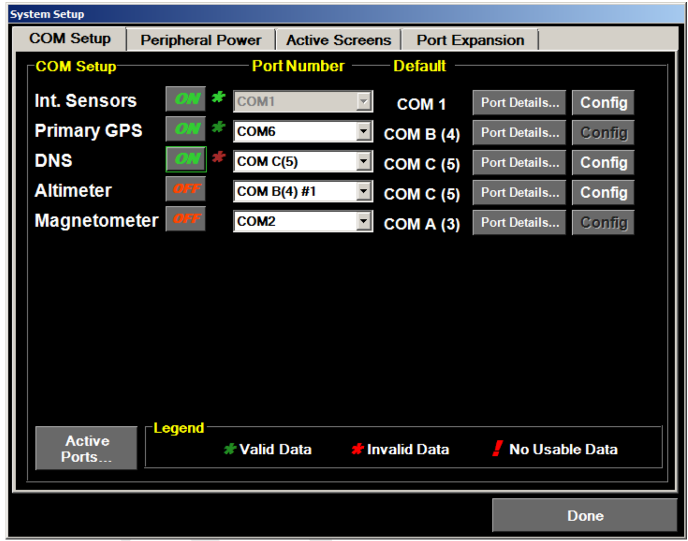


When creating a new quick pick list, you are given the option to make the new list your current project list. If this is done, the list will appear both as a saved list, to be used in other projects, and as the project list. This will overwrite the current project list, so make sure to save if you’d like to keep that list for future use.



13. System Setup Window

The System Setup window allows access to communication settings, power settings for peripheral devices (Navigator Delta and Dive Tablet only), and allows setting which screens and vehicles are active.



To access the System Setup window, click the "Setup" button at the bottom of the main DiveLog Navigation View, or select Setup>System Setup in the DiveLog main Menu.

The System Setup is divided into four tabs: COM Setup, Peripheral Power, Active Screens, and Port Expansion.

13.1. COM Setup Table

Many sensors and external peripherals communicate to DiveLog through serial ports. The settings on this window are very important for proper functionality of the system.

The COM setup table displays a list of devices that use a COM port for communication. Communications to a device and be turned on or off depending on whether that device is currently plugged in. The devices listed in this table are specified by setting the active ports (see section *13.1.2 Active Ports*).

The first column of the table is the name of the device. The second column of the table is a switch that turns the communication to the device **ON** or **OFF**. If a device is not used, the setting should be OFF. Two or more different devices may be configured to the same COM Port, but only one of those devices may be switched to ON since only one device can use a COM port at any point in time.

If swapping an external serial device on the system to a different device, first turn that device to OFF on the System Setup Window, swap the device, and then turn the setting for the new device to ON to enable communications to the new device.

Note: On the Navigator and Dive Tablet, some devices should always be set to "ON" since they are vital internal sensors. These are:

- **Navigator Gamma: "Depth" and "HPR".**
- **Navigator Delta: "Int. Sensors" and optional "Int. MRU".**

- **Dive Tablet: "Int. Sensors", "Depth", and optional "Int. MRU".**

In the column next to the ON/OFF button, is a character that indicates the communication status of the device. The characters represent the following:

* (green asterisk)	This COM port is open and is receiving valid data. The green asterisk will flash to indicate that data is updating.
* (red asterisk)	This COM port is open and is receiving correct data that indicates an *invalid* status. The red asterisk will only appear for devices which indicate a validity status in the data output such as a GPS that has lost its satellite fix. The red asterisk will flash to indicate that data is updating. Note that the red asterisk indicates that the *correct device is connected*, and that is actively communicating.
! (red exclamation)	This COM port is open, but it is not receiving any data, or it is receiving incorrect data that cannot be read (perhaps data from a different device). The red exclamation indicates that there is a problem with this device or COM port such as incorrect settings, or the device is not powered or otherwise not talking.
<no character>	This COM port is closed. This is usually because the device is set to OFF on the System Setup. This can also be caused by a port number being not found on the system, or a port being in use by another device.

The next column is the COM Port Number setting. Clicking the down arrow will allow a choice from a list from all possible COM ports on the system, or none if the device is not currently connected.

Note: Since some serial devices are built into the internal hardware (depending on the system), the COM port setting on certain devices cannot be changed.

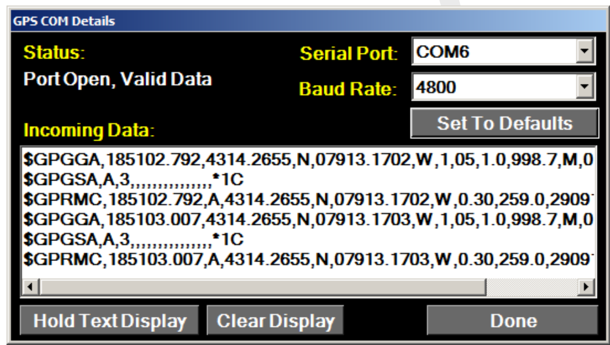
Multiple devices can be set to the same COM Port Number, but only one of those devices may be switched to ON and the others must be switched to OFF since only one device can connect to the same COM port at a time.

The column to the right of the Port Number is the Default Port Number. This is listed for quick reference as the correct COM Port for that device in a standard configuration.

The button in the next column opens up the "COM Details" window for that device. See section *13.1.1 COM Details Window* below for more information.

The button in the right-most column opens up the Configuration Settings window for that device. The Configuration Settings window will vary depending on the device, and not all devices have settings that can be configured. For more information on various configuration settings, see sections *14 Internal Peripherals and Configurations* and *15 External Peripherals*.

13.1.1. COM Details Window



Each of the "Port Details" buttons on the System Setup window will open up a window similar to the one shown to the right. The selected COM Port and Baud Rate is displayed at the top. The Serial Port displayed here will be the same as the value on the System Setup window. On this window, the Baud Rate can also be changed. For many devices in DiveLog that have only one possible baud rate setting, this value cannot be changed. The button "Set to Defaults" will change the COM Port and Baud Rate to DiveLog's standard values

The "Status:" displays the current communication status for this port, and may be one of the following:

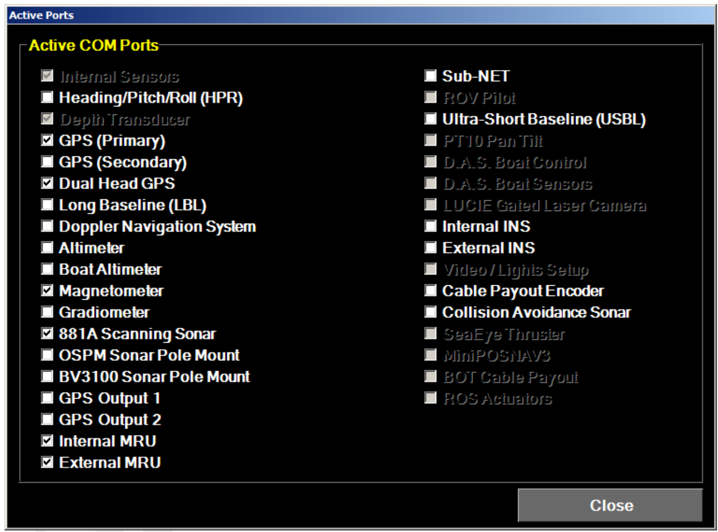
- **Port Open, Valid Data** (communications are active and data is valid; corresponds to the * on the COM Setup table).
- **Port Open, Invalid Data** (communications are active and data is not valid; corresponds to the * on the COM Setup table).
- **Port Open, No Usable Data** (port is connected, but no communication are active or unexpected data is being received; corresponds to the **!** on the COM Setup table).
- **Port Closed** (COM port is not connected).
- **Port Not Available** (COM port is not available for use; it is being used by another device in DiveLog or another software program).
- **Port Not Found** (The COM port number was not found on the system).
- **Port Error** (There has been a hardware or software error and the COM port cannot be connected).

Depending on the direction of main data flow, this window will also display the data that is streaming into DiveLog or out of DiveLog. An indication for either "Incoming Data:" or "Outgoing Data:" shows data flow direction. If the device is not communicating, then the text box will be empty. Note that depending on the way the device communicates, the text here may or may not be readable.

The button “Hold Text Display” will pause the display of the streaming data so that it can be read by the user. This has no effect on the actual communications to/from the device.

13.1.2. Active Ports

The serial devices that are displayed on the COM Setup table (on the System Setup window) are made *active* (shown or hidden) by using the “Active COM Ports” list (see image, right). The Active COM Ports list is reached through the System Setup window by pressing the “Active Ports...” button. The Active Ports list shows a list of all possible serial communication ports that DiveLog may use, and corresponds to a specific device or type of data.



This list will be configured at the factory, but new ports may need to be turned on if new devices are used with the system. Some of these ports are linked to an Active Screen, and the act of turning on the Active Screen will automatically activate the corresponding Port (and the device will then show up in the COM Setup table).

13.1.3. COM Devices

Internal Sensors: Communication for internal hardware on the Navigator and Dive Tablet. The settings are 57600 baud, and COM 1 on the Navigator and COM INT (6) on the Dive Tablet.

HPR: On the Navigator Gamma, this is the connection for the internal Heading/ Pitch/Roll sensor (The default settings are Com 5, 19200 baud).
On any other system, this the connection for an external boat mounted or pole mounted Heading/Pitch/ Roll sensor (default baud rate is 19200).

Depth: On the Dive Tablet and Navigator Gamma, this is the connection for the internal pressure transducer. The default baud rate for NAVPTD-001 is 4800, and the default baud rate for NAVPTD-002, NAVPTD-003, and NAVPTD-004 is 9600. On the Dive Tablet the default COM port is COM

DEPTH (5), and on the Navigator Gamma, the default COM port is COM 6.

Primary GPS: Connection for an external GPS. Since the GPS receiver is an external device, these may need to be changed when the GPS is first connected, or a different GPS is used, (ex. Serial or USB). The baud rate is 4800.

Secondary GPS: Connection for a second external GPS. This is the same as the Primary GPS (discussed above), except for the priority level: If both Primary and Secondary GPS's are ON, the data from the Primary GPS will override the data from the Secondary GPS (effectively making the Secondary GPS a backup GPS source).

Dual Head GPS: Connection for an external Dual Head GPS. This device will provide a position as well as heading, pitch and roll. The default baud rate is 19200.

RTK GPS: Connection for an external RTK GPS. The default baud rate is 19200. See section *15.4 RTK GPS* for setup details.

LBL: Connection for the long baseline positioning system (LBL). For the standard LBL (the VLT-10), the default COM port is COM A (3) on the Navigator, and the baud rate is 4800. If using the VLT-1 type LBL, then the default is COM 17 at a baud rate of 38400.

DNS: Connection for the Doppler Navigation System (DNS). The DNS unit will normally use COM B (4), or COM C (5) on the Navigator Delta, but may be connected to COM A (3). Baud rate is 9600. See section *15.6 Doppler Navigation System* for more information.

DNS with MRU: Connection for the Doppler Navigation System (DNS) with built in Motion Reference Unit (MRU). The Baud rate is 230400. See section *15.6 Doppler Navigation System* for more information.

Altimeter: Connection for an (optional) external Altimeter. The Altimeter default setting is COM C (5) on the Navigator Delta and COM B (4) on the Navigator Gamma, but it may be used on any external serial port (COM A (3), COM B (4) or COM C (5)). The baud rate is 4800. This port is meant for an

	altimeter mounted directly to the Navigator; see below for using a boat mounted altimeter.
Boat Altimeter:	Connection for an external Altimeter that is mounted to a pole on a boat. The baud rate is 4800. The “Boat Altimeter” may be calibrated separately from the “Altimeter” (by clicking the “Config” button). Only one of the Altimeter and the Boat Altimeter may be used at once and if one is turned on, the other altimeter will be automatically turned off. This allows rapid changing between diver operations and boat mounted operations.
Magnetometer:	Connection for an external Magnetometer. The SDM-4000 magnetometer communicates at a baud rate of 9600, and the SDM-N300 uses a baud rate of 19200. This device is used by the Magnetometer Screen.
Gradiometer:	Connection for an external Gradiometer. It communicates at a baud rate of 19200. This COM port is used by the Gradiometer Screen.
OSPM Pole Mount:	Connection for the Over the Side Pole Mount sensor unit. The default setting is COM C (5) on the Navigator Delta and COM B (4) on the Navigator Gamma and communicates at a baud rate of 57600. The port number and baud rate only apply if the pole mount configuration is set to “Combined Altimeter and HPR”. If not combined, then the port settings of the individual devices in the list will be turned on and used when the Pole Mount is turned on (see section *15.9.2 OSPM Pole Mount* for more information).
BV3100 Pole Mount:	Connection for the BV3100 pole unit. Since this is a USB device, a port will be created on the system when it is plugged into the computer. To check the proper COM port settings, under “Ports” in Device Manager in Windows, there will be a “USB Serial Port”. The COM port number listed there should be set in DiveLog as the port number. Depending on the settings on the Configuration window in DiveLog, this device may also turn on and off the port for an HPR device, and/or an Altimeter device (see section ***15.9.3 BV3100 Pole Mount Setup*** for more information).
GPS Out1:	Connection for outputting a GPS signal from DiveLog. If a standard GPS is being used, then DiveLog will repeat that

data on this port. If another position source is used, then DiveLog re-creates standard NMEA GPS data by using the position data from the positioning source DiveLog is using at the time. The data can then be received by other software packages that require a GPS input.

GPS Out2: Connection for a second GPS Output, identical to GPS Out1, above. This allows the user to output GPS data to a second software package.

Internal MRU: (Navigator Delta and Dive Tablet only) Connection for an optional high accuracy internal motion reference unit (provides heading, pitch, and roll). There is no need to change these settings other than diagnostics purposes. The settings are 115200 baud, COM 2 on the Navigator and COM MRU (3) on the Dive Tablet.

External MRU: Connection for an optional high accuracy external motion reference unit (provides heading, pitch, and roll). The com port may be set to any external com port, and the baud rate is 115200.

Sub-NET: Connection for the “Sub-NET” acoustic modem. The baud rate is 9600.

Sub-NET Radio Connection for the “Sub-NET” radio modem. The baud rate is 19200.

Sub-NET RF/GPS: Connection for the Sub-NET RF GPS, which is a combined radio modem and GPS. This units allows for Sub-NET communications over a radio link, as well as determining the system’s position. The default baud rate is 230400.

881A Scanning Sonar: Connection for an external 881A scanning sonar. This port is associated with the 881A scanning sonar Active Screen. The 881A communicates at a baud rate of 115200.

Pan / Tilt Platform: Connection for a Pan/Tilt unit, which is used as the camera positioning platform on some ROV models. The default baud rate is 9600.

Ultra-Short Baseline: Connection for the USBL COM Port, which communicates with other software that outputs transponder data over a virtual serial port link. The default baud rate is 9600.

USBL Target Output: Connection to output information for the targets tracked by the Ultra-Short Baseline System. This is for a serial connection to another software program. The default baud rate is 9600.

D.A.S. Boat Control: Connection for the control data for the DiveLog Automated Survey Boat. The default baud rate is 115200.

D.A.S. Boat Sensors: Connection for the telemetry data (GPS and Altimeter) received by DiveLog from the DiveLog Automated Survey Boat. The default baud rate is 115200.

Internal INS: Connection for an internal Inertial Navigation System. The default baud rate is 115200.

External INS: Connection for an external Inertial Navigation System. The default baud rate is 115200.

Video/Light 1: Connection for a Video/Light controller interface. The controller interface communicates at a baud rate of 57600.

Video/Light 2: Connection for a second Video/Light controller interface, used when controlling a second independent camera/light system. Communicates at a baud rate of 57600.

Cable Payout Encoder: Connection for an external encoder for measuring cable payout. This would normally be used in Survey (PC) mode. The baud rate is 9600.

Collision Avoidance Sonar (CAS):
Connection for an optional collision avoidance sonar, used on the MAKO Diver Delivery System. The baud rate is 4800.

SeaEye Thruster: Connection for a SeaEye thruster (to be fitted to custom ROVs et cetera). The baud rate is 9600.

MiniPOSNAV3: Connection for the MiniPOSNAV3 position sensor. Baud rate is 9600.

BOT Cable Payout: Connection for a Brook Ocean Technologies cable payout sensor. The baud rate is 9600.

ROS Actuators:	Connection for a network of ROS Actuators (to be fitted to custom ROVs et cetera). The baud rate is 9600.
Radiation Detector:	Connection for a Radiation Detector. The baud rate is 9600, and the default COM port on the Navigator is 9600.
ROV Pilot:	Connection for the "ROV Pilot", which communicates with a Remotely Operated Vehicle. The default baud rate is 19200, but may be different depending on the type of ROV.
Five Function Manipulator:	Connection for a five-function manipulator fitted onto an ROV. The baud rate is 9600.
ESX External Port #1:	Connection that allows an external device or piece of software to connect to a serial device that is plugged into an Ethernet Serial Expander. Baud rate is configurable to any value, depending on the connecting device.
ESX External Port #2:	A second connection that allows an external device or piece of software to connect to a serial device that is plugged into an Ethernet Serial Expander. Baud rate is configurable to any value, depending on the connecting device.
Boat GPS:	Connection for an additional GPS, used so a boat position can be displayed and recorded as a separate position from the primary position on the Track Screen. The default baud rate is 4800.
Camera Control:	Connection for a camera to control functions such as camera zoom.
Pinger Locator:	Connection for the Pinger Locator device. The default baud rate is 38400.
UHMD MRU:	Connection for an MRU contained inside an Underwater Head Mounted Display. The baud rate is 115200.
Pendant MRU:	Connection for an MRU contained inside a hand controller pendant. The baud rate is 115200.
Pendant:	Connection for the pendant hand controller. The baud rate is 57600.

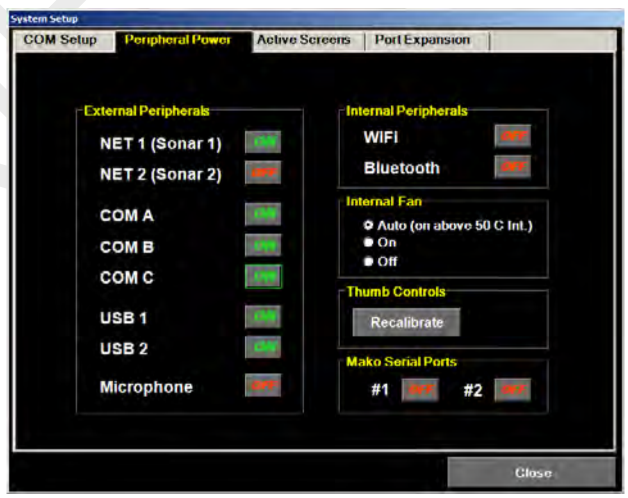
13.1.4. *Using a Virtual Serial Connection*

Depending on the accessories used on the system, a program called Virtual Serial Port Kit may run in the background. This program creates virtual serial ports for serial communication from one software program to another. This can be used for sending data such as GPS information from DiveLog to another software package. Virtual Serial Port Kit will create pairs of serial ports that are connected to each other (one for DiveLog to send the GPS data to and the other for the software package to receive that GPS data from). These virtual ports can be set up and turned on by opening the Virtual Serial Port Kit program found in Start -> All Programs -> Virtual Serial Port Kit -> Virtual Serial Port Kit.

The port pairs may be numbered differently depending on the setup:

- On a survey system or topside unit, the default pairs are COM 11 to COM 12, COM 13 to COM 14, et cetera.
- On the Navigator, the default settings are COM 7 to COM 17, COM 8 to COM 18, and COM 9 to COM 19.

13.2. Peripheral Power Settings

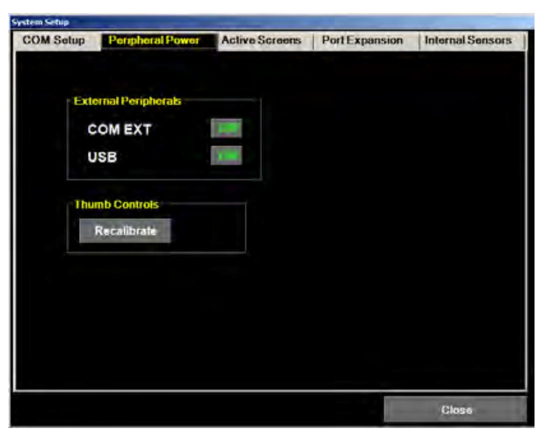


The second tab on the System Setup window allows toggling power to internal or external device ports. This tab may not be available on systems that do not have hardware with power toggling capability. Click the ON/OFF button to toggle the state of the device. See image upper right, for the Navigator Delta, and image lower right for the Dive Tablet.

These settings can be used for saving power by turning off devices, or resetting a device by turning power off then back on.

On the Navigator Delta, wireless devices are off by default each time the Navigator is started. To use the WiFi or Bluetooth, they must be turned on here.

Turning off a device has the effect of cutting power to the device or port. This applies to all options here, except for the microphone. The power to the A/V port is always on; selecting OFF for the microphone nulls out the signal, while selecting ON activates the microphone signal.



On the Navigator Delta, the internal fan is used for helping internal circuitry to dissipate heat. The fan may be turned off if a "quiet" mode as desired, but the setting will default to Auto when the Navigator is started.

The "Recalibrate" button under the Thumb Control heading is used to force a thumb stick recalibration when the thumb controls (mouse cursor) have developed a drift during operation. Note: The thumb controls on both the Navigator Delta and the Dive Tablet have an automatic recalibrate function. See below for more information.

If the MAKO DDS is active, there is also power toggling functionality for the serial port(s) on the MAKO control box. See section *17.4 MAKO COM Ports* for more information.

13.2.1. Thumb Control Recalibration (Navigator Delta and Dive Tablet)

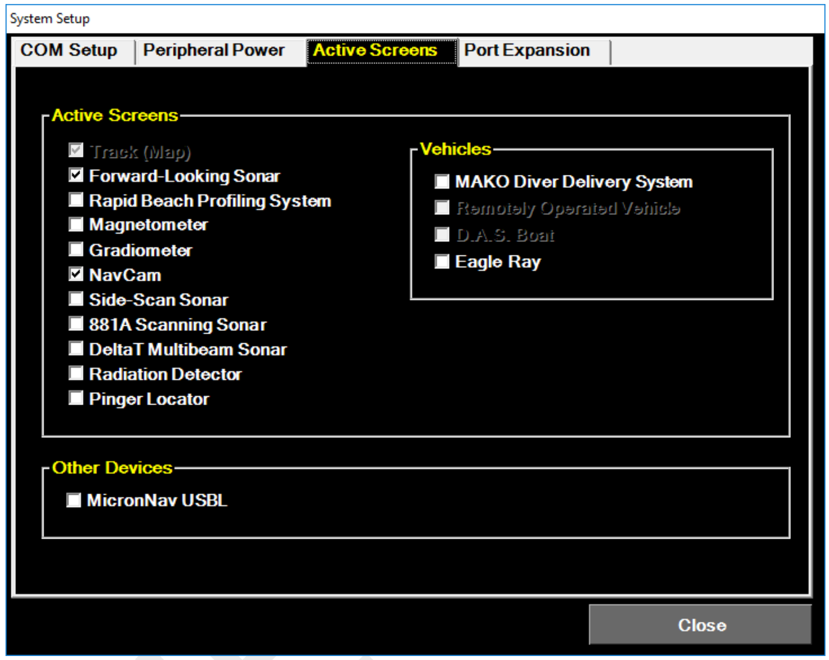
The thumb controls on the Navigator Delta are calibrated each time the Navigator starts up. Subsequent swings in temperature may cause a drift to develop in the mouse cursor movement. Recalibrating the thumb controls can be done in two ways:

- Auto-Recalibrate – The Auto recalibrate feature will engage automatically if the cursor is drifting. When the operator releases the thumb sticks, the cursor will hit the edge of the screen, and after ten seconds DiveLog will automatically recalibrate the thumb controls.
- On the Peripheral Power tab of the System Setup window, pressing the Recalibrate button will engage the calibration procedure.

The calibration procedure will execute as follows:

1. A window will instruct the user to let go of the thumb controls. Releasing the controls is important for proper recalibration.
2. A countdown of a few seconds will be displayed while the thumb controls are recalibrated.
3. The thumb controls will be ready to use again.

13.3. Active Screens



"Active Screens" in DiveLog refers to the expansion modules in DiveLog that build upon the base DiveLog framework. The Active Screens will be displayed in the DiveLog main window as either the Primary Screen (which takes up most of the viewing area), or a Secondary Screen (which are displayed as thumbnails). The Primary Screen and Secondary Screens may be toggled back and forth to change the device that the operator is focusing on. Different modules can inhabit these screens, such as the Track (Map) screen, the Forward-Looking Sonar, the NavCam, the Magnetometer, etc. As new expansion modules are added to DiveLog, the list of active screens will change. See section *3.1 Active Screens, Primary Screen and Secondary Screens* for more information on the display of active screens.

The Active Screens list on the System Setup window sets which screens are active and which are disabled. To select which screens are actively used, select the checkbox beside that item which will turn on the Active Screen for display and use. De-selecting the checkbox here effectively disables and hides that device/module so that no interface is displayed and files will not be recorded.

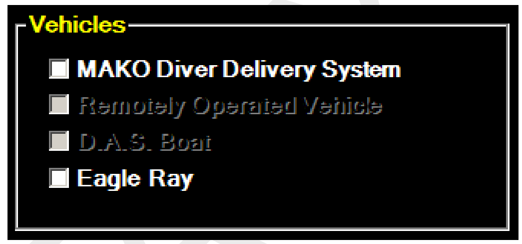
The Track (Map) Screen is the only Active Screen that cannot be disabled, since it performs important functions for DiveLog. Most Active Screens require the Track Screen to record and display the tracks that accompany the main recorded files. In general, tracks will still be loaded and displayed if there are recorded files in the project for other Active Screens even if the other Active Screens are turned off.

13.3.1. Active Vehicles

DiveLog can be configured to operate in special modes to run in conjunction with various vehicles. With certain vehicles, DiveLog will provide intelligent control of the vehicle with auto functions such as depth control, route following, et cetera.

Enabling or disabling the control for a vehicle is done on the Active Screens tab on the System Setup window. Enabling or disabling the control for a vehicle does not enable or disable any particular Active Screen, instead a vehicle control bar is added across the top of the Primary Screen so the most common functions can be readily accessed at all times.

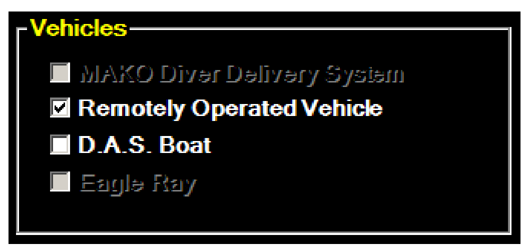
Active Vehicles on the Navigator



When DiveLog is running on the Navigator Delta, two vehicle options are available: The MAKO Diver Delivery System and the Eagle Ray diver propulsion device. For the MAKO, DiveLog will provide full control of the thrust to perform an array of autonomous functions. When the MAKO is set as active here, DiveLog will automatically search and connect to the vehicle when the Mako is plugged in and powered up. See section *17 MAKO Diver Delivery System* for more information.

If the Eagle Ray is set as active, the auto controls are not available due to the simpler nature of the control of the Eagle Ray. However, DiveLog will use special HPR and MRU calibrations to provide the most accurate compass results when the Navigator is mounted to the Eagle Ray. To calibrate the compass for the Eagle Ray, simply perform the eight point compass calibration when the Eagle Ray is set as active here. To switch back to the standard compass calibrations (when removing the Navigator from the Eagle Ray), disable the Eagle Ray as an active vehicle. See section *14.3.5 Eight Point Compass Calibration* for more information on calibrating the compass.

Active Vehicles in PC / Survey Mode



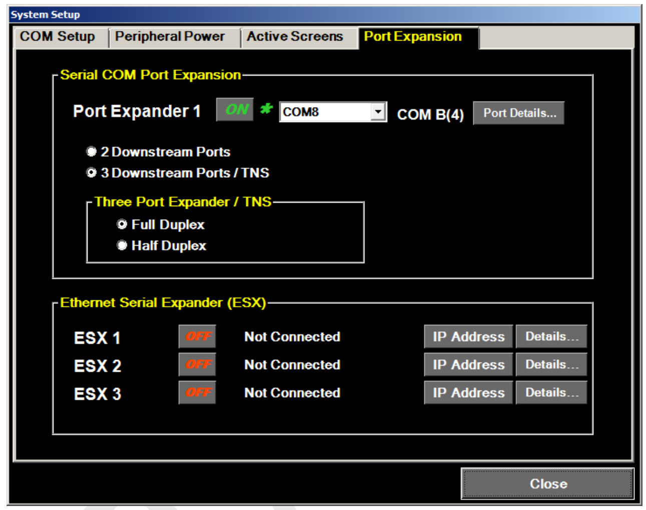
When DiveLog is running on a Topside or PC/Laptop, there are two vehicle types available: Remotely Operated Vehicle, and the D.A.S. Boat.

When the ROV is made active here, in additional to the auto controls panel at the top of the screen, a separate window will become visible to provide status information of ROV functions. This window can be positioned on the screen as the operator sees fit with their particular ROV display layout (see section *16 Remotely Operated Vehicle (ROV) Pilot*). The communication to the ROV is through a COM port and should be setup via the COM Setup Table (see section *13.1 COM Setup Table*).

For the D.A.S. Boat, see section *18 DiveLog Automated Survey Boat*. The communication to the boat is done through three separate COM ports (One for the

Heading/Pitch/Roll sensor, one for control data, and one for sensor/telemetry data) and should be setup via the COM Setup Table (see section *13.1 COM Setup Table*).

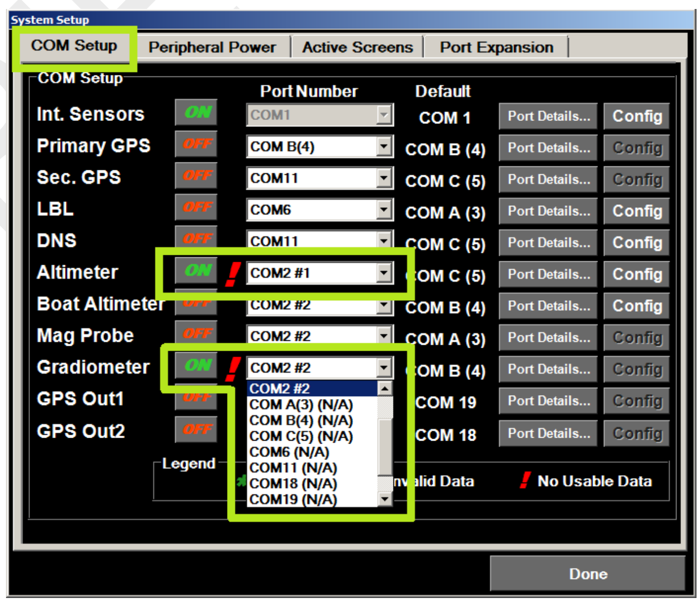
13.4. Port Expansion



This tab of the System Setup window provides setup options for optional hardware that allows increasing the number of COM ports available to DiveLog.

13.4.1. Serial COM Port Expansion

The COM Port Expander (CPE) is meant to expand the functionality of any one of the serial connections (COM Ports) on the system. That is, two or three accessories that use a COM port can use the CPE and plug into a single COM port connection.

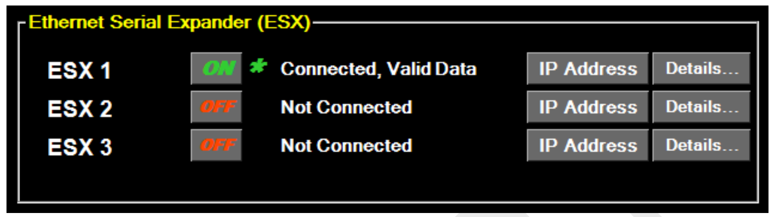


The CPE hardware has one upstream port and two or three downstream ports. The upstream port will connect to a serial port connected to the computer, and the downstream ports connect to two or three devices.
Some Shark Marine devices, such as the TNS (Total Navigation System), require a three port expander. The three port expander is set up in the same way as the two port expander, with the added option of using Full or Half Duplex communication, based on the hardware setup of the expander.

To setup the device, beside Port Expander 1 on the System Setup window, specify the external COM port on the unit that the CPE is connected to. Once this port is specified, two or three sub-ports (#1, #2, and #3) will appear for that same port number in the main pull down lists for COM Port Numbers. Now when you setup the communications for the downstream devices in the COM Setup tab of the System Setup window, choose #1 or #2 or #3 to select the expanded COM ports.

13.4.2. *Ethernet Serial Expander (ESX)*

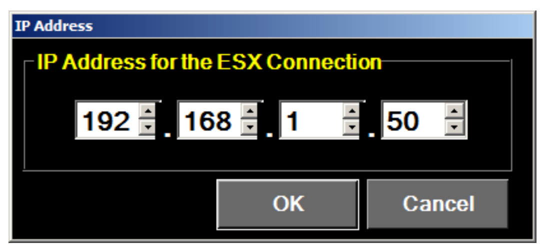
On the Port Expansion tab of the System Setup window, there are setup options for up to three Ethernet Serial Expanders (ESX). In general, topside control consoles and remotely operated vehicles may use an ESX to allow serial devices to communicate over the Ethernet connection. Each ESX will provide up to five additional serial ports that can be used by various serial devices.



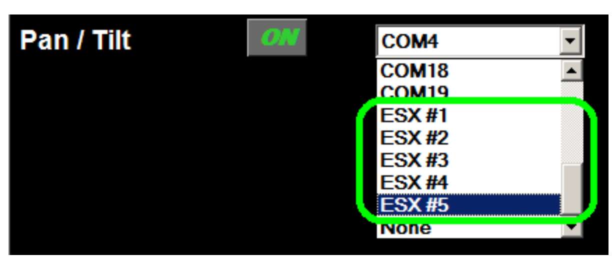
If the ESX hardware is installed, the ON/OFF button should be ON. If ESX's are not being used, the button should be OFF, otherwise DiveLog will continuously search for the device. To the right of the ON/OFF button, the status will be displayed. Like the COM Ports, a blinking asterisk will show the status of received data over the fiber/Ethernet link. A text field shows the state of the Ethernet connection, which may read as follows:

- Not Connected: The connection is currently OFF.
- Searching: DiveLog is attempting to connect to the remote IP Address.
- Connected, Invalid Data: DiveLog has found the remote unit but is not receiving useable data.
- Connected, Valid Data: DiveLog is connected and receiving valid data.

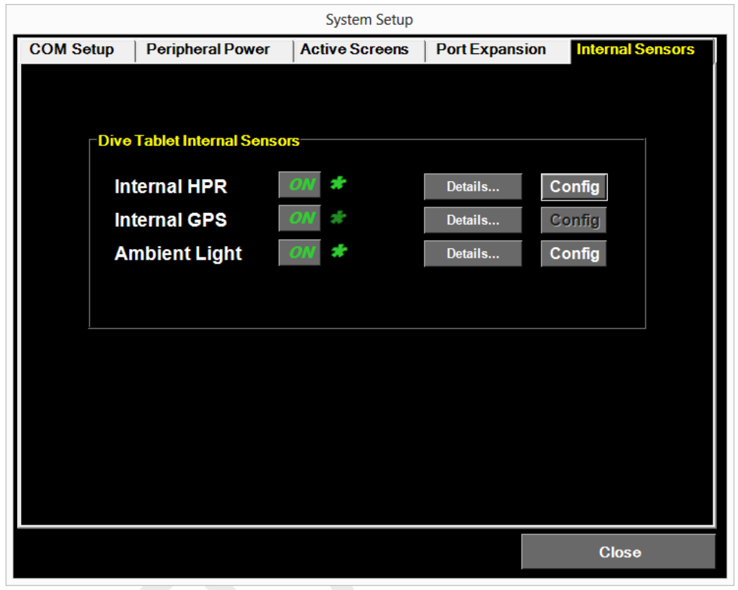
The IP Address button allows setting the IP Address that DiveLog will connect to. Be sure that this IP Address is correct, otherwise DiveLog will not be able to communicate with the device. The default setting for the ESX IP Address is the one shown to the right, 192.168.1.50. If this IP Address appears correct, but DiveLog cannot connect to the remote ESX, then the cause could also be that the IP settings on the computer may not be correct/compatible (the usual IP Address of the computer/topside is 192.168.1.200).



When the ESX is turned ON, there will be five more COM Ports available in the Port Number dropdown list on the COM Setup Table on the first tab of the System Setup window (see image, right). To connect one of the serial devices through the ESX, choose the proper ESX port number for that device on the COM Setup Table (for example, in the image to the right the Pan/Tilt Platform is being set to communicate using ESX Port 5).



13.5. Internal Sensors (Dive Tablet Only)

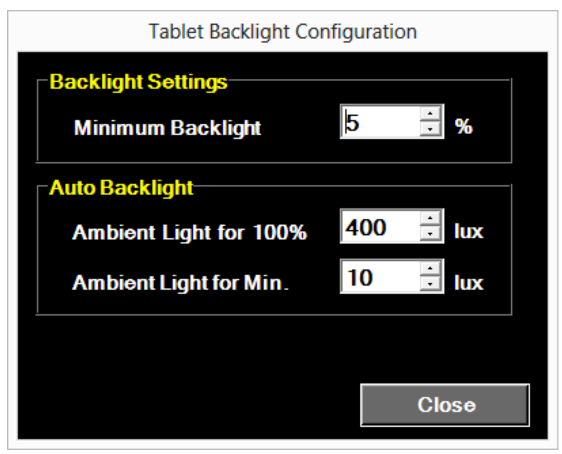


The Internal Sensors tab on the System Setup window allows the user to enable, disable, and access settings for the internal Dive Tablet sensors. The Details window for these sensors does not include a COM port or baud rate settings, as they are internal to the Dive Tablet itself and cannot be altered. Included in this list are:

Internal HPR: Built-in heading, pitch, roll sensor, used in cases where the MRU is not available. The Config button opens the standard HPR Configuration window (see section *14.3 Heading Pitch Roll (HPR) Configuration*).

Internal GPS: Built-in GPS that is used in cases where an external GPS position source is not available.

Ambient Light: This sensor measures the ambient light intensity surrounding the tablet. It is used to determine the screen brightness when it is set to automatically adjust (see section *11.2 Screen Brightness (Dive Tablet)*). The Config button opens the Tablet Backlight Configuration window. This window allows the user to change the following settings:



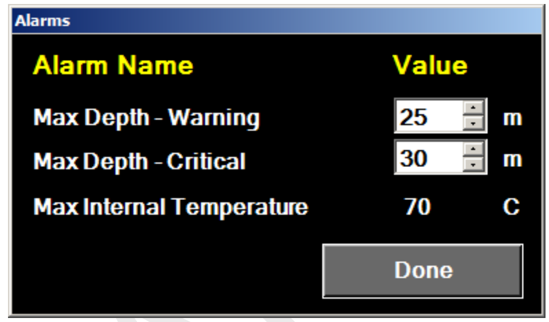
Minimum Backlight: The lowest backlight setting DiveLog will allow in both Manual and Auto screen brightness modes.

Ambient Light For 100%: The ambient light level that the backlight will be set to the highest possible brightness.

Ambient Light for Min: The ambient light level that the backlight will be set to the Minimum Backlight brightness.

14. Internal Peripherals and Configurations

14.1. Alarms



The alarms window can be reached from the main menu by selecting Setup > Alarms.

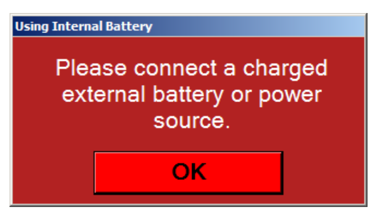
Note: Depending on the hardware, not all alarms shown to the right may be available.

The Maximum Depth - Warning alarm is a depth that will warn the user by flashing the background of the depth displayed on the main screen orange. The on-screen warning will remain while the depth of the unit is equal to or greater than this alarm value. This value can be any depth selected by the user, and is not related to the depth rating of the system.

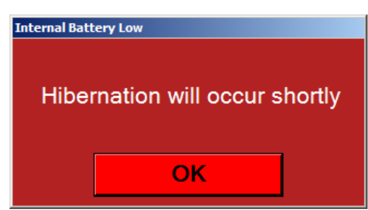
The Maximum Depth - Critical alarm is a depth that will warn the user by flashing the background of the depth displayed on the main screen red. Also, a message box will pop up warning the operator that the alarm depth level has been reached. If the depth is not reduced within 30 seconds, then the pop up message will come up again. The flashing on-screen warning will remain while the depth of the unit is equal to or greater than this alarm value. This value can be any depth selected by the user.

The last alarm listed is the Maximum Internal Temperature alarm (available if the system has an internal temperature sensor). This value cannot be changed by the user. If the internal temperature reaches this temperature, then a warning message will pop up. In this case, the system should be turned off or cooled down.

14.2. Internal Battery Alarms (Navigator Delta Only)

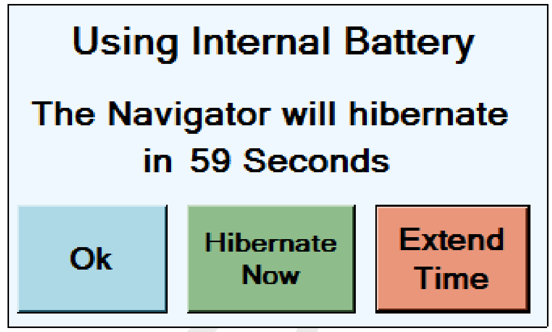


The “Using Internal Battery” alarm will warn the user when the Navigator has switched to its backup internal battery. This is usually caused by complete depletion of the external battery, or physical disconnection of the external battery. An alert will also be raised if the internal battery is getting low.



Also, if the internal battery has been depleted, the Navigator will automatically hibernate. An alarm will be shown if the internal battery is very low to inform the user that hibernation will occur soon.

Whether or not the “Using Internal Battery” alarm is on, DiveLog will prompt the user for action after the Navigator has been running for three minutes on the internal battery. The user can extend the time by clicking the “Extend Time” button. Clicking “Ok” will hide the message but Hibernation will automatically occur within the minute. Click “Hibernate Now” to immediately put the system into Hibernation.

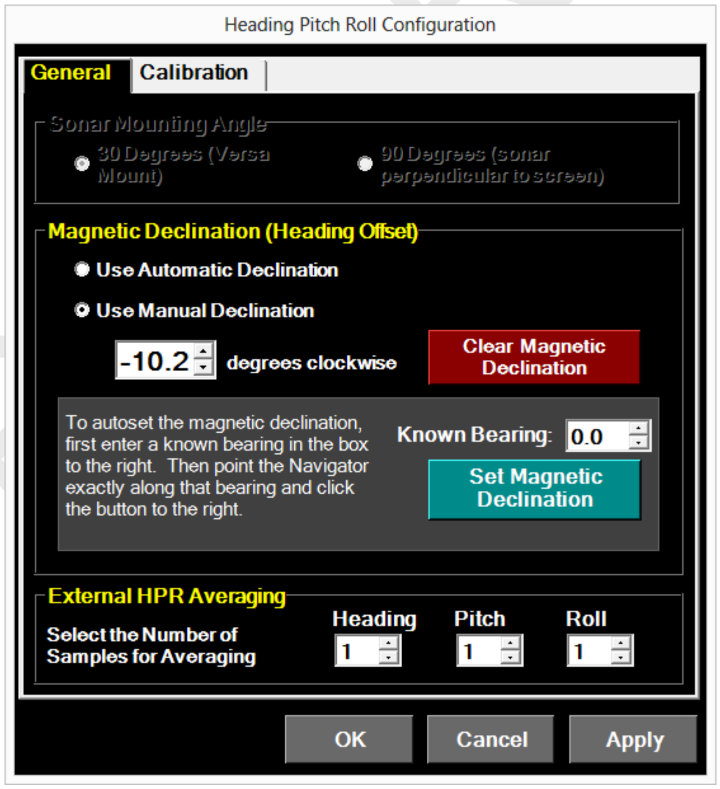


14.3. Heading Pitch Roll (HPR) Configuration

This window allows setup and calibration of the heading, pitch, and roll sensors. Since DiveLog supports a variety of sensors and configurations, this window may be slightly different or some options may not be available depending on the particular device being configured.

14.3.1. HPR General Tab

The general tab allows setting of the mounting angle, the magnetic declination, and set averaging for the sensors.



The “Sonar Mounting Angle” group box (Navigator only) allows an offset to the pitch based on which sonar mount is used on the Navigator. This is normally set for “30 Degrees (Versa Mount)” if the Forward-Looking Sonar is used. For external attitude sensors, the mounting angle is disabled.

The “Averaging” is used to smooth the changes of the compass, pitch and roll. Increasing these numbers will make the changes smoother, but there will be a longer delay when the HPR is moved before the graphic updates. Decreasing these values will give a more responsive update, but the changes will not be as smooth. For example, there are approximately 10 samples per second on the standard HPR sensor, so an averaging value of “10” would delay changes in the compass for one second longer than the inherent delay of the sensor. Different sensors may have different update rates; therefore averaging over 10 samples may affect other sensors differently.

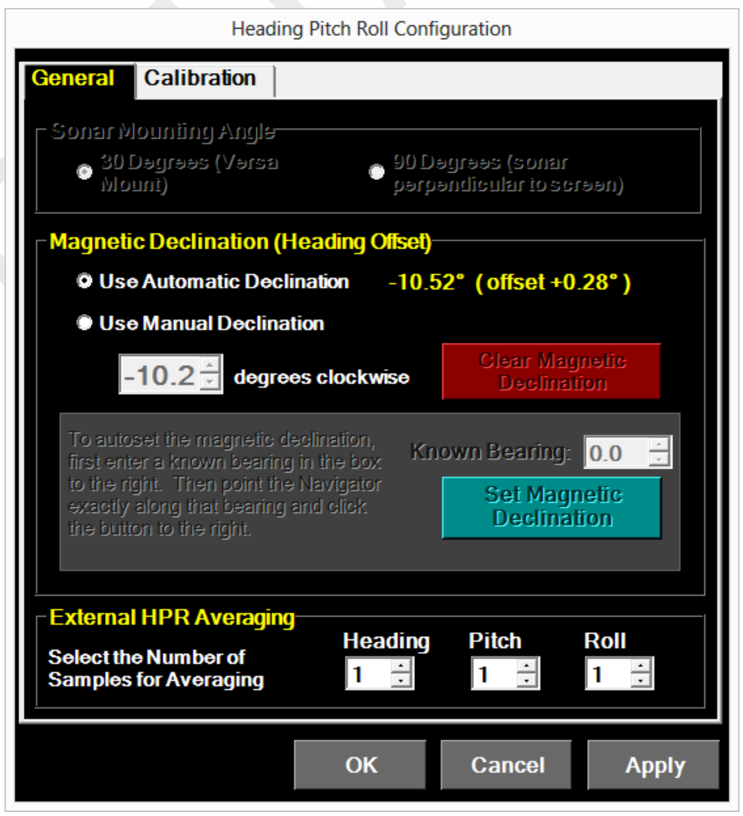
14.3.2. Magnetic Declination (Heading Offset)

An offset value is giving to the compass reading to compensate for the magnetic offset from true north (Magnetic Declination). You can manually set the Magnetic Heading Offset by entering the value if it is known. Alternatively, it can be automatically set if you are able to determine a true heading in any direction.

There are two ways to accomplish this:

1. If you have a map of the area you are in, pick a point that is at a known true bearing from your current position. Point the unit's heading at that point (so that the heading is pointed at the exact known bearing). Enter the known bearing in the field labelled "Known Bearing" in the Heading Pitch and Roll Configuration window, then click "Set Heading Offset". You should then see the graphical compass display rotate to show that bearing. This is an indication that the compass is now calibrated to True North.

2. Alternatively, if you are on a vessel, the GPS Heading can be used as a reference to True North. The "COG" on the main screen in DiveLog displays the "Course Over Ground" (GPS Heading) when a GPS is connected. As the vessel is travelling straight, line up the unit's heading to the bow of the ship, then enter the GPS Heading (COG) as the "Known Bearing" and hit "Set Heading Offset". This can only be done with minimal current or wind and from a vessel with a low magnetic signature.

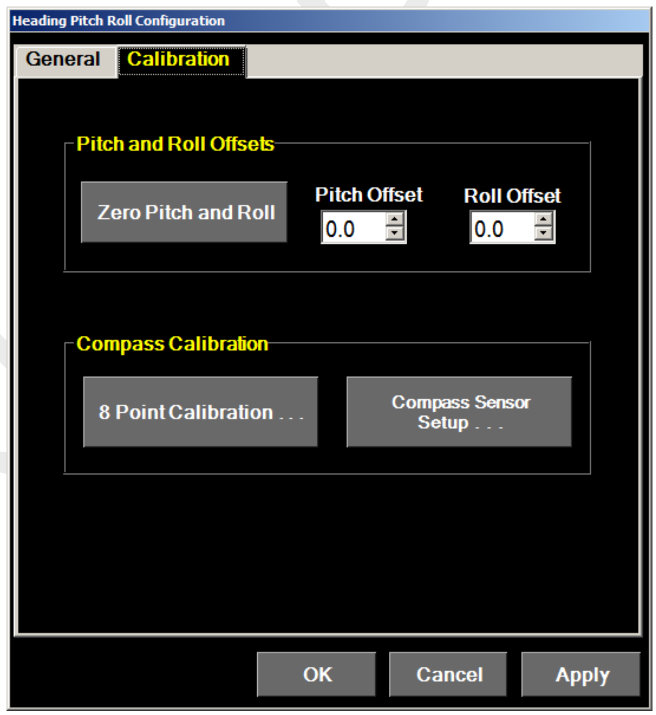


In addition to these options, DiveLog is also able to automatically determine the magnetic declination of the current location without a known heading. This option uses a precise magnetic model to determine the best estimate for declination given DiveLog's currently known position. You may switch to this option at any time by clicking the "Use

Automatic Declination" radio button. The yellow text to the right of the radio button will show the current declination and the declination correction offset. This correction offset is generated and updated by DiveLog automatically when automatic track corrections occur. Automatic Track Correction is not currently implemented, but will be seen in later version of DiveLog.

Note: Different geographic locations have different corrections for magnetic declination from true north. To maintain compass accuracy, it will be necessary to change the Magnetic Declination value when using the system in different regions, unless automatic declination is being used.

14.3.3. Calibration Tab



This allows calibrating the level orientation (pitch and roll) and calibrating the compass.

Offsets can be added to the pitch and roll to fine-tune the readings. To automatically set these values, set the unit on a flat surface such as a table so that the bottom of the unit is parallel to the ground. The "Zero Pitch and Roll" will get the offsets, then clicking; the "OK" or "Apply" button will actually apply the settings to the sensor readings.

Sensor Specific Details

External HPR and ROV HPR: The 8 Point Calibration will be available, as well as the Compass Sensor Setup, which allows for more advanced fine tuning. Pitch and Roll Sensor Setup and the #2 HPR buttons are not applicable to this setup.

Navigator Delta Internal HPR(s): If the Navigator Delta is equipped with an optional second internal HPR sensor, then "Pitch./Roll Sensor Setup..." will allow calibrating the offset between the two sensors (if not equipped with the second sensor, or the system is a Navigator Gamma, then this button will be disabled).

Motion Reference Units (MRUs): DiveLog supports an external high accuracy MRU as well as an optional internal high accuracy MRU on the Navigator Delta and Dive Tablet. When using the MRU, the heading, pitch, and roll numeric values on the Navigation view in DiveLog will be shown to a tenth of a degree.

14.3.4. Compass Calibration

On the Heading Pitch Roll Configuration window, there are two options for Compass Calibrations. The eight point calibration will fine tune the compass reading for the most accurate results. The eight point calibration is relevant to all compass sensors (HPRs and MRUs). See below for more information on the eight point calibration.

The button for compass sensor setup is the initial compass calibration to be done on HPR and MRU units. This will be done at the factory so it does not need to be done by the user unless changes to the system have caused the compass to stop working well. If this calibration is performed, then the “Final Compass Calibration” (Eight Point Compass Calibration) should be re-done afterwards.

14.3.5. Eight Point Compass Calibration

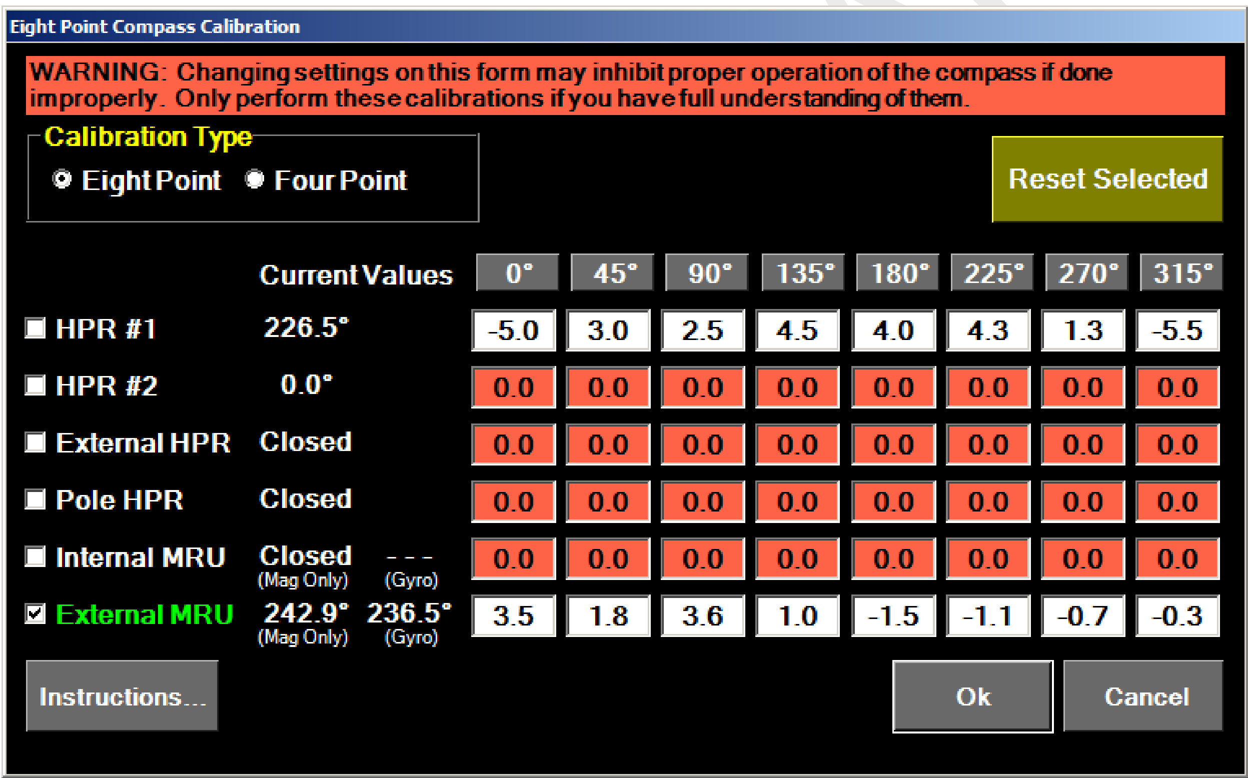
The eight point compass calibration routine is provided to obtain optimal heading accuracy from the compass source. This is extremely important for accurate operation of the Doppler Navigation System. The eight point compass calibration should only need to be done rarely, if done properly. To adjust the compass when using the system in different geographic regions, use only the “Magnetic Declination Offset” on the “General” tab of the “Heading Pitch Roll Configuration” window.

For an external HPR or ROV HPR, the calibration would be done with the unit on a level surface. For the Navigator Gamma, the Navigator Delta (for Compass #1), and the Internal MRU, this will be done with the Navigator on its normal level plane where the faceplate is 30 degrees up from level. For Navigator Delta Compass #2 (optional), this calibration must be done with the Navigator sitting upright so that the faceplate is vertical.

The Eight Point Compass Calibration window can be opened by clicking on the 8 Point Calibration button. From this window, 8 point calibrations can be performed on any one of or all the currently active sources. The left column displays the sources available for compass calibration. The check boxes to the left will indicate the sources to which the calibrations will be applies. The compass source that DiveLog is currently using will be shown in green for reference.

The “Current Values” column will be the current compass values, with any complete or partially complete calibrations values applied so the calibrations can be immediately verified. For any MRUs, a second value may be shown for reference only that favours the gyroscopes and accelerometers, the value being calibrated will be the left value which favours the magnetometers.

For sources that have no calibrations applied the row will read all zeros and be highlighted in red. Once calibration process is begun and the first value is saved, the row will turn white.



Note: When this window is open, the Magnetic Declination Heading Offset (set on the Heading Pitch Roll Configuration window) will not be applied to correct the compass reading. This is so that the compass graphic on the Navigation View will point to Magnetic North during this calibration.

To perform the eight point compass calibration:

First find a good mechanical compass. Take the mechanical compass and the system to be calibrated to a location that is away from any ferrous metal (iron, steel, etc) or other magnetic objects.

The “Eight Point Compass Calibration” window sets offsets for eight points on the compass to compensate for magnetic irregularities of the system. During the calibration, ignore the graphical compass display on the main screen of DiveLog. You will be lining up the Navigator with a mechanical compass. This calibration routine is meant to get the system compass pointing at exactly **Magnetic North**.   The Magnetic Declination offset may be used after this routine to get the system compass pointing to **True North**.

On the Compass Calibration window, either set “Eight Point” or “Four Point”. Setting this to four point allows for quicker and easier setting of the offsets, but there is a loss in accuracy (Eight Point is recommended).

The “Reset Selected” button will clear the current calibration values for any source that has a check to the left of it.

To perform the calibration:

- Point the Navigator/ROV/HPR to the exact North heading that is shown on the separate mechanical compass (drawing a line on a surface helps to get an accurate north direction).
- Click the “0°” button to calibrate the North position.
- Next, rotate the Navigator/ROV/HPR to a position exactly 45° clockwise from North, so that the unit is pointing exactly North East on the mechanical compass.
- Hit the next button, labelled “45°”.
- Continue this step through the next 6 points, setting the Navigator/ROV/HPR on each heading labelled on the button, then clicking the button. All buttons will be blue when you are finished.
- Verify the calibration by pointing the Navigator/ROV/HPR to each of the 8 points and confirming the values in the “Current Values” column match with the mechanical compass.

Note: Allow a few seconds at each point for the compass readings for each active source to stabilize before clicking the heading button.

Click “ok”. At this point you should be able to point the Navigator/ROV/HPR towards different headings and have an accurate heading shown on the graphical compass displayed, although it will point to Magnetic North.

When the calibration is complete, set the Magnetic Declination (See section *14.3.2 Magnetic Declination (Heading Offset)*.

14.3.6. Compass Sensor Setup

The Compass Sensor Setup is meant for the standard HPR unit (External HPR or Navigator internal HPR), and is used to tune the compass for the best operation within its electronic environment. This function is not available for the MRU.

On the Navigator Gamma, and the Navigator Delta main HPR, these calibrations will be done with the Navigator on its normal level plane where the faceplate is 30 degrees up from level. The Navigator will be pitched and rolled in these calibrations, but all pitching and rolling must be done about this center plane.

Note: When the Advanced Compass Calibration window is open, the Magnetic Declination offset, and the eight point calibration will not be applied. This is so that the compass graphic on the Navigation View will point to the raw (uncalibrated) heading.

This window has three different calibrations organized on three separate tabs. They are the sensor Internal Calibration, the Roll Heading Offset calibration, and the Pitch Heading Offset calibration.

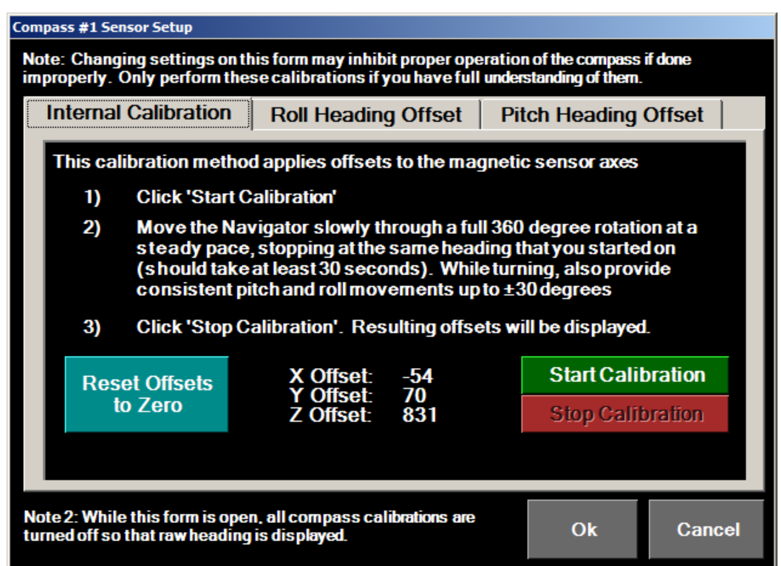
The Sensor Internal Calibration will be performed at the factory, so this usually will not need to be done by the user. Re-perform these calibrations if changes to the system have caused inaccurate compass results.

Sensor Internal Calibration

This HPR sensor calibration window is not relevant to any MRUs. This calibration method applies offsets to each axis of the internal HPR sensor for optimal performance of the compass. This is done by rotating the Navigator a full 360 degrees so that the compass module can is exposed to all possible headings.

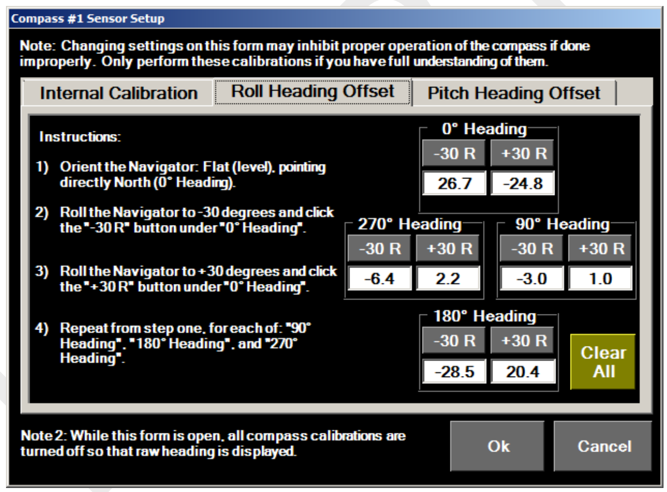
Pressing “Reset Offsets to Zero” will zero each of the axis offsets. This should only be used if the calibration is causing erratic compass operation. Otherwise, replace the offsets with new values by performing the 360 degree rotation.

Make sure the Navigator is as far away as possible to any ferrous metal (iron, steel, etc), or any magnetic devices.



Rotation method: Hold the Navigator so that it is level. Click the "Start Calibration" button. Rotate the Navigator a full 360 degrees at a slow but consistent speed (the full rotation should take at least 30 seconds). While the 360 rotation is performed, also provide consistent pitch and roll movements up to ±30 degrees pitch and ±30 degrees roll. When the rotation is complete, click the "Stop Calibration" button.

The displayed offset values will update with the new values. Since the compass sensor has been recalibrated, the Roll Heading Offset calibration and the Pitch Heading Offset calibration should be performed. After these calibrations are performed, the Final Compass Calibration (eight point calibration) should also be performed.



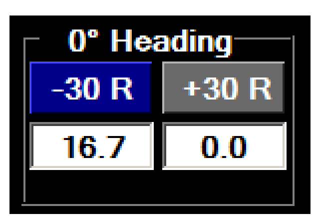
Roll Heading Offset

This HPR sensor calibration window is not relevant to any MRUs. The purpose of the Roll Heading Offset is to compensate for compass swing when the Navigator is rolled to the left or the right. This calibration is important to keep the compass accurate when the Navigator is tilted.

Note: During this calibration, the *pitch* value should be kept close to zero.

To perform the Roll Heading Offset:

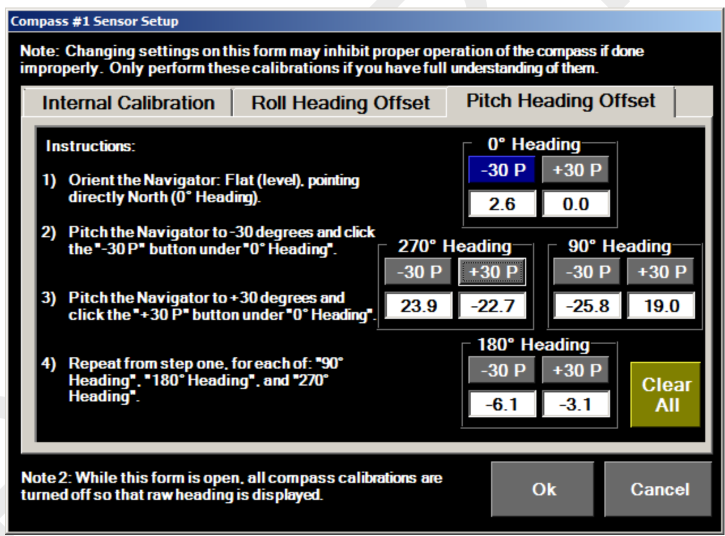
- Set the Navigator on a flat, level surface, far away as possible from ferrous metal, or magnetized objects.
- Watch the compass graphic on the Navigation View, and the numeric "Heading" value below it. Line the Navigator up with what the graphic displays as North (0°).
- Keeping the Navigator pointed in the same direction, roll the Navigator to the left, until the "Roll" value below the graphical compass display reads -30. You may notice that the compass direction changes as you roll the Navigator, which is what will be corrected by this calibration.
- Click the "-30 R" button under the "0° Heading".
- Roll the Navigator back to level. The compass should read approximately O° (if not, move the Navigator to point to O°).
- Keeping the Navigator pointed in the same direction, roll



the Navigator to the right, until the roll indicator below the graphical compass display reads approximately 30.

- Click the “+30 R” button under the “0° Heading”.
- You have now completed the roll calibration for North, but this must be done for East, South, and West.
- Set the Navigator flat and level, and position the Navigator so that the compass displays East (90°). Repeat the above procedure for “90° Heading”, “180° Heading” (South), and “270° Heading” (West). For each of these headings, the Navigator will be rolled to -30 degrees, then +30 degrees, and the corresponding button clicked to set the calibration.

Pitch Heading Offset

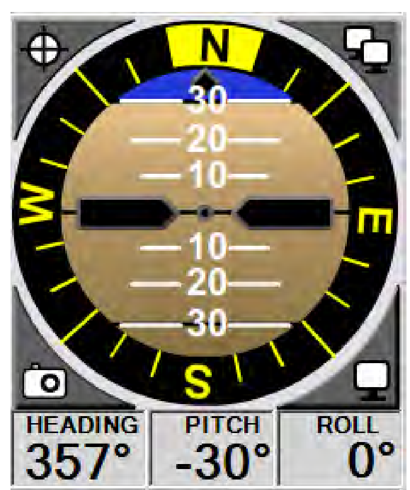


This HPR sensor calibration window is not relevant to any MRUs. The purpose of the Pitch Heading Offset is to compensate for compass swing when the Navigator is pitched up or down. This calibration is important to keep the compass accurate when the Navigator is tilted.

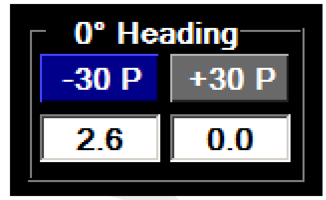
Note: During this calibration, the *roll* value should be kept close to zero.

To perform the Pitch Heading Offset:

- Set the Navigator on a flat, level surface, far away as possible from ferrous metal, or magnetized objects.
- Watch the compass graphic on the Navigation View, and the numeric “Heading” value below it. Line the Navigator up with what the graphic displays as North (0°).
- Keeping the Navigator pointed in the same direction, pitch the Navigator down, until the “Pitch” indicator below the graphical compass display reads -30. You may notice that the compass direction changes as you pitch the Navigator, which is what will be corrected by this calibration.
- Click the “-30 P” button under the “0° Heading”.
- Pitch the Navigator back to level. The compass should read approximately O° (if not, move the Navigator to point to O°).



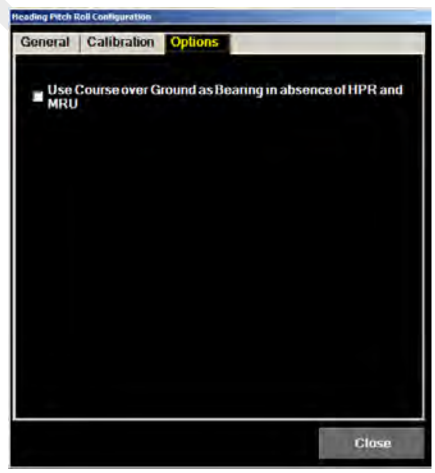
- Keeping the Navigator pointed in the same direction, pitch the Navigator to up, until the pitch indicator below the graphical compass display reads approximately 30.
- Click the “+30 R” button under the “0° Heading”.
- You have now completed the pitch calibration for North, but this must be done for East, South, and West.



- Set the Navigator flat and level, and position the Navigator so that the compass displays East (90°). Repeat the above procedure for “90° Heading”, “180° Heading” (South), and “270° Heading” (West). For each of these headings, the Navigator will be pitched to -30 degrees, then +30 degrees, and the corresponding button clicked to set the calibration.

When all 3 tabs on the Compass Sensor Setup window have been completed, then the Final Compass Calibration (eight-point calibration) should be completed.

14.3.7. Compass Options

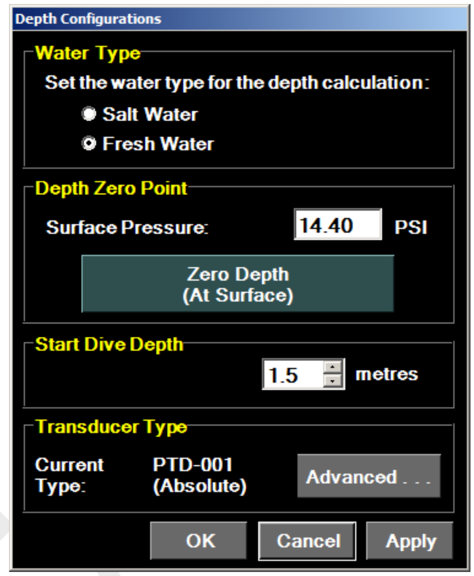


The options displayed on the Options tab depend on the particular system.

The first option allows the compass heading display to use the GPS course over ground as the data source if no Heading Pitch Roll sensor or Motion Reference Unit is installed/connected. This is useful for navigation when only using a GPS. Note that when using this option, if the system stops moving, the compass graphic will show “No Data” since a heading can only be derived from the GPS when the system is in motion.

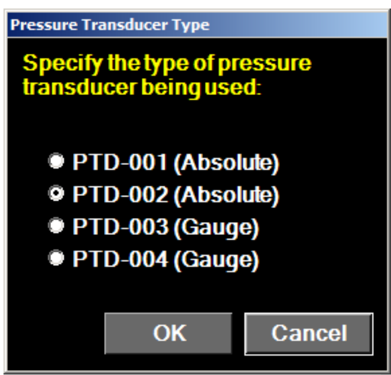
The second option is available on the Dive Tablet only, and enables the built-in compass sensor. Normally the built-in compass is disabled due to the low accuracy compared to the MRU.

14.4. Depth Configuration



Water Type: To get an accurate depth reading, select the type of water that the system will be used in. This setting adjusts the pressure to depth conversion (by setting the water density).

Depth Zero Point: While the unit is just above surface of the water, click the button "Zero Depth (At Surface)". This will effectively set the zero point for the depth, factoring in altitude and atmospheric pressure. If the unit is on the surface and a non-zero value for depth is shown, then this value should be re-set.



Transducer Type: This field displays the type of pressure transducer used. Clicking "Advanced" will open up the "Pressure Transducer Type" window (shown right). Different systems are designed to work with different types of pressure transducers, and it is important that this setting is correct for DiveLog to be able to communicate with the pressure transducer. This should normally not be changed once the system is initially set up. If in doubt, consult Shark Marine before changing this setting.

Start Dive Depth: This setting is the depth threshold which will cause a dive to be started or ended. When the unit's depth descends beyond this value, a dive is started: The Dive Time starts counting and the track starts to record. When the unit ascends back up past this depth, the track will stop recording and the Surface Interval will start counting. If the dive is not continued within ten minutes then the dive will be logged in divelog.txt. See section *8.3 Dive Time, Dive Number, and "divelog.txt"* for details on starting dives.

15. External Peripherals

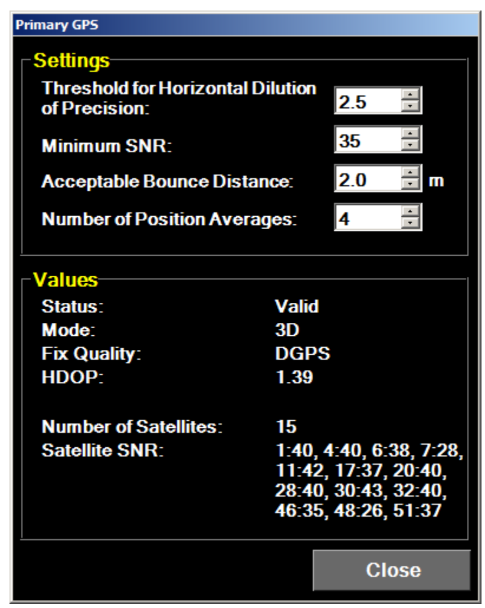
This section outlines the software operation of hardware accessories that can be connected to the system. These peripherals are optional, and a system may or may not be equipped with these devices. Refer to the hardware manual for each of the devices for information on set-up and operation.

15.1. GPS

The GPS (Floating GPS, Surface GPS, Pole GPS, et cetera) connects to one of the system's serial or USB ports and provides geodetic positioning. If a USB GPS is used, the device will create a COM port on the system. For either device, simply ensure the COM port on the System Setup window is set to the port that the GPS is connected to, and ensure the COM device is turned ON (this setup will not need to be changed unless changing where the GPS is plugged in). Once set up, DiveLog will have a position when the GPS is able to acquire the necessary satellite fix.

15.1.1. GPS Config

To reach the GPS information window, click "Config" beside Primary GPS or Secondary GPS on the System Setup window.



Threshold for Horizontal Dilution of Precision:
This setting allows DiveLog to filter out low accuracy position fixes. The default setting is 2.5. Horizontal Dilution of Precision (HDOP) is an indicator of the position accuracy determined by the GPS device, where a lower number indicates a more accurate position. If an HDOP value reported by the GPS is above the setting on this window, then DiveLog will throw out the position (DiveLog will invalidate it). This is useful where position accuracy is important and GPS positions become inaccurate or "bouncy".

Minimum SNR (Signal to Noise Ratio):
This setting also invalidates poor quality GPS readings. A higher SNR means a better signal, so lowering this threshold will allow poorer quality position fixes to be used by DiveLog. This is meant to filter out bad readings when acquiring satellites after the GPS has been underwater. After 30 seconds of invalidated readings, DiveLog will allow positions with a lower SNR if all SNR values during that time are below the threshold.

Acceptable Bounce Distance:
At slow speeds, GPS position fixes usually appear bouncy. Within the Acceptable Bounce Distance radius, DiveLog will smooth out this bouncing by averaging the positions. Outside of this radius, DiveLog will assume the GPS is actually moving by that amount and will not perform position averaging.

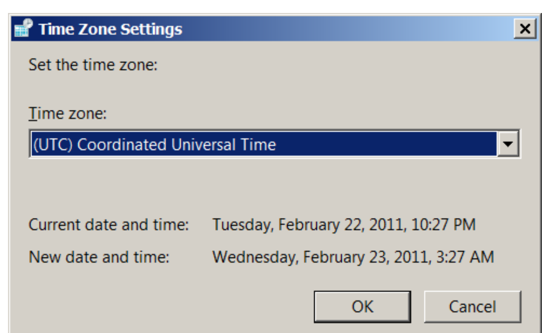
Number of Position Averages:
When averaging positions (as described above), this is the number of consecutive positions that will be averaged. A higher number will give smoother tracks (at low speeds), but the position will have some lag.

Status:
This indicator shows the validity status of the GPS. The possible states are:

Valid:	A good position is being received.
Invalid:	The GPS device does not have a satellite fix.
Acquiring:	The GPS device has found satellites, and the signal should be valid momentarily.
Bad - 2D:	The GPS doesn't have enough satellites for an accurate 3D fix, so DiveLog will consider the position invalid.
Bad - HDOP:	The HDOP reading is above the "Threshold for Horizontal Dilution of Precision", so DiveLog will throw out these positions.
SNR Too Low:	The SNR is below the "Minimum SNR" threshold and DiveLog is throwing out the current position fixes.

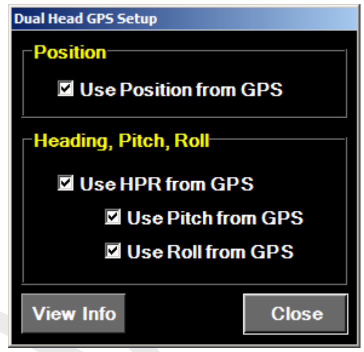
The other fields displayed on this window are values transmitted to DiveLog from the GPS and are displayed for informational purposes.

15.1.2. Setting of System Time and Time Zone



Due to the importance of proper time-stamping of files for cross referencing, the GPS will set the system clock on the computer each time it acquires a fix and every ten minutes if a long term fix is established. This keeps the system clock accurately set. When setting the system clock, DiveLog will use the current time zone setting in Windows to offset the time from UTC time. If you wish to always use UTC time for all time-stamping of files, set the time zone in Windows to "(UTC) Coordinated Universal Time". To use local time for time-stamping, set the time zone in windows to your local time zone. The time zone setting can be checked by clicking on the date on the Windows Start Bar, then selecting “Change date and time settings...”.

15.2. Dual Head GPS



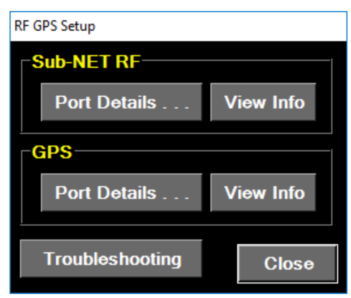
The Dual Head GPS connects to one of the system’s serial ports and provides both geodetic positioning and HPR information.

To reach the setup window, click “Config” for Dual Head GPS on the System Setup window COM Setup table. On the Dual Head GPS Setup window, you can configure which inputs are used. The GPS and HPR portions of the input data are utilized by DiveLog just like any other GPS or HPR source.

The “View Info” button opens a window to setup and view details on how the GPS is functioning . See section *15.1.1 GPS Config* for more information.

15.3. RF GPS

The RF GPS is a floating, combined radio modem and GPS unit. This is a useful component in a Sub-NET network to both establish the current position, and communicate with other systems to share positions and messages. See section *15.15 Sub-NET System* for details on Sub-NET.



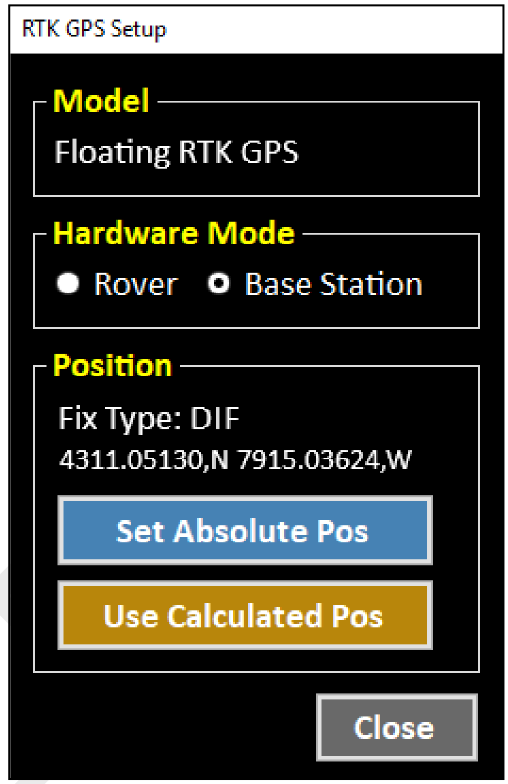
To reach the RF GPS communications setup window, click “Config” for the RF GPS on the System Setup window COM Setup table. On the RF GPS Setup window, you can view the communication details for both the RF modem and the GPS.

The “View Info” button under Sub-NET RF opens the Sub-NET Hardware Window, which allows viewing and configuring Sub-NET hardware. See section *15.15.6 Sub-NET RF Settings* for more information.

The “View Info” button under GPS opens a window to setup and view details on how the GPS is functioning. See section *15.1.1 GPS Config* for more information.

The “Troubleshooting” button opens a window to view details on the port expander hardware used to multiplex the RF modem and GPS communications.

15.4. RTK GPS



The RTK GPS connects to DiveLog through the RTK GPS COM port. This device provides DiveLog with a high accuracy geodetic position. When the GPS and its base station are operating in a "fixed" high accuracy mode, the main position display will indicate "GPSr" (see section *3.4.3 Position Sources*).

If an RTK GPS is connected to DiveLog, the RTK GPS Setup window can be used to configure its hardware mode and position settings. To open this window, click the RTK GPS Setup button at the bottom of the GPS Configuration window. See section *15.1.1 GPS Config*. Note, this button is only available for the RTK GPS device.

If an RTK GPS is connected and communicating, the window will open and show the current hardware mode. This can be either:

- **Rover**: Provides GPS position information to DiveLog.
- **Base Station**: Sends correction data to the Rover to improve position accuracy.

Selecting a different hardware mode will set and save the new setting in the RTK GPS head. This will persist after powering off the GPS unit.

If the unit is in the Base Station hardware mode, the Position field shows the current fix type and the current position of the unit. Two options are available for the Base Station position:

- **Absolute Position**: Used when the location of the Base Station is precisely known (e.g. a surveyed landmark). User provides the position.
- **Calculated Position**: Used when the location of the Base Station isn't precisely known. GPS head provides the position, which locks in after a fixing period.

If the unit is not a Base Station, or the unit hasn't yet found a fixed position, the options to set the position, both absolute and calculated, are disabled. The unit is polled every 2 seconds to ensure these options become available when a fix is found.

15.5. VLT-10 Long Baseline System

15.5.1. LBL Overview

The VLT-10 Long Baseline System provides DiveLog with a very precise underwater position source. A Floating GPS is used for setting the positions of the Remote Baseline Stations (RBS) when they are deployed. Alternatively, the positions of the Remote Baseline Stations may be entered manually.

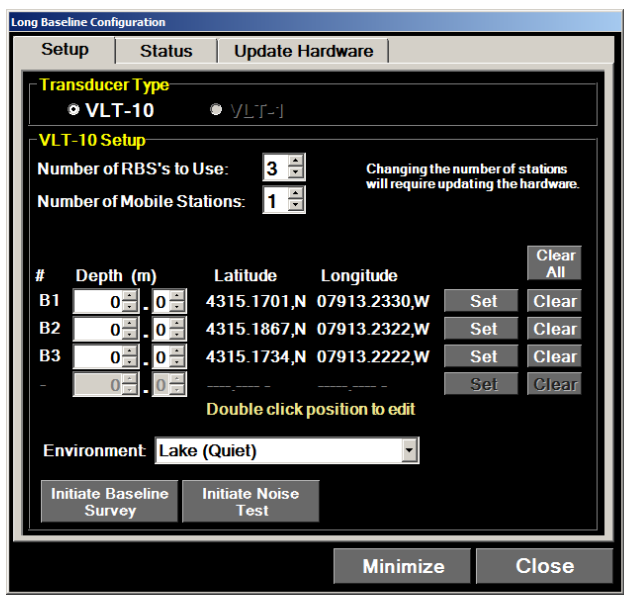
When a GPS position becomes invalid (such as when submerged or otherwise unavailable), the VLT-10 system will immediately activate and provide DiveLog with a position. When the GPS again provides a valid position, the VLT-10 system will stop pinging to conserve power.

When deploying the Remote Base Stations, their placement is important. The baseline is defined as the line starting from station 1 to station 2. The placement of station 3 must be placed on the **right** side of the baseline. This is covered in the "VLT-10 and RBS1-H Navigator Long Base Line (LBL) Hardware Manual".

15.5.2. LBL Communication Settings

See section *13 System Setup* for a description on setting up the LBL Communication Settings. The default communication settings are listed in section *13.1.3 COM Devices*.

15.5.3. LBL Configuration



The Long Baseline Configuration Window can be reached with the "LBL" button on the bottom right of the Navigation View, or from the "Config" button for the LBL on the System Setup window.

The LBL Configuration window allows set-up, configuration, and checking the status of the long baseline positioning system. The LBL configuration window is organized as three tabs.

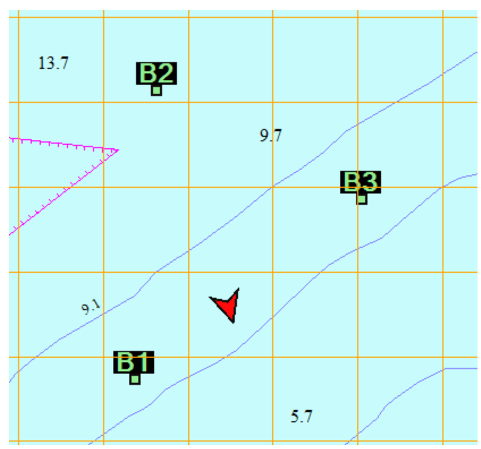
Under the Setup tab, the model of the LBL system is chosen. The standard type of LBL is the VLT-10. If using a VLT-1, no set-up on the window is required other than selecting the option for the VLT-1. The setup for the VLT-1 will take place in an external application which is not part of the standard DiveLog installation.

If using the VLT-10, then the setup of the system must be specified. The first entry is the number of remote baseline stations (RBS). Two, three, or four stations may be specified (the default is three stations). The second entry is the number of mobile stations that will be used. The default is one mobile station, but up to four mobile stations may be used simultaneously. If using multiple mobile stations, then a synchronizer station must be used to coordinate them.

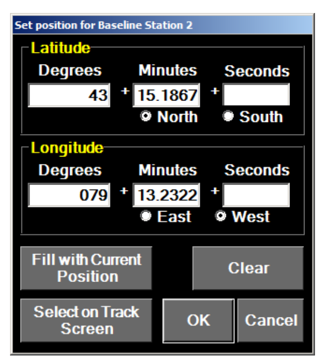
If either of these two numbers are changed, then all stations used (mobile, RBS, and synchronizer if applicable) must be updated with the proper operational parameters. See the document *VLT-10 and RBS1-H Navigator Long Base Line (LBL) Hardware Manual* for more information on updating the units.

If using two RBS's, another option will become visible for specifying the side of the baseline to be used, either left or right. The left or right selection specifies while side of this line the mobile station will be positioned during operation.

Note: The baseline is the line made <u>from</u> station B1 <u>to</u> station B2



The table on the Setup tab displays the setting for depth and position of each station. When deploying the stations, estimate the depth below the surface of each transponder. The values for each station depth can be changed with the up and down arrows. The RBS's will be identified in the table with its number: either B1, B2, B3, or B4. Be sure during deployment that the position set in the table corresponds to the correct number as labelled on the housing of the RBS.



When a station is deployed, the position for that station must be set. If a GPS is connected (or other position source other than the LBL), when the transducer is put in the water, click the "Set" button. This will automatically set the position of the station based on DiveLog's current position. Do this for each station when they are deployed. By double clicking the position text, a window will be displayed that allows manually entering or editing the position (see image, right). Also with this window, the "Select on Track Screen" button allows a position to be selected by clicking a point on the Track Screen image.

After the positions of the baseline stations are set, the positions will show up on the Track screen as “B#”, where # is the station number. The color of the station on the track will represent the station status, and is as follows:

- **light blue** DiveLog has not completed setting up the base station positions.
- **green** if the remote base station is communicating normally
- **red** if the remote base station is not providing a valid range. This may happen intermittently if a remote baseline station is far from the mobile station, or an object is blocking the acoustic signal from the station.

When deploying the stations, the order that they are placed in the water does not matter, but the locations they are placed is important. The placement of station number three must be placed on the **right** side of the baseline. See section *15.5.1 LBL Overview* or the document *VLT-10 and RBS1-H Navigator Long Base Line (LBL) Hardware Manual* for more information.

The last parameter to be set up is the environment, which is used to determine the noise threshold. Beside “Environment:”, choose the setting that represents the environment used for the best results. If there are problems with signal validity then try choosing a noisier environment setting, which will use increased noise filtering although the system’s maximum range may be decreased.

VLT-10 BaseLine Survey

The baseline survey is a self-adjustment, where the VLT-10 communicates with the stations to determine the most accurate positioning. The survey is not required, but should be performed after the RBS’s have been deployed, especially if the accuracy of the positioning may be questionable.

Note: If the system is using a synchronizer station, then the baseline survey feature will not be active since in that case the synchronizer station performs the interrogating rather than the mobile station.

Before initiating the baseline survey, make sure of the following:

- The RBS’s have been deployed in the water, and are turned on.
- The positions of all remote baseline stations are set, or at least stations 1 and 2.
- The VLT-10 mobile station is in the water, somewhere within the baseline network

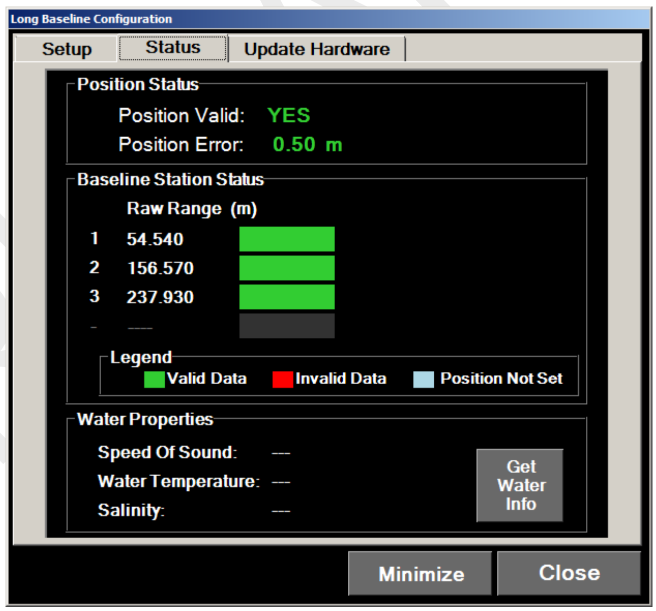
If the above conditions are met, then click “Initiate Baseline Survey”. During the survey process the mobile station should stay in the same place relative to the remote baseline stations. Once the survey completes, the station positions may be adjusted based on the distance measurements taken by the VLT-10. Adjustments in the station positions will be reflected on the Setup tab and the Track Screen. The survey should take less than two minutes. If it takes longer or doesn't complete successfully then that is an indication of a problem with noise or station geometry.

VLT-10 Noise Test

A noise test can also be performed to test the environment, by clicking "Initiate Noise Test". When performing the noise test, the VLT-10 listens to the ambient noise in the water. During the noise test, the present noise level will be displayed at the bottom of the window. Make sure the VLT-10 remains in the water during the noise test. When "End Noise Test" is clicked to terminate the test, a recommendation will be made by DiveLog for the "Environment" setting.

15.5.4. VLT-10 System Status

Under the Status tab on the Long Baseline Configuration window, information for the status VLT-10 system is displayed.



For the position status, validity and the position error are indicated. The position will be invalid if the VLT-10 transducer is unable to obtain ranges from the required number of remote base stations. The position error will give an indication of how closely the geometry resolves a position. For a good setup, error should be around 0.5 meters. For a poor setup, error may be around 1.5 meters.

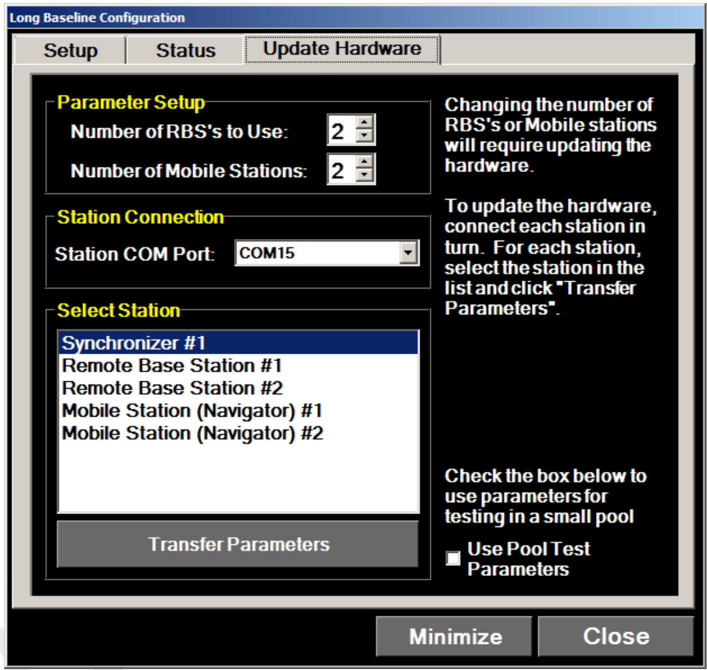
The Baseline Station Status table shows the raw range to each station, which are used to calculate DiveLog's position. The status bar as well as the base station indicator on the track screen will change color as follows:

- **Light blue** indicates that RBS position has not been set (set-up has not been completed)
- **Green** indicates that a raw range has been received and the station status is ok.
- **Red** indicates that a range cannot be obtained from this station, or the range does not fit the baseline geometry. This may indicate an obstruction in the water is inhibiting communication of the station, the station is too far away, the station is not switched on, or a multi-path situation.

To view the water properties that the VLT-10 is using for the position calculation, click “Get Water Info”.

15.5.5. Updating LBL Hardware

The “Update Hardware” tab on the Long Baseline Configuration window allows updating the operating parameters for each station. Depending on the number of stations used, each station must contain a set of identical parameters for proper operation. When either of the settings “Number of RBS’s to Use” or “Number of Mobile Stations” are changed, all stations must be updated. A station can also be updated with this interface to change its number (such as if swapping a baseline station with another one).



Updating the parameters in the stations is done by connecting one unit at a time to the Navigator/computer with the proper programming cable. Refer to the document “VLT-10 and RBS1-H Navigator Long Base Line (LBL) Hardware Manual” for more information on cable connections.

The communication port for the transfer must be selected. It is recommended that the same external COM port on the system that is normally used by the VLT-10 is also used for programming the stations, although any external COM port may be used. If the selected COM port is already in-use by DiveLog, that is ok. Communications to the other device will be automatically closed during the parameter transfer and re-opened when the parameter transfer is complete.

After the station to be programmed is connected to the external COM port, in the “Select Station” list, choose proper the type and number of the station that is currently connected for programming, as follows:

- Select “Remote Base Station” with the appropriate number when programming an RBS. Make sure the number matches the number labelled on the housing of the RBS. *Note: the hardware is the same for each RBS, and the numeric label is just used to keep track of the programmed number of each station.*
- Select “Mobile Station (Navigator)” with the appropriate number when programming the VLT-10 mobile station which mounts to the Navigator. This number will usually be “1” unless using a setup with multiple mobile stations and

a synchronizer station. In a multi Navigator setup, make sure each mobile station is programmed with a different number.

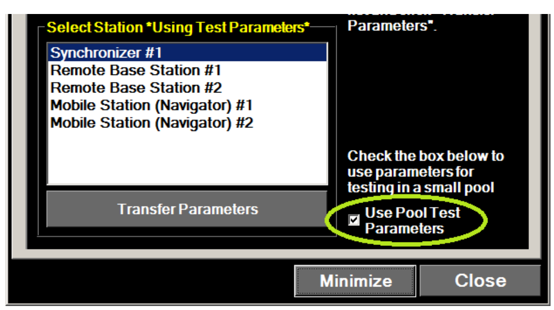
- Select “Synchronizer #1” if programming a synchronizer that will co-ordinate the communications when using multiple mobile stations in the same baseline network. The synchronizer station will always have the number “1” since multiple synchronizers cannot be used.

NOTE: The same hardware is used as an RBS, and in this case the station is being programmed to act as the synchronizer.

When ready, click the button “Transfer Parameters” (or you can just double click the selection in the Select Station list). If the device is connected and ready, you will see a percentage increase from 0 to 100 as the parameters are sent.

If you see a “failed” message during the transfer then it is likely that the station was not turned on, not yet ready, or the connection was interrupted. Check the connections and then retry the transfer. Remember that the stations have a short initialization period after power-up before they will accept the update.

When the device has received the new parameters, unplug it. If programming a series of LBL devices with new parameters simply connect the next device and turn it on. When the new device is connected, select the station type/number from the list to repeat the process.



If testing the system in a small pool or tank, special parameters may be required to allow proper operation. Checking the box beside “Use Pool Test Parameters” will cause parameters to be used allowing very short range operation. All stations must be updated as normal once this option is selected, and the system can be used as normal in the pool. Once the test is complete, the “Use Pool Test Parameters” box should unchecked, and all stations should be programmed again with the regular parameters.

15.6. Doppler Navigation System

The Doppler Navigation System (DNS) consists of system comprises of several components: DiveLog, a Heading Pitch Roll unit (HPR) and the DNS hardware which employs a Doppler Velocity Log unit. DiveLog performs the processing of the heading and Doppler velocity data to generate updates to the system's position.

DiveLog uses a hierarchical approach for positioning: DiveLog will primarily look for position information from an external GPS device. If no GPS information is available (or the data is invalid), DiveLog will then try to get position information from a Long Baseline Positioning System and/or the DNS if connected.

To derive a position from the Doppler, DiveLog will use the data from the Doppler along with the built in compass. The Doppler transducer sends sonar pings downwards to the sea bed and reads the unit's relative movement with respect to the sea bed. The current position will be updated based on the unit's magnitude of movement plus the direction of the movement. As the DNS is used, the geodetic position will then be continuously updated based on the tracked movement. If an LBL positioning system is simultaneously used with the DNS, then the DNS will fill in positions between the LBL updates (the LBL will have less frequent updates than the DNS). As soon as position information from a GPS is available, DiveLog will stop using the DNS for position updates. If a GPS is used, DiveLog will also turn off the Doppler transducer when not needed to conserve power if the DNS mode is set to automatic. See section *15.6.3 Doppler Configuration* for more information.

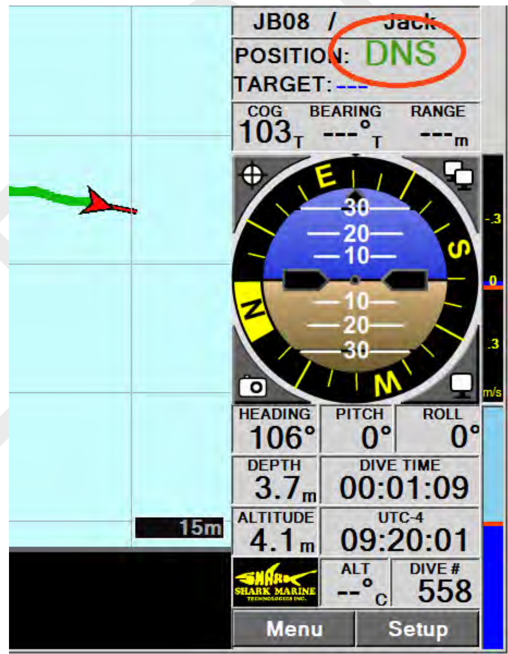
The DNS is also capable of determining velocity relative to the water below the sonar. This can be used to calculate the water current speed if the unit velocity relative to ground is known. Either the DNS velocity relative to ground or a GPS velocity may be used and will be automatically detected by DiveLog. The water current speed and direction is useful when performing Dead Reckoning operations (see section *20.8 Dead Reckoning and Water Current*).

Note that the DNS requires an initial geodetic position before it will operate, since the DNS can only detect movements relative to a known position. The initial position can be from any position source such as a GPS, an LBL positioning system, a topside link, or a position manually set the user (see section *15.6.4 Entering the Current Position*).

The DNS is designed to fill in the positioning gaps when the standard positioning methods such as the Floating GPS and Long Baseline System cannot get a valid position. While the DNS is running, the resulting computed position will be subject to an accumulative error. This is due to the repeated addition of small inaccuracies in the compass heading and the velocity measurements. To prevent an inaccurate position to develop over time when a large distance is covered, it is recommended that DiveLog's position be corrected as often as feasible with the GPS or LBL.

While the Doppler is running, the Altitude above the seabed will be displayed on the Navigation View in DiveLog, and the water column display will show the unit's relative position within the water column. If the DNS is set to automatic mode, the altitude value will become invalid when the Doppler turns off (when there is a valid GPS fix). To have the altitude always updating, change the DNS to continuous mode (see section *15.6.3 Doppler Configuration)*.

15.6.1. DNS Software Operation



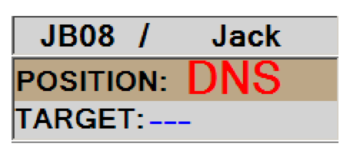
When the DNS is providing DiveLog with a position, "DNS" will be indicated as the position source on the Navigation View of DiveLog (see image, right). If a valid position from a source that provides a hard fix (such as a GPS or LBL system) becomes available, DiveLog will switch over to use that source, and the POSITION indicator will change accordingly. For more information, see section *3.4.5 Hard and Soft Position Sources*.

When the DNS system is operating, DiveLog may make several indications to the user:

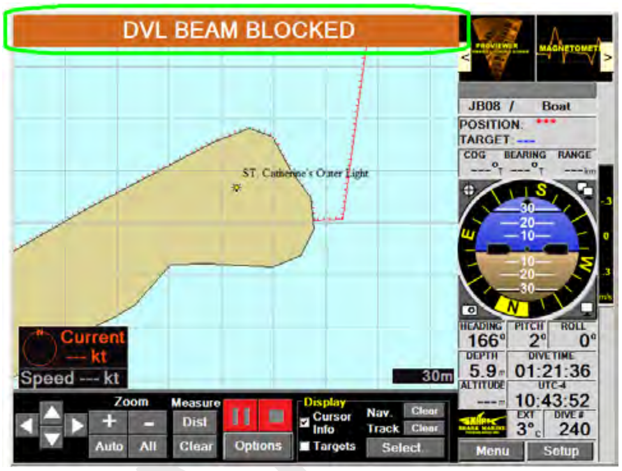
- If the pitch or roll is greater than +-15 degrees, the display box for either pitch or roll will flash red (see image, middle right). This is a warning to the user that the positioning accuracy is decreased due to the large pitch or roll.
- If the Doppler data is invalid, the position box will flash red to indicate this (see image, lower right).

The Doppler data could be invalid for several reasons:

- The Doppler transducer could be too close to the bottom.
- The Doppler transducer could be too far away from the bottom.
- The pitch or roll of the Doppler transducer is greater than +- 25 degrees.
- The material or shape of the sea bottom does not return usable acoustic data.
- One or more of the beams could be blocked by an obstruction such as a cable.



If the head has detected an extremely close object, a “DVL Beam Blocked” message will be shown to the operator (see image, right). Upon seeing this message, the operator should check for an obstruction, as the obstruction may be affecting the quality and accuracy of the DVL readings.



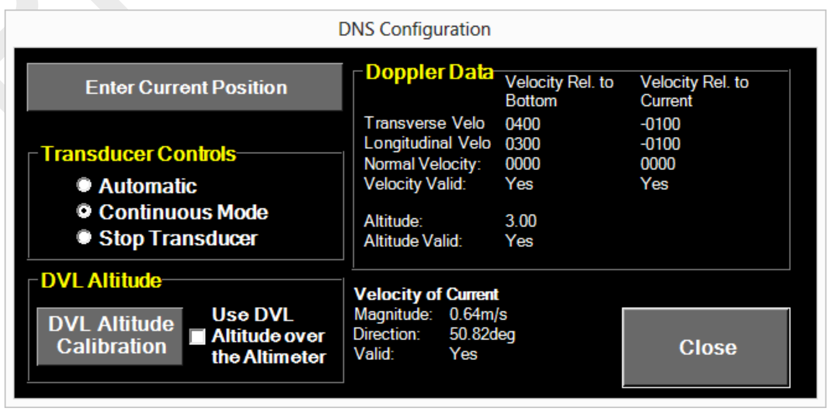
15.6.2. Doppler Communication Settings

See section *13.1 COM Setup Table* for a description on setting up the Doppler Communication Settings. The default communication settings are listed in section *13.1.3 COM Devices*.

15.6.3. Doppler Configuration

To view the configuration settings for the DNS, go to the System Setup window and click “Config” in the DNS row of the table.

Enter Current Position



The “Enter Current Position” button at the top of the DNS Configuration window allows the user to manually enter the current position to *seed* the DNS if no other position source is available. See section *15.6.4 Entering the Current Position* for more information.

Transducer Controls

The Transducer Controls allow the operator to set the operating mode of the Doppler. Normally, this is set to “Automatic”, where DiveLog controls the starting and stopping of the head based on requirement. In this mode, the head will be turned off if there is a valid position from the Primary or Secondary GPS. When the GPS position goes invalid, the

Doppler will be turned on and used to update the position as long as the GPS remains invalid. Once the GPS becomes valid, the Doppler will be turned off to save power.

Selecting “Continuous Mode” changes the head mode to be always on. Since the head is always pinging in this mode, the altitude displayed on the Navigation View will always be available even when the Doppler is not being used for positioning.

To manually stop the head, select “Stop Transducer”. The transducer will then not produce pings until one of the other two options is selected or when DiveLog closes and starts again.

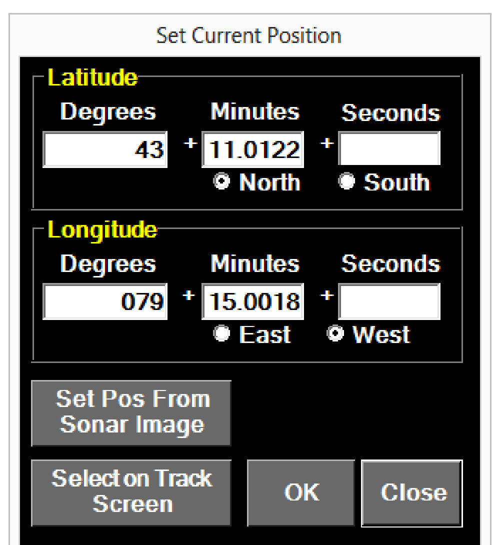
DVL Altitude

The “DVL Altitude” controls allow configuring the altitude value returned from the Doppler head. The button “DVL Altitude Calibration” will open the “Doppler Altitude Calibration” window. This window adjusts the *speed of sound adjustment factor* for the Doppler to accurately calibrate the Doppler altitude readings. See section *15.8 Altitude Calibration* for more information. Note that the settings changed here will only affect the Doppler, and will not affect the Altimeter device.

The setting “Use DVL Altitude over the Altimeter” only applies if the system has both the DNS equipped and a standard Altimeter unit equipped. Select this checkbox if you would like the altitude from the Doppler head to override the altimeter altitude when the Doppler altitude is available.

Doppler Data

The data from the transducer is shown for troubleshooting purposes. The six velocity vectors (3 relative to bottom, 3 relative to water) are given (in mm/second), as well as the altitude (in metres). The validity of the velocities and the altitude are also shown, as “Yes / No”. The calculated magnitude and direction of current is also given at the bottom of the window.



15.6.4. Entering the Current Position

The “Enter Current Position” can be reached by clicking the “POSITION” text in the Navigation View on the main display, or by the button at the top of the DNS Configuration window.

This function allows the user to manually enter the current position if no other position source is available. The geodetic position can be entered in several different formats. The values for latitude and longitude can be entered in decimal degrees, or degrees with decimal minutes, or degrees and minutes and seconds with decimals. If you have a position in decimal degrees, then leave the minutes and seconds boxes blank. If you have a position in degrees and minutes, then leave the seconds box blank. If you have a position in degree, minutes, and seconds, then fill in all three boxes. The current (or last known) position will automatically fill the positon fields when the window is opened, and can then be manually modified.

The button “Select on Track Screen” allows using the mouse cursor to choose a position on the Track Screen image. Once the Track Screen image is clicked, the coordinates of that position will be filled in on the Set Current Position window. The coordinates can then be modified. Click “Ok” to use this position as the current position.

The button “Set Pos From Sonar Image” allows you to set the current position by referencing a point on the Forward-Looking Sonar screen. To set this position this way. Click the “Set Pos From Sonar Image” button, then click the point on the sonar screen you wish the reference. DiveLog will then toggle to the Track screen, where you can click the point on the screen that matches the reference point.

15.6.5. DNS Track and Target Correction

Recorded tracks and targets set while the DNS was used can be adjusted during post-processing to account for heading inaccuracy and cumulative error that may occur when the DNS is used. See section *20.3.1 DNS Track and Target Correction* for more information.

15.6.6. DNS Operational Considerations:

The DNS uses travel over bottom and heading information to determine the present position. The way in which the operator controls the Doppler can also affect the accuracy.

To following is a guideline to achieving the best results using the DNS:

1. Keep the unit as level as possible. You will need to tilt the Navigator/vehicle to properly use the sonar but tilting beyond 15 degrees will degrade accuracy and after 25 degrees the data will not be used to update the position.
2. It is very important that the compass is properly calibrated, and the magnetic declination is properly set to give true bearings. The direction of travel calculated by the DNS will have an error at least equal to the error in the heading.
3. Make sure there is no equipment or cables below the Doppler transducer.
4. Maintain a distance off bottom of at least 30cm. If you are too close the position bar will flash red to indicate invalid returns.
5. As there will always be an accumulative error. Re-setting the position by GPS or LBL at regular intervals is recommended.
6. The more you see the red bars for pitch or roll, the more the position accuracy may be degraded.

15.7. Altimeter

The Altimeter is an external device that will provide DiveLog with an altitude above the seabed. If using the RBPS system, either an Altimeter, or Doppler (DNS) will need to be connected. If the Altimeter is connected, DiveLog will display the altitude on the Navigation View with each valid altitude update. The relative vertical position of the unit will also be indicated on the water column. See section *3.4 Navigation View* for more information on the display of altitude data.

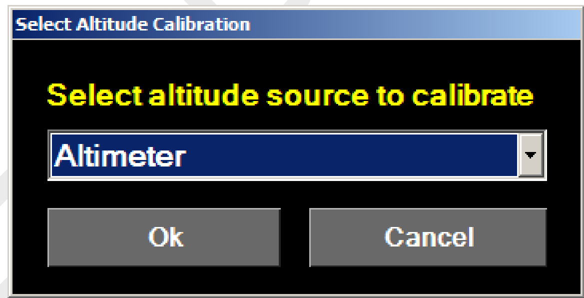
15.7.1. Altimeter Calibration

The distance returned by the altimeter is based on the speed of sound in water. This will vary depending on water temperature and water salinity. To ensure accuracy of the depth readings, it is important that the altimeter is calibrated properly. The Altitude Calibration can be reached by clicking the “Config” button in the Altimeter row of the System Setup window. See section *15.8 Altitude Calibration* for more information.

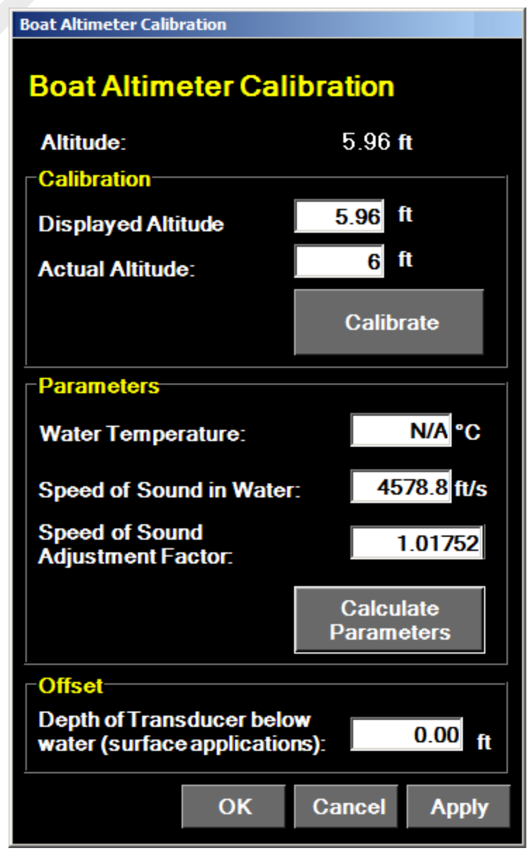
15.8. Altitude Calibration

The distance returned by any sonar device is based on the speed of sound in water. This will vary depending on water temperature and water salinity. To ensure accuracy of the altitude readings, the altitude calibration should be done each time water conditions may be different.

The Altitude Calibration is used for any source of altitude, such as the DNS (Doppler), Altimeter, Boat Altimeter, and Pole Mounted Altimeter. Each of these devices will have separate calibration parameters so they must be calibrated separately if different devices are used.



The calibration window can be reached by double clicking the altitude value on the Navigation View of DiveLog. If a specific altitude source is currently being used, then the calibration window for that device will be displayed. Otherwise, a selection for the proper device will pop up (shown to the right).



Calibration is done by setting a “Speed of Sound Adjustment Factor”. This number is a constant that is used as a multiplier to the distance returned by the head, and compensates for the difference in the speed of sound.

The “Speed of Sound Adjustment Factor” can be set one of two ways. The first (and most accurate) involves running the altimeter in the body of water that it will be used in. Measure the actual distance from the head to the seabed (or a calibration device such as a metal plate) and take note of the distance that the software displays. Beside “Displayed Altitude, enter the value that is displayed for altitude. Beside “Actual Altitude”, enter the actual distance to the bottom (or metal plate). Then click the “Calibrate” button. The program will then calculate the proper “Speed of Sound Adjustment Factor” to multiply the readings by. Note that the “Offset” at the bottom of the window must be set to zero when performing the altitude calibration. Click OK or Apply to use the new adjustment factor.

The second method is easier, but less accurate.

Enter the water temperature then click “Calculate Parameters”. The program will then calculate the “Speed of Sound Adjustment Factor” based on a standard curve for speed of sound versus water temperature. Note that this method does not account for the level of salinity.

If the Altimeter is used on a boat mounted system, the depth of the head below the water surface should be entered so that the depth readings can be offset by this amount. If the Altimeter is mounted to the Navigator, then this value should be zero.

Press OK when done, or hit Cancel to cancel the changes to the calibration.

Note: For RBPS, the setting on this window for “Depth of Transducer below water” should be set to zero since the same setting is set on the RBPS Survey Setup window.

15.9. Pole Mount for Forward-Looking Sonar

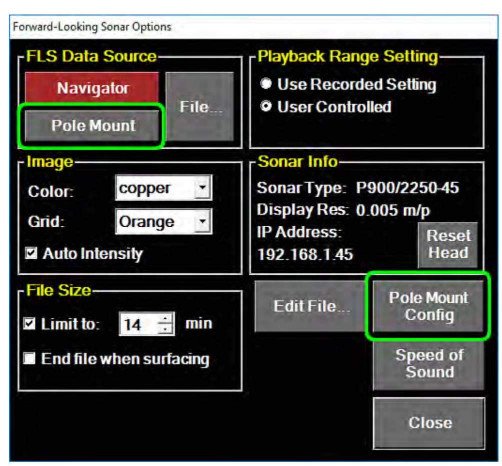
The Pole Mount is used to allow the Forward-Looking Sonar to be operated from the side of a boat or dock. It is currently available in two different types:

- The OSPM Pole Mount with manual pan/tilt.
- The BV3100 Pole Mount with digital software controlled pan/tilt.

Both Pole Mount systems can be combined with a Heading Pitch Roll sensor and/or an Altimeter sensor to provide reference data for the sonar image. Selection of these additional sensors is done on the configuration window for the pole mount.

The Pole Mount communications can be turned on or off in either of two possible ways:

- On the Forward-Looking Sonar options window, in the “FLS Data Source” box, select Pole Mount.
- On the System Setup window, in the COM Settings list, turn ON or OFF the Pole Mount.



If the pole-mounted sonar is connected to a Navigator, then the data source for the FLS can be switched between the Navigator-mounted sonar and the pole-mounted sonar (see image, right). When this is done, power will be toggled ON/OFF to the proper sonar.

On a PC or survey system, the Pole Mount data source must be used. When the Pole Mount data source is active then the pole mount communications port(s) will automatically be turned on.

On the Navigator, when the pole mount is not selected (turned off), the Navigator will use the standard sensors for the source of data for the sonar, as well as HPR, depth, and altitude. When the pole mount is selected (turned on), the data source for the sonar, HPR, altitude, and depth will switch to the pole mount sensors. The selection of these sensors depends on the setup on the Pole Mount Setup window.

15.9.1. Pole Mount Setup

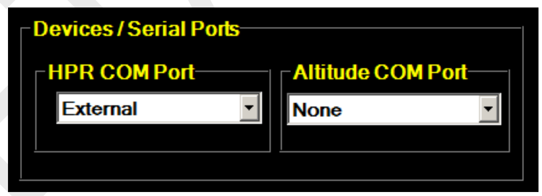
The Pole Mount Setup configures the sensors and connections that are used in pole mount mode. The setup window for the pole mount can be reached in two ways:

- On the FLS Options window, with the button Pole Mount Config.
- On the System Setup window, click the Config button in the COM Settings list for the proper device.

The two pole mount types have a common setup described here. For additional setup unique to the pole mount type, see their respective section below.

Devices/Serial Ports

Note: The OSPM Pole Mount is equipped with a combined HPR/Altitude Sensor. See *15.9.2 OSPM Pole Mount* for information on setup of this model.



For Pole Mount systems not using a combined HPR/Altimeter sensor, the data sources are listed below.

Possible HPR Sources:

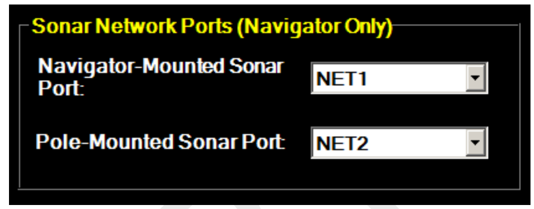
- Internal – The standard internal HPR sensor in the Navigator.
- Internal MRU – The optional internal high accuracy motion reference unit in the Navigator Delta.
- External – An external HPR sensor, which will use the External HPR port in the COM Settings list.
- External MRU – An external motion reference unit which will use the External MRU port in the COM Settings list.
- None – No heading data will be used (Data will be blank on the Navigation View, and the sonar image will not be geodetically referenced).

Possible altitude sources are:

- Altimeter – The port labelled “Altimeter” in the COM Settings list will be used.
- Boat Altimeter – The port labelled “Boat Altimeter” in the COM Settings list will be used. This would normally be an altimeter that is mounted to a boat.
- DNS – The doppler unit will be used for the altitude source (DNS on the COM Settings list).

- None – No altitude will be used (data will be blank on the Navigation View, and the water column graphic will not be available).

Network Ports

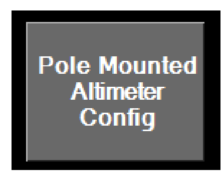


The settings for Network Ports apply only to the Navigator. When the Navigator turns on the pole mount mode, the power is turned off to the Navigator-Mounted Sonar, and the power is turned on to the Pole-Mounted Sonar Port (and vice versa). Specify the NET ports on the Navigator that each of the sonar units are connected to so that the proper sonar is turned on for each mode.

Sonar Depth

Specify the depth the sonar head is from the surface when the pole mount is being used. When pole mount mode is on, this depth will be taken into account for positioning and setting of targets. This value will also show up on the Navigation View in DiveLog and will be recorded to files as the current depth of the system.

Altimeter Config



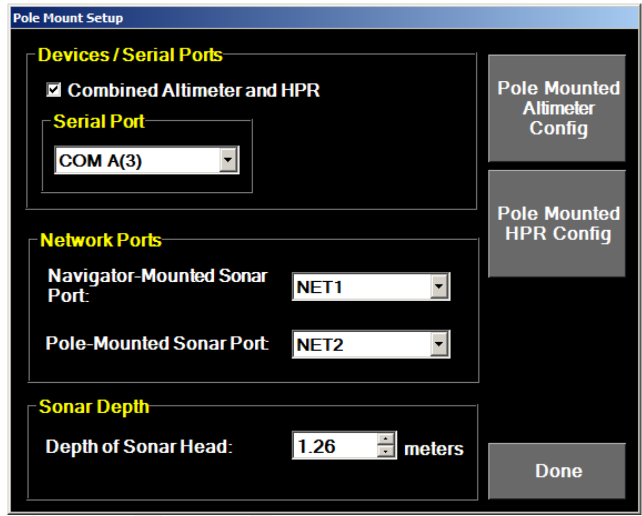
This button opens up the calibration window for the altimeter. Depending on the setting under Devices/Serial Ports, this config button will open up the calibration for the altimeter device that is to be used with the pole. For more information on altitude calibration, see section *15.8 Altitude Calibration*. The calibration settings are separate for each of the several possible altitude sources (the standard altimeter, boat altimeter, combined pole-mounted altimeter, and DNS).

HPR Config

This button opens up the configuration window for the HPR. Depending on the settings under Devices/Serial Ports, this config button will open up the configuration for the device that is to be used with the pole. For more information on HPR configuration, see section *14.3 Heading Pitch Roll (HPR) Configuration*. All of the configuration settings are separate for each of the possible HPR sources (the Internal HPR, Internal MRU, External HPR, External MRU, and combined pole-mounted HPR), except for the mount angle and magnetic declination.

15.9.2. OSPM Pole Mount Setup

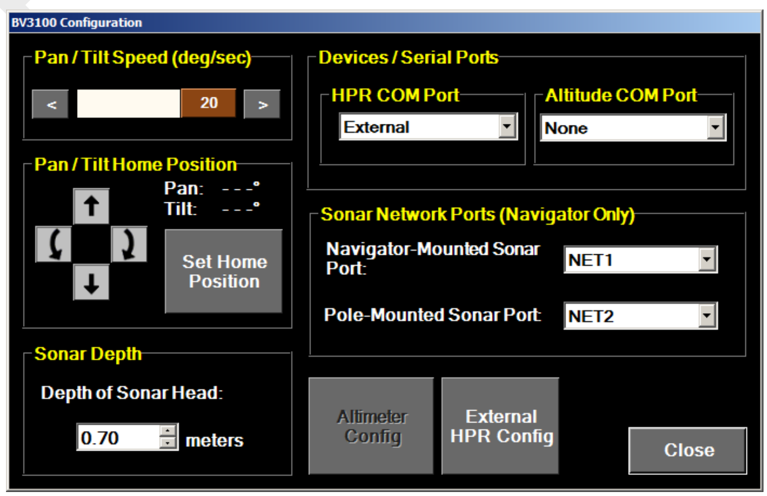
Devices/Serial Ports



In addition to the standard Pole Mount setup described above, the OSPM has the option for using a combined altimeter and HPR device. If the combined altimeter and HPR unit is used, then check the option "Combined Altimeter and HPR". In this case, both HPR and altimeter data will communicate via the OSPM COM port. Otherwise, uncheck this option, and controls will appear to allow selection of alternate data sources. In this case, other COM ports in the COM Settings list will be used.

If the combined Altimeter and HPR is used, the pole mount has an automatic switch back to default sensors: If the pole mount cables are unplugged when pole mount is on, then DiveLog will automatically toggle off pole mount mode and the default sensors will be then used.

15.9.3. BV3100 Pole Mount Setup



In addition to the standard Pole Mount setup described above, the BV3100 Configuration window has additional controls for setting the speed of the unit and the home position.

Pan/Tilt Speed

Use the slider bar to specify the speed that the sonar head will be panned and tilted in degrees per second.

Pan/Tilt Home

The Pan/Tilt Home Position is the position that the sonar head will move to when the home button is pressed on the Forward-Looking Sonar active screen. To set the home position, first make sure the BV3100 communications is turned on and the unit is operating. Then press the arrow button on this window until the sonar is in the desired home position. Press the “Set Home Position” button to save this position.

15.10. Ultra-Short Baseline (USBL) System

15.10.1. USBL Overview

The Ultra-Short Baseline System is used as a position source for DiveLog. It consists of a transceiver, connected to the topside unit running DiveLog through a serial cable and a transponder, connected to a vehicle. The USBL will provide DiveLog with a range and bearing from the transceiver to the transponder, which DiveLog will use to calculate the current vehicle position. The TrackLink software will communicate with the USBL transceiver, and send range and bearing to DiveLog over a virtual serial port connection.

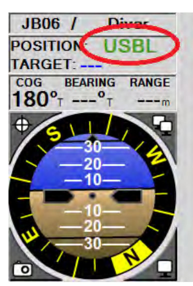
Note 1: The TrackLink software must be configured to use **meters** to work properly with DiveLog. In TrackLink, the units setting can be checked by clicking Configuration > Unit. For more information about the setup of the TrackLink software, see the document *TrackLink Startup Procedure*.

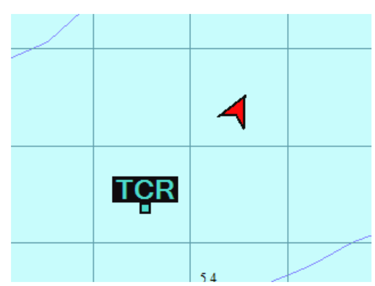
Note 2: The USBL is an “Enabled Feature” in DiveLog, and must be enabled to be functional in DiveLog. Activation will be set from the factory if purchased as part of a Navigator or ROV Topside, or may also be activated with a Security Dongle if on a survey system.

See section *13 System Setup* for a description of setting up the USBL Communication Settings. The default communication settings are listed in section *13.1.3 COM Devices*. For more information on a virtual serial port connection, see section *13.1.4 Using a Virtual Serial Connection*.

15.10.2. USBL Displayed Position

The position of a vehicle provided by the USBL will be displayed as the current position in DiveLog. The POSITION box in the Navigation View will show “USBL” to indicate the current source (see image, right).

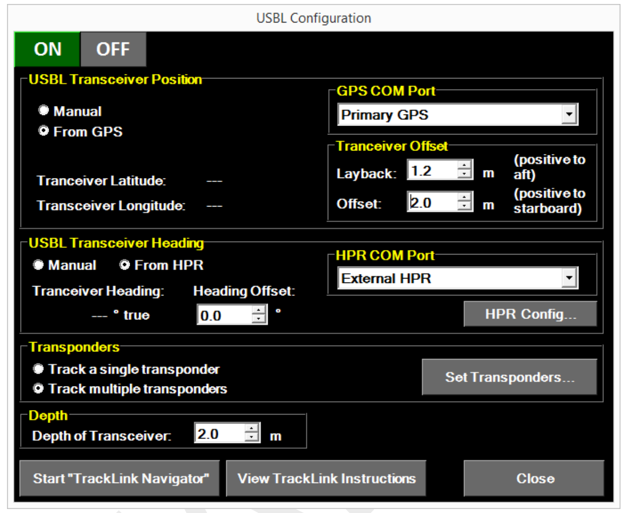




On the Track Screen, the red chevron will be the vehicle (transponder) position. The location of the transceiver will be indicated by a blue dot with the label “TCR” (see image, rightmost).

If any files are recorded with an Active Screen, the standard track files will also be recorded. The vehicle position will be recorded in the track files, but the transceiver position will not be recorded.

15.10.3. USBL Configuration

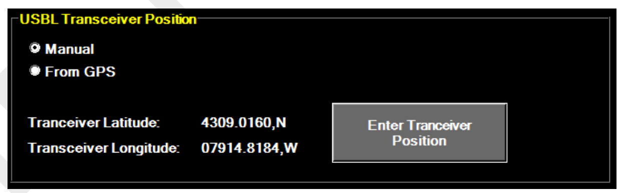


The USBL Configuration Window can be reached with the "USBL" button on the bottom right of the Navigation View, or from the "Config" button for the USBL on the System Setup window.

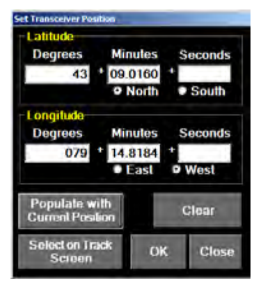
The USBL Configuration window allows configuration of the position and orientation of the transceiver. This information is required to determine a geodetic position for the transponders based on the bearing and range.

USBL Transceiver Position

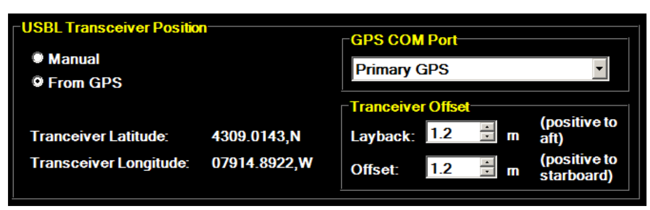
The USBL Transceiver position can be specified in two different ways. The "Manual" selection is used if the transceiver will be mounted in a static location, such as a dock or shoreline. "From GPS" should be selected if using a GPS device for dynamic positioning (i.e. the USBL transceiver is mounted to a moving vessel).



When using "Manual", click "Enter Transceiver Position" to specify the position. The position can be entered manually, or selected on the Track screen.



When using "From GPS", choose the positioning device that will be used from the list. One of these two GPS ports should be set-up on the System Setup window (see section *13.1 COM Setup Table* for more information).



If the transceiver is not directly under the GPS device, then a layback and offset can be specified. If the transceiver is behind the GPS (closer to the aft of the ship) enter a positive value for layback, and if the transceiver is closer to the bow than the GPS, enter a negative layback. If the transceiver is further starboard than the GPS, enter a positive value for the offset, and if the transceiver is further port than the GPS, enter a negative value for the offset. These directions are all with respect to the heading of the transceiver, discussed below.

USBL Transceiver Heading

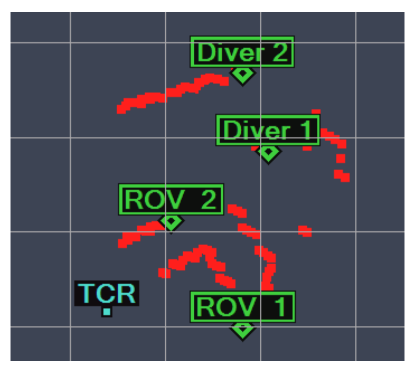
The USBL Transceiver Heading can be specified in two different ways. Select “Manual” if the transceiver is mounted in a static location such as a dock. Select “From HPR” if the heading should be taken an active Heading/Pitch/Roll device (i.e. the transceiver is mounted to a moving vessel).

Note: The static heading must be entered in degrees true. If using a magnetic compass, then the value must be adjusted with the magnetic declination of the region of the application. Alternatively, a true heading can be retrieved from the Track Screen using the measure distance tool if there is a map of the area available.

When using “From HPR”, choose the orientation device that should be used from the list. One of these HPR ports should be set up on the System Setup window (see section *13.1 COM Setup Table* for more information). When the device is connected and communicating, the current heading of the transceiver, in degrees true, will be displayed. A heading offset can be applied in order to correct for the mounting direction of the chosen HPR sensor.

Note: When a dynamic heading “From HPR” is used, the reading will be automatically adjusted with the magnetic declination offset. See section *14.3.2 Magnetic Declination (Heading Offset)* for more information on setting the magnetic declination value.

Transponders



When tracking a single transponder, the tracked position will become the main navigation position in DiveLog.

When tracking multiple transponders, the “Transponders” button will open the Team List, allowing you to enter units by Tranponder ID, and set which unit represents your local position.

All transponders that are not set as “My Pos” will be displayed on the Track Screen with a labelled green diamond. Each transponder will have a separate track recorded when the primary track in DiveLog is being recorded.

If there is a desire to view the tracked positions on another computer, there is a “USBL Target Output” COM port that may be enabled. This port will output all the transponder names and positions on a serial link, and DiveLog running on another computer can receive the positions (using the standard USBL COM port) and display them, with the option to record. See section *13.1.2 Active Ports* for instructions on enabling additional ports.

Launching TrackLink Navigator Software

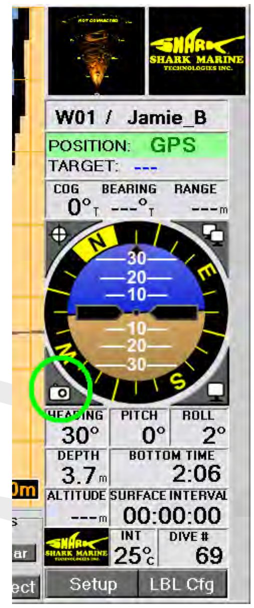
The button “Start TrackLink Navigator” will launch the Tracklink Navigator software, which is the same as clicking the shortcut for TrackLink in Windows.

The button “View Tracklink Instructions” will display a PDF document showing the instructions for initiating USBL tracking, as well as the software setup details that can be used for troubleshooting.

15.11. Cable Payout Encoder

For survey operations utilizing towed sonar or other sensors such as magnetometers, the cable reel may be equipped with a Shark Marine cable payout encoder to measure the length of cable spooled out. This information can be sent directly to DiveLog via the Cable Payout Encoder COM port to be used as the layback for the towed device. For devices (Active Screens) compatible with the Cable Payout Encoder, there will be an option on the Options window to use the data from this COM port. The Cable Payout port can be activated and setup via the COM Settings tab on the System Setup window. See section *13.1.2 Active Ports* for details on activating COM ports.

15.12. NavCam Digital Camera (Navigator Gamma)



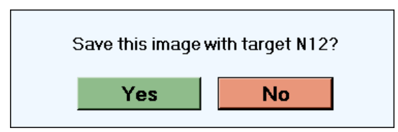
This section applies only to the NavCam running on the Navigator Gamma. If using a Navigator Delta or Survey mode on a PC or topside, refer to section *24 NavCam Screen*.

To open the NavCam preview window, click the Camera button in the bottom left corner of the HPR graphic (see image on right).

If the NavCam is connected to one of the external USB Ports on the Navigator, then the NavCam window will pop up (see image lower right).

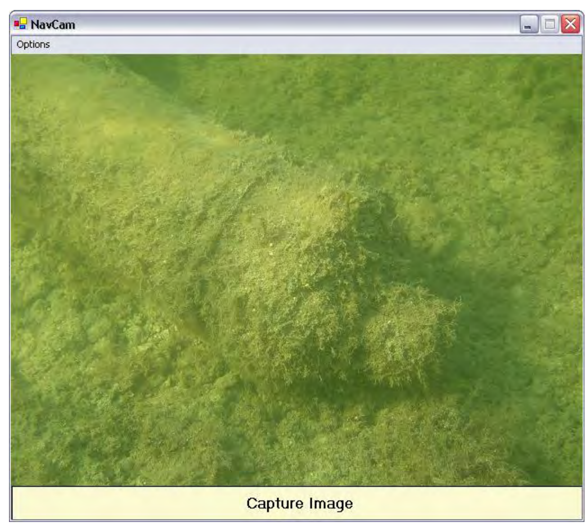
Click the bar at the bottom "Capture Image" to take a snapshot and save the image. The image will be saved with the standard project file naming structure, with the identifier "NavCam", for example: "W01-Joe-NavCam-2009-09-13-11-03-23.jpg".

The normal save location of the image is the "NavCam Images" folder in the folder for the current project. If there is a current target in DiveLog, then the user will be prompted whether they would like to save the image with the target (see image middle right). If answered "Yes", then the image will be saved in the Associated Files directory of the current target. If answered "No", then the image will be saved in the default location (NavCam Images directory in the project directory).



Since the window takes up most of the screen on the Navigator, click the minimize button in the top left of the window to minimize the preview window or close the window when using the Navigator for other purposes.

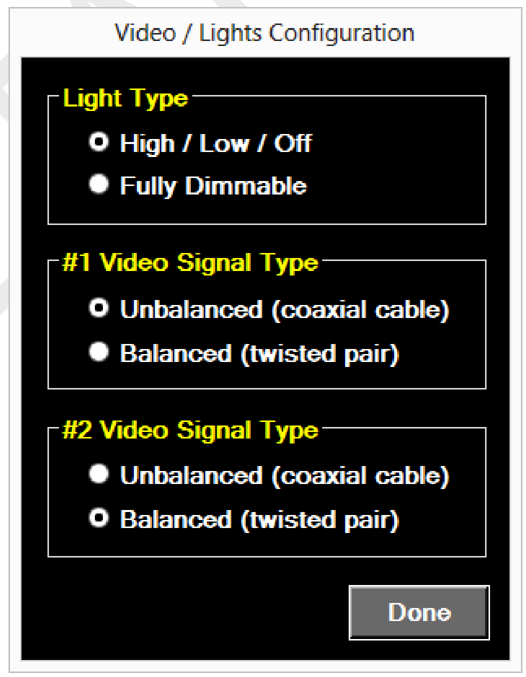
To close the NavCam preview window, click the red X button at the top right corner of the window.



15.13. Video/Light Setup

When using a Shark Marine topside controller with built-in video and light control, the Video/Light Setup COM port should be enabled. This peripheral allows the user to control the brightness of connected lights and configure the type of light and video signal types for up to 2 video sources.

When the Video/Light COM port is on, the NavCam screen will to show a light control bar below the Record and Snapshot buttons on the bottom panel. Depending on the light type, set in the Video/Light Configuration menu, the slider bar will allow either full dimmable brightness control, or switching between HIGH, LOW, and OFF brightness states.



Both light and video signal types are dependent on hardware and will be correctly set at the factory. Changing these settings could cause loss of functionality.

To open the Video/Light Configuration menu, press the Config button on the right hand side of the System Setup menu, under the COM Setup tab, next to the Video/Light port.

15.13.1. Light Type

High/Low/Off

This option is to be used with Shark Marine's AC voltage underwater lights. The AC lights can be set to 3 states of brightness.

Full Dimmable

This option is to be used with Shark Marine's DC voltage underwater lights. The DC lights' brightness can be fully controlled from 0 to 100 percent.

15.13.2. Video Signal Type

Unbalanced

This option is to be used when the video signal is received through coaxial cable.

Balanced

This option is to be used when the video signal is received through a twisted pair. This option is normally used with cables longer than 1500ft.

15.14. Total Navigation System (TNS)

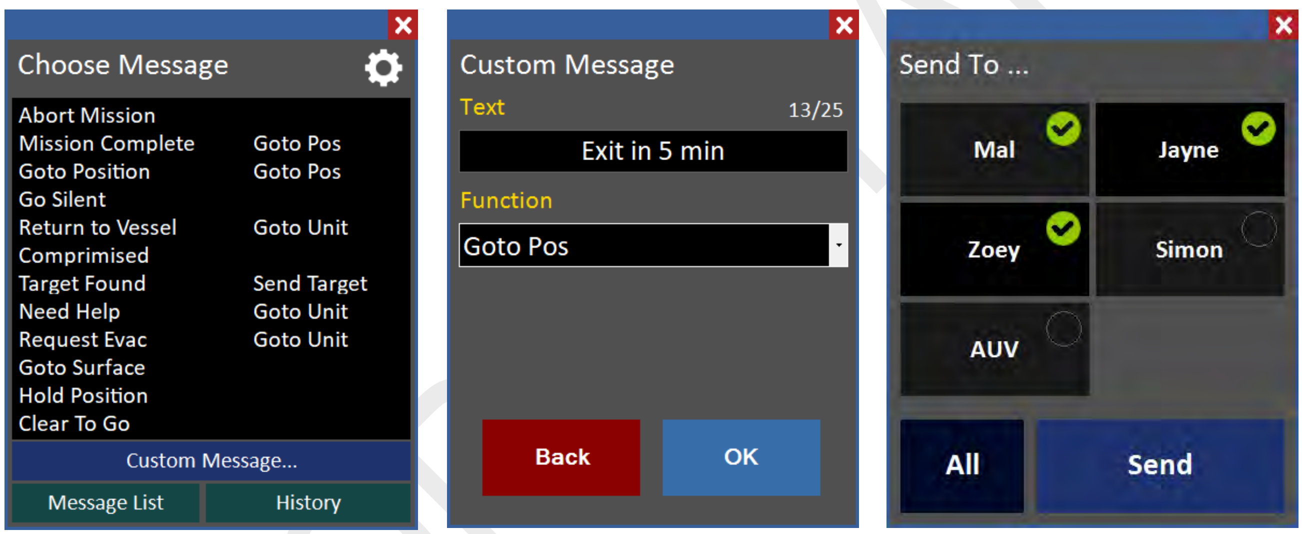
The Total Navigation System is a single peripheral containing all the functionality of DNS (See section *15.6 Doppler Navigation System*), a GPS (See section *15.1* GPS), and an LBL (See section *15.5 VLT-10 Long Baseline System*). The setup of this device happens in two steps. First, the three port expander (See section *13.4* Port Expansion) must be enabled and set to either Full Duplex or Half Duplex depending on the associated hardware configuration. Second, each sub-device must be assigned to a port expander COM port on the COM Setup tab of the System Setup window. Each device will work independently once setup is completed.

15.15. Sub-NET System

The Sub-NET system is a wireless, multi-medium data transfer method designed for sub-sea operations. Using acoustic and radio modems to send data through water and air, the Sub-NET system allows both sub-sea and surface units to communicate positions, messages, and instructions.

15.15.1. Sending a Message

To send a message, open the Choose Message window using the Sub-NET button on the top-right of the HPR. To send a pre-set message, simply click the desired message, then choose your recipient(s). To enter a custom message, click the Custom Message button, enter your text, and select a function from the drop-down list.



15.15.2. Message Structure

All messages sent through the Sub-NET system have 3 parts:

Message	The text associated with this message.
Action	Data and instructions associated with this message.
Priority	The importance of this message.

There are five types of Actions available:

Goto Unit	Commands DiveLog to set a Goto to the position of the given unit. This Goto will be updated whenever a new position is received for that unit.
Goto Position	Commands DiveLog to set a Goto to the given static position.

Send Target Will share the specified target (position and name) with all recipients.

Position Update When not tracking, sends your current position to all recipient units.

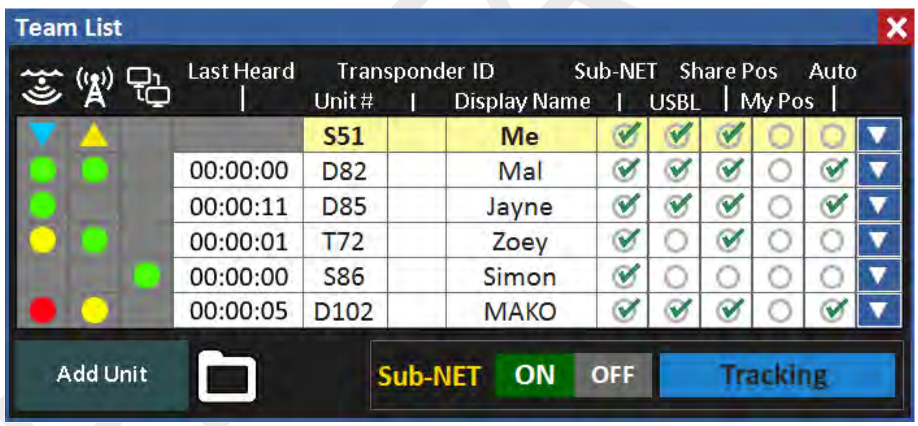
Position Request When not tracking, commands all recipient units to automatically send their current position to the sender.

You may also send a message with no action, or vis versa.

The three **Priority Levels** (High, Medium, and Low) are used to determine which message will be resent or replied to first in the case of multiple messages being sent simultaneously.

15.15.3. Team List

The eligible recipients of your message are determined by your Team List, which can be opened by clicking the gear icon on the Choose Message window.



To add a unit to the list, click Add Unit, and fill in the desired fields. To remove, click the down arrow on the right side of the unit's row, and select "Remove". Your unit will always be added to the Team List automatically.

The available fields are:

Unit # Each unit must be identified by its unit number to allow communication.

Transponder ID Used for identification of units in a USBL system.

Display Name A common name for easier identification.

Sub-NET Checked if communication should be allowed.

USBL Checked if this unit should be tracked by a USBL system.

Share Pos If using a USBL or an IP connection, do we relay this unit's location.

My Pos If using a USBL, should we use this unit's position as our own.

Auto Checked if this unit can be commanded autonomously.

The first three fields represent the connection quality to that unit, on each device type (Acoustic, RF, IP). The next field shows the duration since the last communication with that unit.

To import a Team List from file, or export the current list, click the folder icon and select an option from the drop down list.

To connect to another computer over a standard IP connection, choose “Connect by IP” in the drop-down list for that unit and enter its IP address. This IP connection will automatically share all positions and messages without initialization of a Tracking group.

15.15.4. Operation Modes

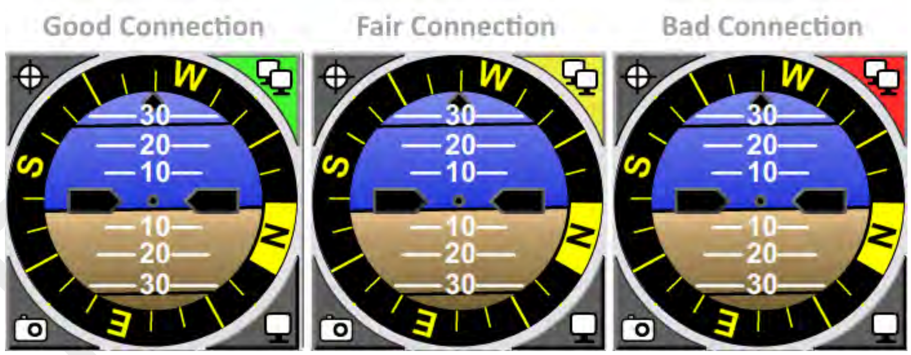
The Sub-NET system has two main modes of operation:

Standard (Message Only)

In this mode, messages can be sent to a list of specified units at any time. To share positions with your team, any operator can send *Position Request* or *Position Update* messages. This mode requires no action and is the default mode on start-up.

Automatic Unit Tracking

While in *Tracking Mode*, each unit in the team will receive and send periodic position and depth updates to the rest of the team. These positions will be shown on the Track Screen along with that unit’s name. Hovering over that unit icon will show info including time last heard and depth. The *Tracking Quality* to each other unit it displayed in the *Team Units List*, and an overall Tracking Quality is displayed as a Sub-NET button color, and on the Control Panel as seen below.



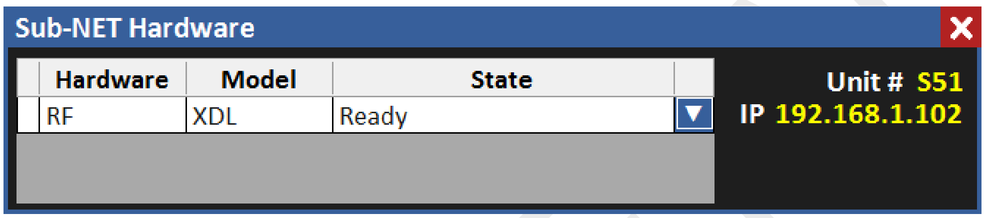
To begin Tracking, **ONE** unit must press the Initialize Tracking button on the Team List. Each other unit in the area will automatically connect to the Tracking Group, and begin sharing positions. If a unit does not connect immediately, or enters the area once Tracking has started, that unit will automatically request to join the Tracking group, and will either be allowed or denied by one of the units in the group.

Always determine which unit will be initializing Tracking before entering the water, as communication delays will occur if more than one unit attempts to initialize.

Messages and confirmations should be expected to take longer to send in Automatic Tracking Mode, as they will be interlaced with position updates.

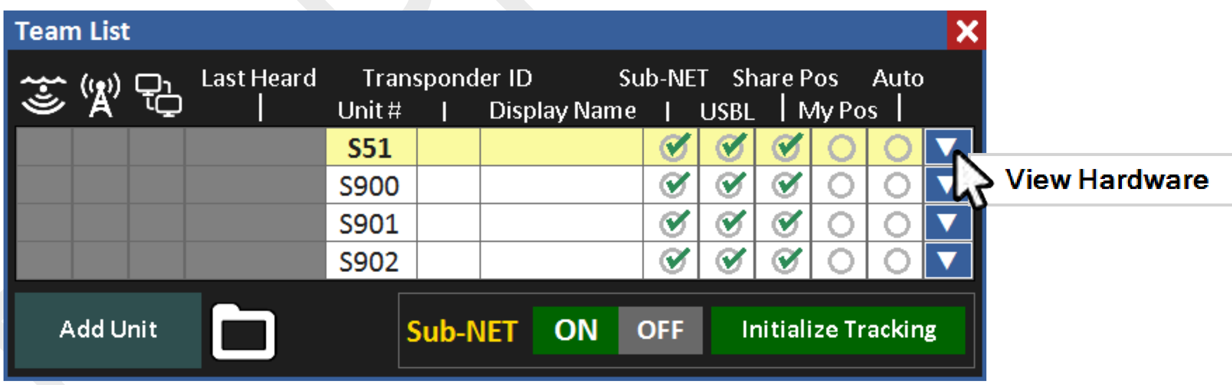
15.15.5. Hardware Settings

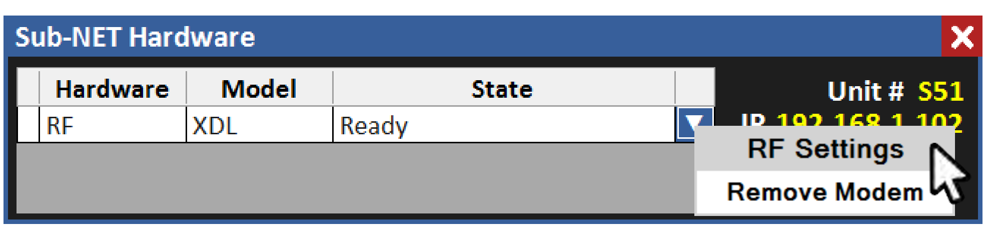
Once COM ports are successfully enabled for an Acoustic and/or Radio modem, you can monitor the connection or view the devices in the Sub-NET Hardware window. To open the window, click the down arrow on the right side of your unit's row on the Team List, and select "View Hardware". The model and state are given, and the down arrow on each device's row allows cancelling a Tracking group, or removing the device.



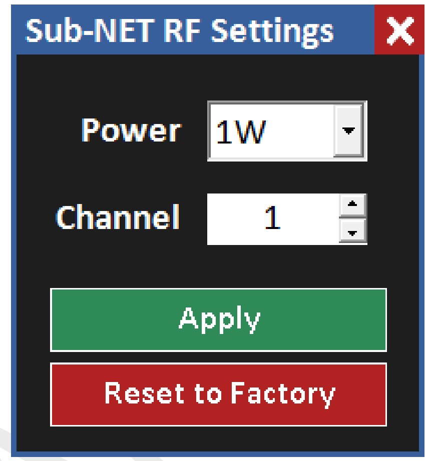
15.15.6. Sub-NET RF Settings

When a Sub-NET RF or RF/GPS unit is connected to DiveLog, it is updated with the last RF settings. A successfully connected and updated RF modem will show up in the Sub-NET Hardware window. You can access this window by clicking the down arrow at the end of your unit's row in the Team List window and selecting "View Hardware".





If you need to configure the hardware settings of the RF or RF/GPS modem, click the down arrow on the RF modem row and select “RF Settings”.



To change either the output RF power (in Watts), or the RF channel number (out of 17 possible channels), change the desired settings and click “Apply”. You will be notified if the change was successful or not. You can also apply the Factory Default settings to the modem by clicking “Reset to Factory”.

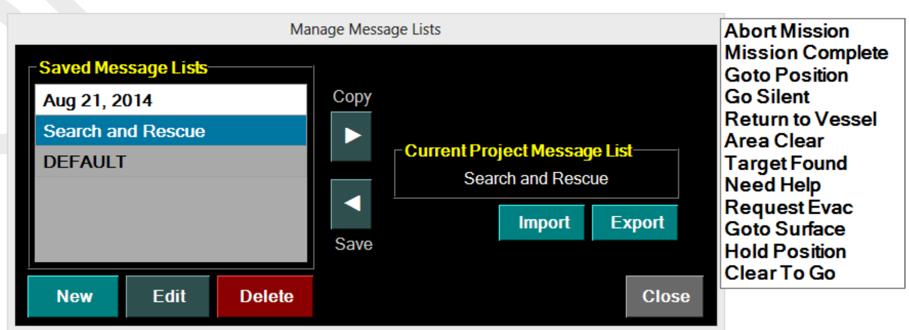
Note: It is important to ensure the RF channel is identical on all communicating units.

15.15.7. Managing Pre-Set Message Lists

The “Manage Message Lists” window can be reached by clicking the “Manage Message List” button on the Sub-NET Control Panel. The Manage Message Lists window allows for setting the current project message list, as well as creating, editing, or deleting saved message lists.

The current project message list is shown on the right side of the window. This list is independent of the saved lists, and won’t be altered if any saved list is changed. The project message list is stored in the current project and must be saved in order for it to be used in any other projects.

A summary of the message list in displayed to the right of the window when the cursor passes over a saved list or the current project list.



To change the current project list, simply click to highlight a saved list on the left of the window and click the Copy button (right facing triangle). If the list is different than a saved list with the same name, or is not listed in your saved lists, you will be prompted with the option to save your current project list before the change.

To save a current project list, click the Save button (left facing triangle). If your project list shares its name with a saved list, but is not identical to that list, you will be prompted with the choice to overwrite that saved list or to save your project list under a new name.

Unsaved lists cannot be edited. If you need to edit a project list, first save it, then make the changes using the Edit button, and copy it back to the project.

If your current project list has the same name as a saved list but is not identical to it, a red exclamation mark will be shown next to the Project List box. This indicates that in order to keep this list for future use, you will need to save it before either clearing it from the project or changing the current project list.

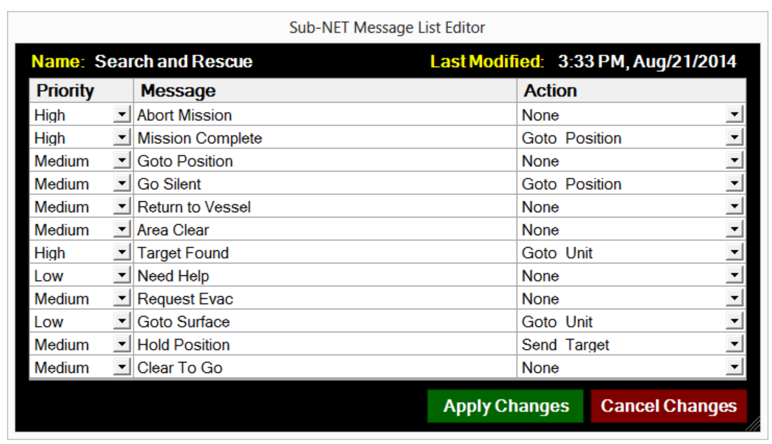
To create a new message list, click "New" and follow the instructions listed in *15.15.8 Creating a New Quick Send Message List*.

To edit a saved list, click "Edit" to bring up the Sub-NET Message Editor window. To delete a saved list, click "Delete" under the Saved Lists box.

To import or export a message list, to or from the project, click "Import" or "Export" to bring up the "Import Data" or "Export Data" forms, detailed in sections *9 Importing Data* and *10 Exporting Data*

15.15.8. Creating a New Quick Send Message List

To create a new Quick Send Message List, click the "New" button to either start a list from scratch, or use a saved list as a template. You will then be prompted for the new list's name, which must not match any other message list.



Creating or editing a Message List opens the Sub-NET Message List Editor. From this window, you can change the priority, message, and action of each message. If you leave a message blank, that message will not show up on the Sub-NET Control Panel. Once you finish editing or creating a list, click "Apply" to save changes, or click "Cancel" to cancel any changes.

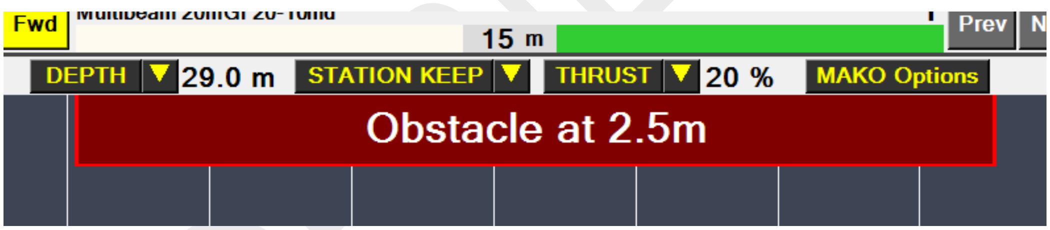
15.16. Collision Avoidance Sonar

The MAKO can be equipped with a forward-looking echosounder, which acts to sense objects lying in the MAKO's path. This Collision Avoidance Sonar (CAS) allows the MAKO to adjust its altitude and speed to avoid potential collisions. The system has two different actions that are applied when an obstacle is within two defined ranges.

When an obstacle is within the Caution Distance, but outside of the Critical Distance, the MAKO will begin to increase its altitude, and slow its horizontal speed, until the CAS no longer detects an obstacle. If the obstacle is not cleared, the MAKO will enter the Critical Distance. When an obstacle is within the Critical Distance, the MAKO will no longer move forward, but continue to increase altitude until the object is cleared.

If the obstacle is cleared in, the MAKO will slowly return to its pre-avoidance altitude and speed. If the Restore Step settings on the Collision Avoidance Sonar Configuration window (see section *15.16.1 Collision Avoidance Sonar Configuration*) are set properly, this recovery state should happen slowly enough to ensure the MAKO does not descend onto an obstacle it just avoided.

When an obstacle is within the Caution Distance, DiveLog will display a warning on the main window as shown below.



The CAS will **only adjust the MAKO's thrust** if the following 3 conditions are met:
1. Either Auto-Depth or Auto-Altitude is ON
2. Either Auto-Speed or Auto-Thrust is ON
3. CAS is enabled on the General tab of the MAKO Options window.

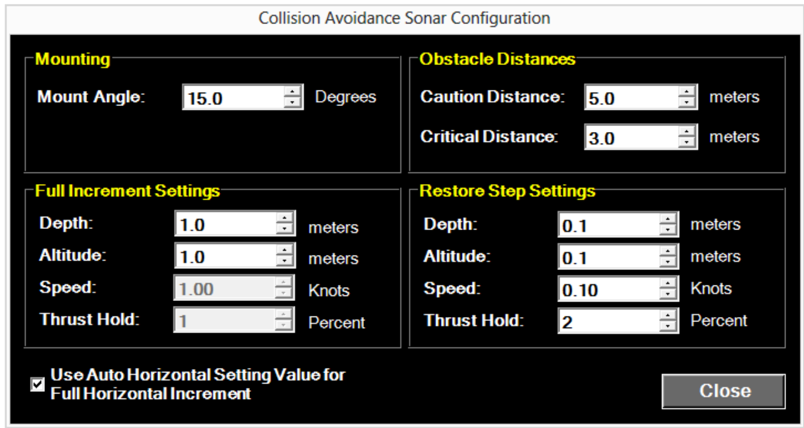
All CAS settings can be altered on the Collision Avoidance Sonar Configuration window, shown below.

15.16.1. Collision Avoidance Sonar Configuration

This window can be reached from the Mako Options window (see section *17.5 MAKO Options*). These settings are critical to proper operation and should only be changed if advised by Shark Marine Technologies Inc.

This window allows the user to change the settings and performance of the collision avoidance sonar. These setting should be set by the factory to the optimal values, so changing these values is not recommended unless advised by Shark Marine Technologies Inc. The settings are as follows:

Mount Angle: The angle between horizontal and the collision avoidance sonar's beam direction.

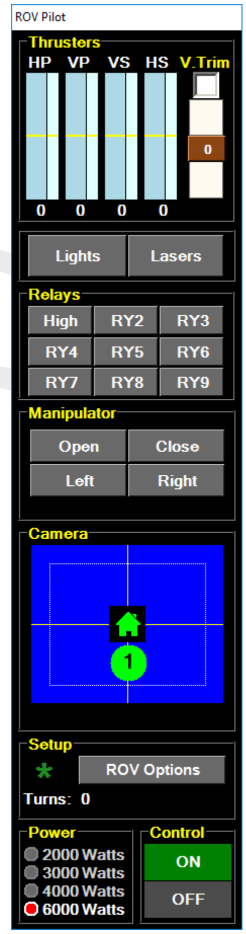


Obstacle Distances: The Caution Distance is the range at which the MAKO will start attempting to avoid an obstacle, while still moving forward. The Critical Distance is the range at which the MAKO stops moving forward, and only moves upwards until clear of the obstacle.

Full Increment Settings: These settings determine how fast or slow the MAKO will attempt to avoid an obstacle at the Critical range. In the caution range, the rate of avoidance will be a linear percentage of these values.

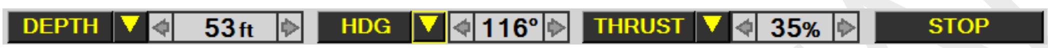
Restore Step Settings: When an obstacle has been avoided, and the sonar is clear of obstructions, these settings determine the pace at which the MAKO returns to its original state. If these settings are too high, the MAKO may descend onto an obstacle it attempted to avoid, so it is critical these settings are only changed if advised by Shark Marine Technologies Inc.

16. Remotely Operated Vehicle (ROV) Pilot

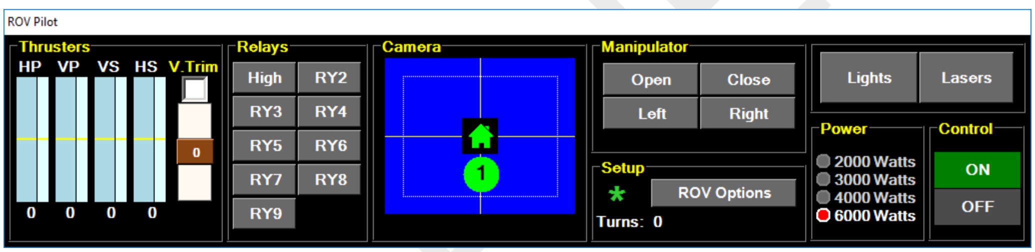


The ROV Pilot feature is enabled by selecting "Remotely Operated Vehicle" on the Active Screens tab of the System Setup window (see *13.3.1* Active Vehicles for more information).

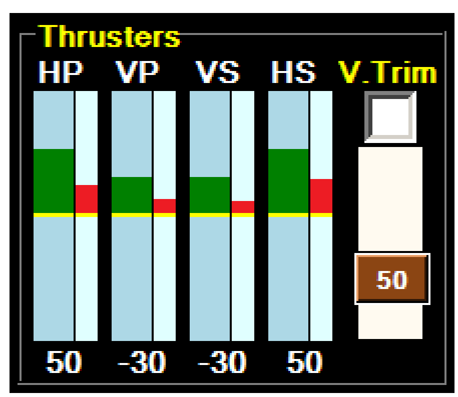
When the ROV Pilot is enabled, two additional display panels will be displayed. An "Auto Controls Bar" will be displayed at the top of the main DiveLog window, and the main ROV Pilot window will be displayed as a separate window, which shows a variety of readings and controls.



The ROV will be primarily controlled with a hand controller connected to the topside unit running DiveLog. Controls on these two panels in DiveLog will supplement the hand controller controls, as well as indicate the status of control functions.

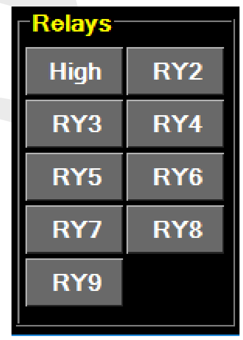


16.1. ROV Pilot Control Window

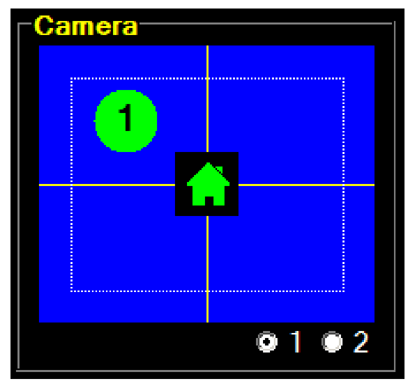


The "Thrusters" box shows the status of the ROV thrusters, along with a control for setting the Vertical Trim. For each thruster, there is a green bar graph and a red bar graph. The labels HP, VP, VS, and HS indicate the thrusters: horizontal port, vertical port, vertical starboard, and horizontal starboard, respectively. The green bar indicates the commanded level of thrust currently being sent to the ROV thruster. The yellow line at the midpoint of the graph indicates zero thrust, while the extent of the graph indicates a level of thrust equal to the Forward/Reverse Thrust Limit (see section *16.6.1 Thrusters Tab* for more information). The numbers below each bar show the percent value of the green bar. The red bar indicates the amount of current that is being drawn by the thruster or the rpm of the thruster (depending on the thruster type). The midpoint of the graph indicates zero current/rpm, while the extents of the graph indicate a current equal to the Current Limit, or the maximum rpm (see section *16.6.1 Thrusters Tab* for more information).

The V.Trim checkbox and slider bar allows for setting a trim value for the vertical thrusters. Set the slider bar to a percent between -100 and 100 and then click the checkbox at the top to enable vertical trim. A value of 100 or -100 indicates a thrust equal to the Forward Thrust Limit or Reverse Thrust Limit, respectively.

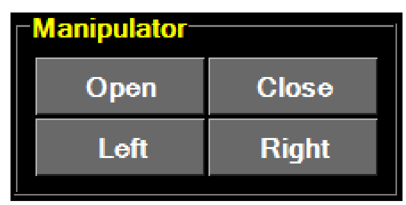


The Relays group provides on/off controls for various optional functions. The button will be gray when a function is off, and red when a function is on. The functions associated with these relays will vary depending on what optional accessories the ROV is equipped with. These nine buttons can be configured with custom text and can be configured to operate as toggle switches or momentary switches. This button group can be hidden if no optional relays are used (see the *Hardware Tab* on the ROV Options for more information).

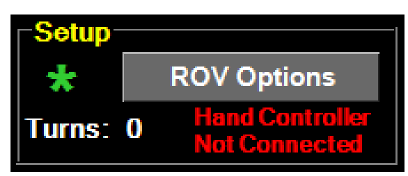


The Camera box contains an image representing the camera's field of view, as well as controls for switching between alternate cameras, moving the camera pan/tilt platform, and changing the camera home position.

The video feed can be toggled between different cameras by clicking the camera number at the bottom of the Camera display. Dragging the green circle will change the pan/tilt position of the camera. The blue area can also be clicked to move the camera to that location in the camera's field of movement. Dragging the home icon will update the position of the camera home. Clicking the home icon will move the camera to the home location.



The contents of the Manipulator box will vary depending on the type of manipulator that is installed on the ROV. See section *16.1.1 Manipulator Display* below for more information.



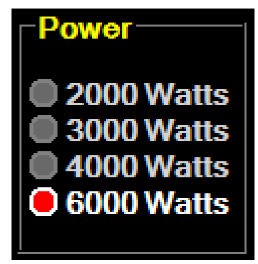
The Setup group of controls contain the following:

- Green Asterisk: Indicates the status of the connection to the ROV:
    - Flashing Green indicates the connection is active.
    - Red indicates that DiveLog is attempting to establish a connection.
    - No asterisk means the COM Port has not been opened by DiveLog.

- The ROV Options button opens up the ROV Configuration window.
- “Turns:” indicates the number of times that the ROV has made a full rotation. A positive number indicates turns to the right, and a negative number indicates turns to the left. This is useful to prevent loops in the ROV umbilical cable.
- Status information: Text may appear in the bottom right corner for important status messages.

The lights and lasers buttons turn on and off power for these functions (if equipped). If the ROV is equipped with fully dimmable lights, then the lights button will turn on and off the lights, but the dimming level needs to be set through additional controls. A “Lights” slider bar will be displayed on the NavCam controls, below the video image (see image, right). If the hand controller is set up with a slider for setting the brightness, then the hand controller button will be the primary means of setting the brightness.

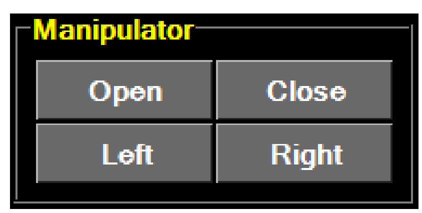
The power display allows choosing a power range for the ROV to operate within. Each of the power settings set a limit on the percent of thrust that the ROV will use, which effectively limits how much power the ROV will draw. The purpose of this setting is to limit the electrical power that will be used, which is useful to stay within the limits of the power source when using a generator to power the system. See section *16.6.1 Thrusters Tab* for information on setting up the power levels.

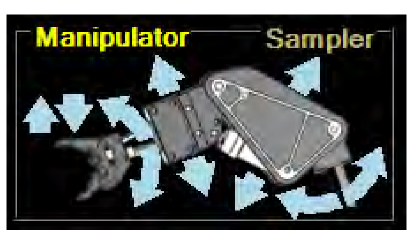


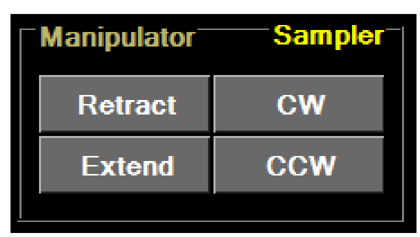
The Control on/off buttons enable or disable the ROV connections, including the main communications, the sonar connection, and the camera connection. Turn this OFF to allow another network enabled computer to take over control of the ROV. This connection will default to ON if the Auto Connect setting is enabled. See section *16.6.7 Hardware Tab* for more information.

16.1.1. Manipulator Display

The contents of the Manipulator display will depend on the type of manipulator that is installed on the ROV. If using a one or two Function manipulator, the box will contain controls for the jaw and wrist. Open and Close are used to open or close the manipulator jaw. Left and Right are used to rotate the manipulator wrist counter-clockwise and clockwise.





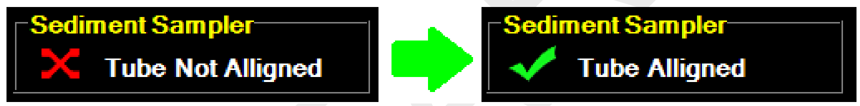


SHARK MARINE TECHNOLOGIES INC.

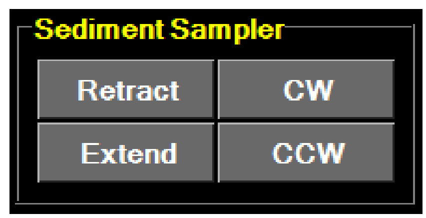
If a four function or a five-function manipulator is used, the display will appear as shown below. There are arrows for both directions for each of the manipulator functions. When the hand controller is used, the arrows will light up to show the active function. The arrows can also be clicked with the mouse to activate the function.

If a sediment sampler is used along with a four or five function manipulator, click the “Sampler” text to change the on-screen controls for controlling the sampler. Use the “Retract” and “Extend” buttons to operator the plunger on the sediment sampler, and use the “CW” and “CCW” buttons to rotate the sampler carousel clockwise and counter-clockwise, respectively.

16.1.2. Sediment Sampler Display



If the ROV is equipped with a sediment sampler, there is an additional display on the main window that will indicate if the tube on the carousel is aligned in sampling position or not. To enable or disable this display, go to Menu > Help > Enabled Features > Custom Features, and enter the code “SM SEDIMENT SAMPLER 001”.



Another optional display can be used if the sediment sampler is being used, and a manipulator is NOT controlled through DiveLog. This display shows buttons for the sediment sampler on the main display rather than the manipulator buttons (see image, right). To enable or disable this display, go to Menu > Help > Enabled Features > Custom Features, and enter the code “SM SAMPLER ONLY 002”.

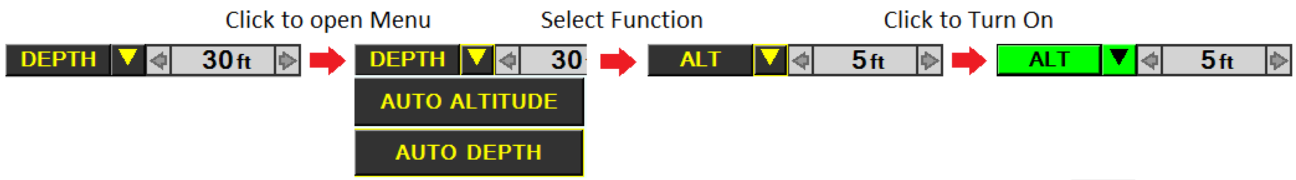
If the sediment sampler is used along with a manipulator, the controls will appear as discussed above in section *16.1.1 Manipulator Display*.

16.2. Auto Function Controls

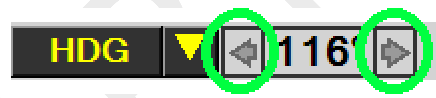
When the ROV is enabled in DiveLog, the auto functions controls will be visible along the top of the main DiveLog screen. The buttons along the top are as follows:

- Auto Depth or Auto Altitude: Used for controlling the vehicle’s vertical position.
- Auto Route / Target Goto, Auto Heading, or Station Keeping: Used for automatic control of the vehicle’s heading (and forward thrust when station keeping).
- Auto Speed or Thrust Hold: Used for controlling the forward thrust.
- STOP: Turns off all auto functions, as well as the vertical trim.

The three main buttons turn a particular function on or off. When the function is on, the button will be highlighted green. The function of each of these three buttons can be changed by selecting the function in a drop-down menu. The drop-down menu is opened by clicking the down arrow to the right of each button.



Beside each auto control value, there are up/down arrow buttons. Clicking up or down will increment or decrement the set-point.



16.3. Auto Depth and Auto Altitude

The Auto Depth and Auto Altitude functions automatically hold a constant depth, or a constant altitude off bottom. The depth/altitude set-point is displayed to the right of the button. The set-point can be changed manually by clicking on the number. To set the set-point to the current depth or altitude, click and hold the “DEPTH” or ”ALT” button for one second.

NOTE: For Auto Altitude, an optional altimeter or doppler unit must be connected to the vehicle.

16.4. Auto Heading, Goto Route / Target, Station Keeping

Auto Heading, Goto Route / Target, and Station Keeping all automatically adjust the heading (turn the vehicle) when turned on. While Auto Heading simply points towards a given heading, the other two functions have more complex behaviour.

16.4.1. Auto Heading

The Auto Heading will turn to correct the vehicle’s heading until the compass heading (displayed on the Navigation View in DiveLog) matches the set-point (displayed beside the “HDG” button). To set the set-point to the current heading, click and hold the “HDG” button for one second (see image, right).

While Auto Heading is on, the pilot of the vehicle can still use the horizontal control stick to change the heading of the vehicle. Once the stick is released or pushed straight forward, the heading control values from DiveLog will resume guiding the vehicle along the proper heading.

16.4.2. Goto Route / Target

When the Goto Route / Target is turned on, DiveLog will control the heading of the vehicle to point towards the current Goto in DiveLog, which can be either a target or route point (see sections *12.7 Tracking a Target* and *20.6 Routes*). To have the vehicle drive to the Goto point, turn on "Thrust Hold" or "Auto Speed" (if a position source is connected and valid).

Depending on the Goto type, there are a few different options. A point "arrival distance" or "standoff distance" can be set, which sets the distance from the point that DiveLog will consider as its end point. For routes, there is also a setting to continue to the next point, or stop at each point. For more information, see *Auto Goto Tab* in the ROV Configuration section.

NOTE: If Auto Speed or Thrust Hold is turned ON while Goto Route / Target is ON, the vehicle will travel at the specified speed/thrust until it arrives at the Goto point. At this time it may toggle off the Auto Speed / Thrust Hold, or perform Station Keeping depending on the setting.

16.4.3. Station Keeping

When turned on, Station Keeping will automatically control the vehicle's position and depth to remain close to its current location, even in the presence of significant water current. When turned on, station keeping specifically controls forward thrust, in addition to turning thrust, unlike Auto Heading or Goto Route/Target. It will also automatically enable the Auto Depth function to hold the vehicle's vertical position, although this can be manually turned off if not desired. There are some settings to configure how station keeping will operate; see the ROV Configuration *Auto Goto Tab* for more information.

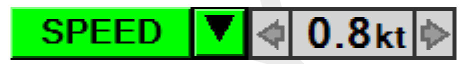
NOTE 1: For station keeping, the vehicle must have a valid position source.

NOTE 2: When turning station keeping ON, Auto Speed or Thrust Hold will turn OFF (if previously ON). Forward thrust is only used if required by the station keeping function to remain close to the proper point.

16.5. Auto Speed and Thrust Hold

Auto Speed and Thrust Hold both control the forward thrust of the vehicle. See below for details.

16.5.1. Auto Speed



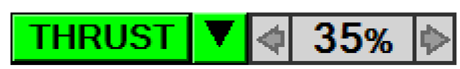
When turned on, the Auto Speed function will control the forward thrust of the vehicle. DiveLog will determine the proper level of thrust to remain at the set speed, in knots. The desired speed is set by clicking on the value displayed beside the “Speed” button, or using the up/down arrows.

Auto Speed is especially useful when combined with the other auto functions. Turn on Auto Speed and Goto Route / Target to have the vehicle automatically traverse a pre-set route.

Auto Speed will be toggled OFF by the software if the user pulls back on the horizontal control stick of the hand controller. This is a safety feature to ensure the vehicle does not continue forward if the user notices a collision risk and pulls back the stick to stop.

NOTE: For Auto Speed, a position source must be connected and valid. If the position source goes invalid, Auto Speed will continue with the same thrust level as it waits for the position to become valid again.

16.5.2. Thrust Hold



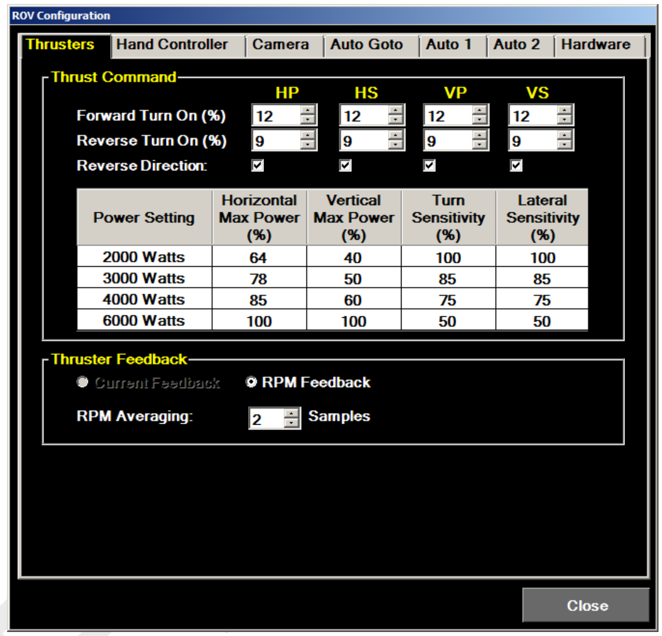
The Thrust Hold button sets the forward thrust to a specified percentage. Just as with Auto Speed, Thrust Hold can be used in conjunction with Goto Route / Target to have the vehicle automatically traverse a pre-set route.

Thrust Hold will be toggled OFF by the software if the pilot pulls back on the horizontal control stick on the hand controller.

16.6. ROV Configuration

The ROV Configuration window is opened by clicking the ROV Options button on the ROV Pilot window. The configurations window is divided into seven tabs that each contains various setup parameters.

16.6.1. Thrusters Tab



The Thrusters tab contains various setup parameters for each of the vehicle thrusters.

The Thrust Command box sets the thruster limits and optionally reverses the direction of the thrust command value.

The Forward Turn On percent sets the minimum percent power that will be sent to the thrusters, when the thrusters are commanded to move at the slowest speed. This value is used to overcome the internal friction of the thruster by sending enough power to make the prop spin. For example, setting this value to 10% means that when pushing the smallest possible amount on the control stick, the thrusters will be sent 10% power, which should cause the thruster to spin at the lowest desirable speed to allow very fine vehicle control. The Reverse Turn on Percent configures this setting for each thruster when thrusting in the opposite direction.

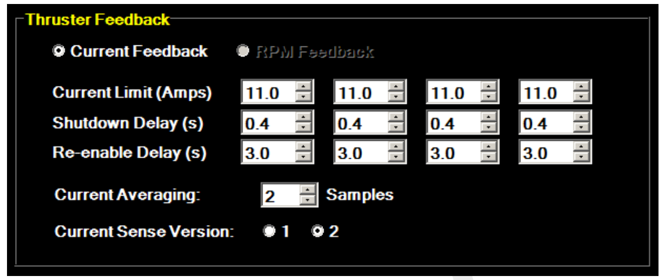
The Reverse Direction checkbox can be used to reverse the spin of the thruster. This would be used for example, if the thruster is equipped with a propeller with a sweep in the opposite direction.

The Power Settings table defines four different power levels that will limit the electrical power that the ROV uses. The setting that is currently used is set and displayed in the Power box on the main ROV Controls window (see section *16.1 ROV Pilot Control Window*, above). For each of the four power settings, four different values are specified, as follows:

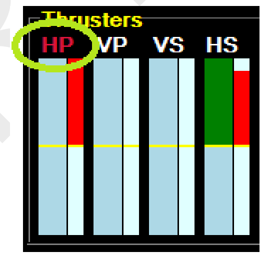
- Horizontal maximum power: A percentage limit of the maximum speed for the horizontal thrusters.
- Vertical maximum power: A percentage limit of the maximum speed for the vertical thrusters.
- Turn sensitivity: A reduction of the control stick sensitivity for turning the ROV. A lower value will use less of the maximum power available for turning, which will improve the precision of turns.
- Lateral sensitivity: A reduction of the control stick sensitivity for lateral movement of the ROV. A lower value will use less of the maximum power available for lateral thrust, which will improve the precision of lateral movements.

Each value in the table (including the names of each power setting in the first column) can be updated by clicking the value and typing in a new entry.

The Thruster Feedback box allows the user to set the type of thruster used: thrusters that provide current feedback, or thrusters that provide rpm feedback. Depending on the ROV model selected (on the Hardware tab), this setting may not be configurable.



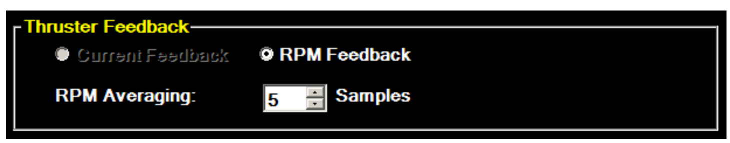
When set to “Current Feedback”, the Thruster Feedback box sets up the current limit and current averaging. Note: this does not apply to thrusters that only provide RPM feedback.



Current feedback is used to ensure the thrusters are not damaged in the instance they draw too much current. If the current for any thruster is greater than or equal to the current limit (in Amps) for an amount of time equal to the Shutdown Delay (in seconds), then that thruster will shut down for the amount of time equal to the Re-enable Delay (in seconds). During the shutdown period, that thruster will not be given any power and the label for that thruster on the main ROV Pilot window will glow red, indicating the overcurrent condition.

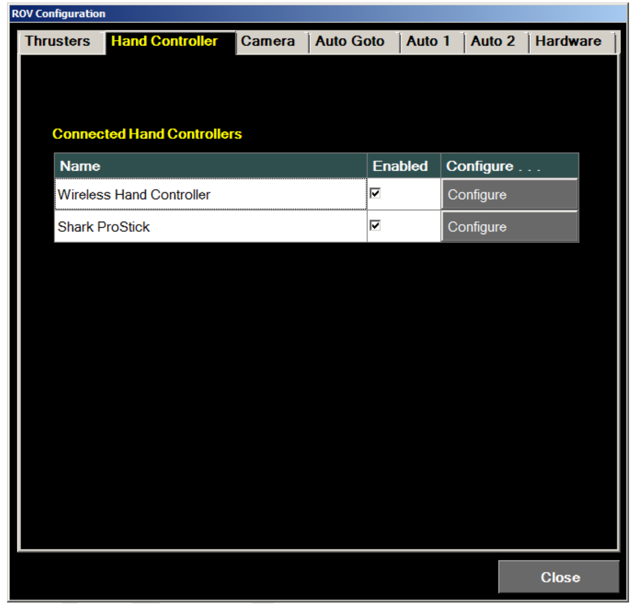
The current averaging is for smoothing out the current reading used for display and overcurrent checks; the recommended value is 10 samples.

The Current Sense Version specifies the scaling that DiveLog will use when displaying the current value, and depends on the hardware used. If unsure of this setting, contact Shark Marine Technologies.



When set to “RPM Feedback”, the Thruster Feedback box allows setting RPM averaging. Note: This does not apply to thrusters that only provide current feedback. The recommended setting for the RPM Averaging is 5 samples.

16.6.2. Hand Controller Tab



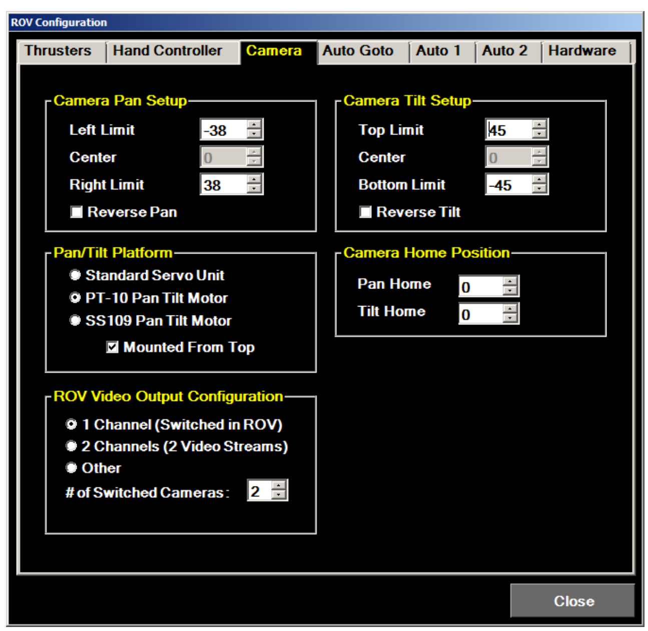
The Hand Controller tab shows the hand controllers that are currently connected. If multiple hand controllers are connected then all controllers can be used simultaneously.

Any hand controller in the list can be enabled or disabled using the Enabled checkbox for that controller. This allows multiple controllers to be used simultaneously, allowing separate systems of the ROV to be controlled by different operators (e.g. thruster control and manipulator control), for the most precise operations. If desired, any PC compatible controller can be connected to the Topside, and will be capable of controlling ROV functions once it is configured in DiveLog.

The Configure button for each controller opens the Button Mapping Setup menu, which sets up that hand controller's button and axis mapping (i.e. assigns a function to each button). See section *16.7 Hand Controller Button Mapping Setup* for more information.

16.6.3. Camera Tab

The Camera tab has controls for setting up the number of cameras used and for setting parameters for the pan/tilt platform, such as specifying the center and limits of the camera pan/tilt, as well as the camera pan/tilt home position.



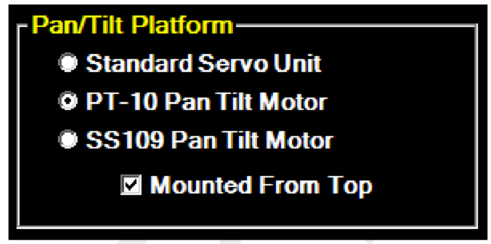
The limits and center for the pan and tilt are provided to configure the range of motion of the pan/tilt unit on the ROV.

The "Center" value determines where the camera will point with a pan and tilt of zero. It should be adjusted to ensure the camera points exactly forward. This only applies to the "Standard Servo Unit" pan/tilt model.

Configure the left, right, top, and bottom limits to set where the camera pan/tilt will stop when moved to the edge of the camera control interface on the main ROV

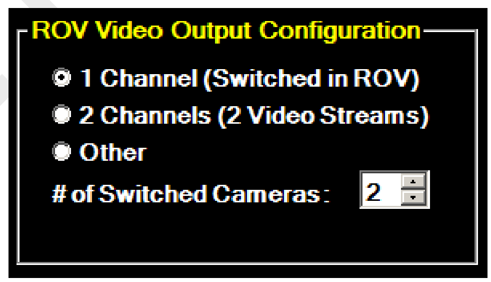
Pilot window.

The Pan Home and Tilt Home values give a numeric representation of the home location on the camera control interface on the main ROV Pilot window.



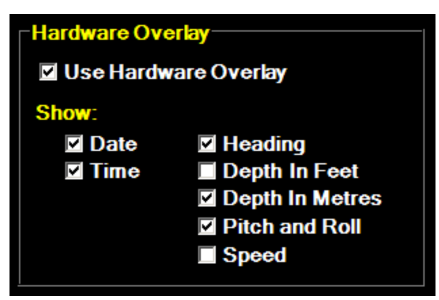
Depending on the ROV configuration, the type of pan and tilt platform may vary. The choice between pan-tilt motors can be done on this window, in the “Pan/Tilt Platform” box. These settings may or may not be configurable, depending on the ROV model selected on the Hardware tab. In general, a Stealth ROV will use the Standard Servo Unit, and a SeaWolf ROV will use the PT-10 Pan Tilt Motor or SS109 Pan Tilt Motor. Some SeaWolf ROV’s may have the camera pan/tilt platform mounted from above. In this case, the “Mounted From Top” checkbox must be checked for proper operation.

The ROV Video Output Configuration must be set up according to the type of video hardware utilized by the ROV:



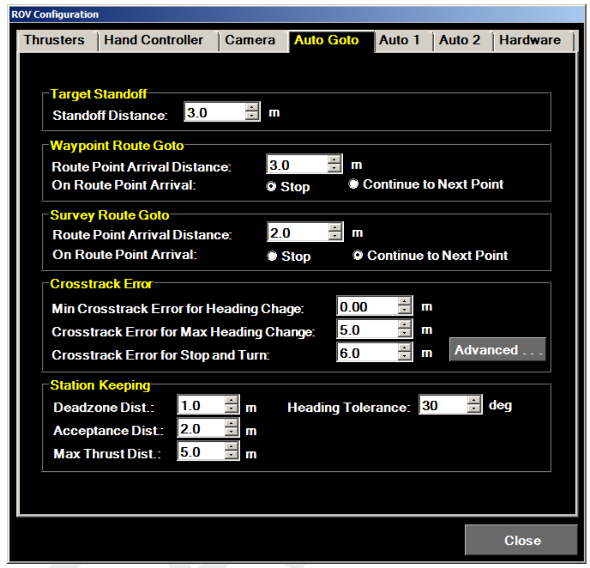
- 1 Channel (Relay Switched): Used when there is a single video feed up the umbilical cable, and one or two cameras are used. If two cameras are used, one camera will use the video feed at any given time, and the choice of camera is swapped by toggling a relay inside the vehicle.
- 2 Channels (2 Independent Streams): Used where there are two separate video feeds up the umbilical so that two cameras can be viewed simultaneously.
- Other: Used for any custom video setups.

Depending on the ROV camera configuration, the video feed may be switched between up to four cameras, although most ROV’s have one or two cameras. Specify the number of cameras that are connected to the primary video feed using the setting “# of Switched Cameras”.



The “Use Hardware Overlay” is only available for certain ROV models, and is a legacy option for ROV’s that overlay text onto to the video signal inside the vehicle. Since the NavCam Screen in DiveLog has many advanced overlay options, the “Use Hardware Overlay” is no longer necessary, except if running on legacy hardware.

16.6.4. Auto Goto Tab



These settings configure how DiveLog's Goto Route / Target, and Station Keeping functions will control the ROV.

Target Goto:

- Target Standoff Distance: This applies when using a Target or Target Route as the Goto in DiveLog. When the vehicle gets to within this distance from the target, DiveLog will stop travelling forward towards the target, and will start performing station keeping to remain about the set distance from the target.

Waypoint Route Goto:

These settings apply when using a Waypoint Route as the Goto in DiveLog.

- Route Point Arrival Distance: The distance from the Goto route point at which DiveLog will determine the ROV has arrived at the point, and will either perform the stop or continue function.
- On Route Point Arrival: Determines what the vehicle will do when it has arrived at the Goto route point.

    - Stop: If Auto Speed or Thrust Hold is turned ON, it will toggle OFF. The route point is not incremented, but can be manually incremented by the user when they are ready to proceed.
    - Continue to Next Point: The route point will be incremented to the next point in the route. The heading will turn towards the next point. At the last point in the route, the vehicle will perform station keeping.

Survey Route Goto:

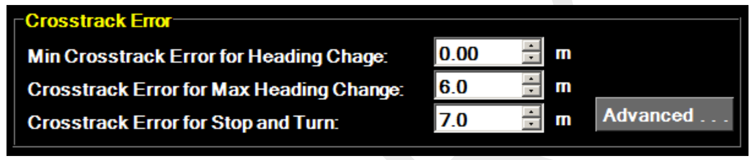
These settings apply when using a Survey Route as the Goto in DiveLog.

- Route Point Arrival Distance: Determines the distance from the Goto route point that DiveLog will consider that it has arrived at the point, and will either perform the stop or continue function.
- On Route Point Arrival: Determines what the vehicle will do when it has arrived at the Goto route point.
    - Stop: If Auto Speed or Thrust Hold is turned ON, it will toggle OFF. The route point is not incremented, but can be manually incremented by the user when they are ready to proceed.

- Continue to Next Point: The route point will be incremented to the next point in the route. If Auto Speed or Thrust Hold is turned ON, the forward thrust will stop to allow the vehicle heading to turn to the proper direction. When the heading is correct for the next point, the forward thrust will resume. This action is done to eliminate overshoot, and make sure the vehicle remains as close as possible to the proper line start point when following a survey grid. At the last point in the route, the vehicle will perform station keeping.

Crosstrack Error:

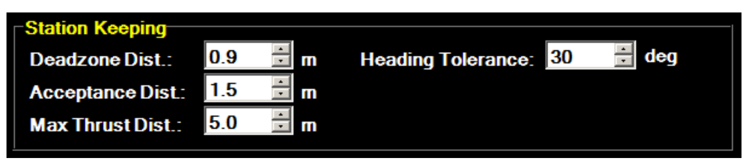
These settings apply when using any type of route as the Goto in DiveLog.



- Min Crosstrack Error for Heading Change: This value determines how far to the right or left of the route line the vehicle can be before it begins to turn to get closer to the route line. To follow a route line more accurately, reduce this value.
- Crosstrack Error for Max Heading Change: This value determines how far to the right or left of the route line the vehicle must be to have the vehicle head entirely back to the route line itself, rather than the Goto point. To follow a route line more accurately, reduce this value, but if this value is too low then changes in heading may be too abrupt when the position gets closer or further away from the route line. When following a route, if the crosstrack error is between the min and max values, the vehicle heading will be somewhere between the two extremes, allowing the vehicle to correct itself to get back to the line as well as keep heading towards the Goto point at the end of the route line.
- Crosstrack Error for Stop and Turn: At this distance the vehicle will check that it is going in the correct direction, and will cut thrust and turn towards the route if the direction is wrong. This prevents the vehicle from performing a large arcing turn if it was heading in the wrong direction (such as when a route point is manually incremented or due to a loss of a valid position).
- Advanced Button: This button sets up the PID control loop for the Crosstrack Error Correction (Route Following correction). See section *19.4 Crosstrack Error (Route Following) PID* for more information.

Station Keeping:

These settings apply when using the "Station Keeping" auto function, such as at the end of a route, using the route "loiter" function, standing off from a target, or using the main station keeping function.

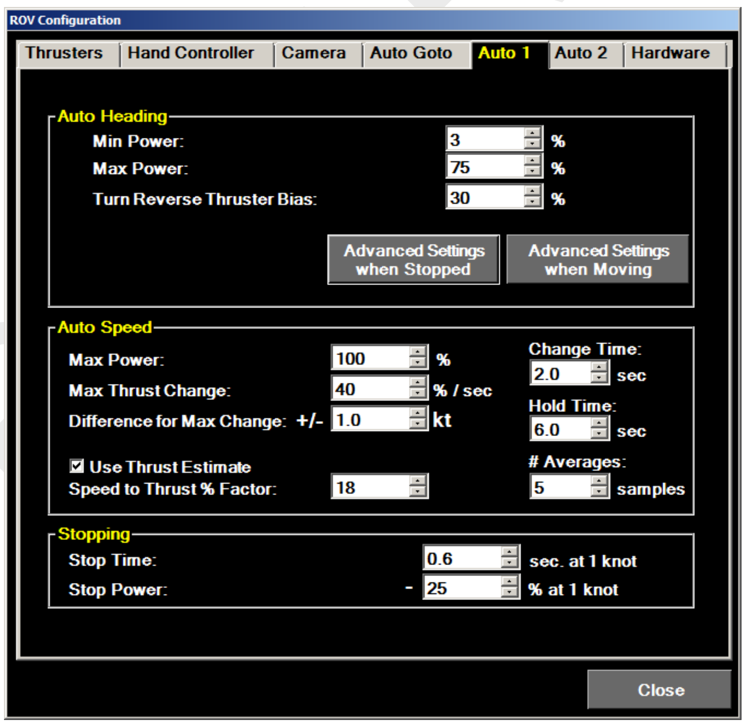


- Deadzone Dist.: Within this radius from the station keeping position, neither forward thrust will be used, nor will the heading be adjusted. This value should be small, but if too small then the vehicle may try to turn too much if the position source is bouncing.

- o Acceptance Dist.: This value determines how far from the station keeping position the vehicle may drift before it will provide some forward thrust to get closer. If the vehicle is within this distance, then no forward thrust will be used, but the heading will be adjusted to point towards the station keeping point.
- o Max Thrust Dist.: When the vehicle is between the Acceptance Distance and the Maximum Thrust Distance, then a varying (proportional) amount of thrust will be used to get closer to the station keeping position. Outside the Maximum Thrust Distance, full thrust will be used to get closer to the point.

16.6.5. Auto 1 Tab

Auto Heading

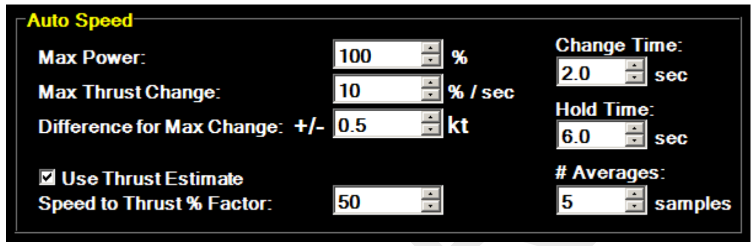


The Auto Heading settings determine the strength of heading corrections (used in Auto Heading, Goto Route / Target, and Station Keeping).

- Min Power: Applies a dead-band, so thrust below this percent will not be used.
- Max Power: The maximum amount of power that will be used if the current heading is far away from the proper heading.
- Turn Reverse Thruster Bias: This setting is used to compensate for the mismatch in thrust between a forward and reverse turning thruster. If not set correctly, this difference can result in forward creep of the vehicle when turning on the spot. Set this percentage to even out the power when turning to reduce forward creep.
- Lateral Reverse Thruster Bias (Six Thruster ROV models only): On the six thruster ROVs, the vectored horizontal thrusters are used for lateral (sideways) movement. During a lateral movement, some thrusters thrust in the forward direction and some thrust in the reverse direction. This causes an undesired turning movement due to the imbalance of power. Set this percentage to even out the power when moving laterally to reduce vehicle turning.
- Advanced Settings when Stopped: This button sets up the PID control loop for the Auto Heading when the vehicle is not moving forward. See section *19.2 Auto Heading PID* for more information. The settings are different than the settings used when the vehicle is moving, since turning dynamics are different in these two states.

- Advanced Settings when Moving: This button sets up the PID control loop for the Auto Heading when the vehicle is moving forward. See section *19.2 Auto Heading PID* for more information.

Auto Speed



The Auto Speed settings determine the strength of a speed correction. The auto speed routine works as a "Change and Hold" cycle, where DiveLog changes the thrust then holds the new thrust for a period of time. DiveLog will first compare the actual speed provided by the position source to the speed setpoint. If they do not match, then DiveLog will increase or decrease thrust for a period of time, known as the Change Time. DiveLog will then keep the thrust constant for a "Hold Time" to allow the vehicle to accelerate or decelerate, and for the speed to stabilize with the new level of thrust. The cycle then repeats as DiveLog will compare the speed and perform the adjustment, then wait for the actual speed change to occur.

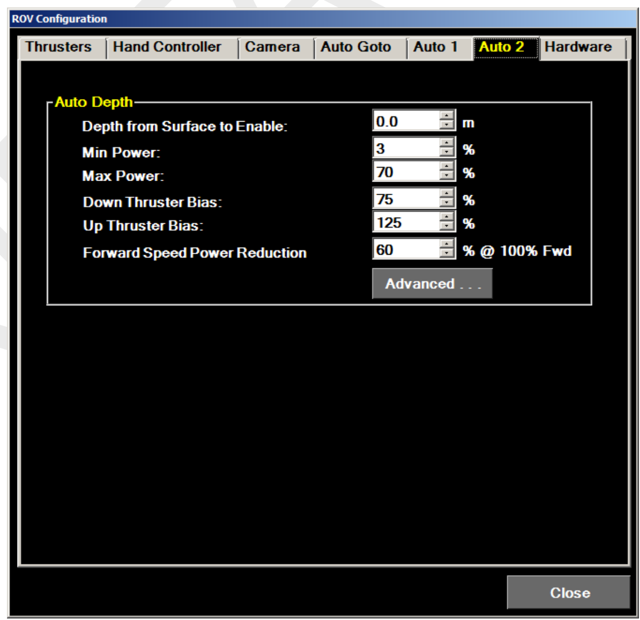
- Max Power: The maximum amount of power that will be used by the auto speed routine.
- Max Thrust Change: If the current speed is very different from the speed set-point (i.e. at or beyond the setting for "Difference for Max Change"), then this is the increase in thrust that will be used. Reduce this value to have the thrust respond slower to a change in speed.
- Difference for Max Change: Sets how far the speed must be from the set-point for the maximum change in power to be used. At a difference in speed below this value, a proportional change in thrust (less than "Max Thrust Change") will be used.
- Use Thrust Estimate: Turns on the thrust estimate feature. When the vehicle is starting from a stopped state, DiveLog will estimate the proper thrust to get to the given speed.
- Speed to Thrust % Factor: Used to estimate the proper thrust to get to a given speed. This value is multiplied against the speed setpoint to get a thrust percent. For example, if the speed setpoint is 1.0 knots, then 1.0 * factor of 50 = 50% thrust to be used.
- Change Time: The amount of time that DiveLog will adjust the thrust while performing the "Change and Hold" cycle.
- Hold Time: The amount of time that DiveLog will hold the thrust constant while performing the "Change and Hold" cycle.
- # Averages: Since the speed measurement from the positioning sensor can be "bouncy", the auto speed routine will average a number of speed readings to smooth out the changes. Do not increase this value too high, as it will delay the changes to the thrust.

Stopping

Stopping settings are used when the vehicle is following a route and needs to stop when arriving at a point. These settings should allow the vehicle to stop as close to the route point as possible.

- Stop Time: The amount of time that reverse thrust will be applied to stop when travelling at 1 knot. If travelling slower than 1 knot, the stop time will be reduced proportionally, and if travelling faster than 1 knot, the stop time will be increased proportionally.
- Stop Power: The percent power of reverse thrust will be applied to stop when travelling at 1 knot. If travelling slower than 1 knot, the stop power will be reduced proportionally, and if travelling faster than 1 knot, the stop power will be increased proportionally.

16.6.6. Auto 2 Tab



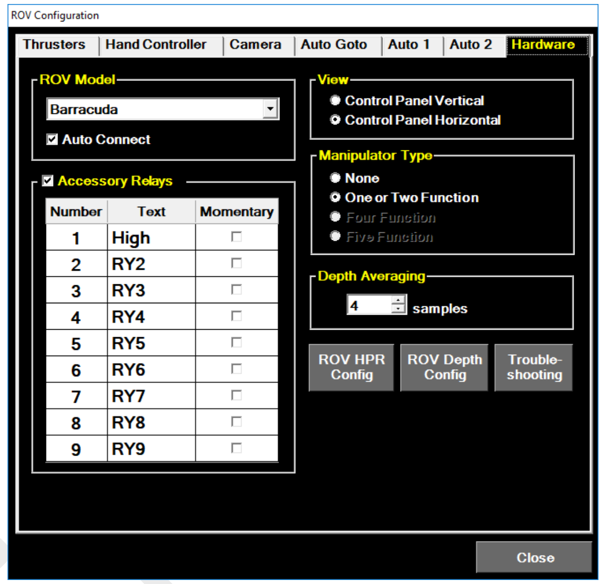
Auto Depth

The Auto Depth settings determine the strength of a depth correction (used in Auto Depth, and Auto Altitude).

- Depth from Surface to Enable: Right at the surface, no depth correction will be performed. This value determines how deep the unit must be to perform depth corrections.
- Min Power: Applies a dead-band, so thrust below this percentage will not be used.
- Max Power: The maximum amount of power that will be used if the current value is far away from the set-point.
- Down Thruster Bias and Up Thruster Bias: This setting is used to compensate for the mismatch in thrust between a forward and reverse turning thruster. If needed, set these percentages to reduce down power and increase up power to give even strength in either direction when the auto depth is making a depth correction.
- Forward Speed Power Reduction: When the vehicle is moving forward, vertical thrust tends to have an amplified effect. This setting reduces the auto depth power depending on the forward thrust. This reduction in power will be applied linearly over the range of forward thrust. For example, a value of 60% will result in full power auto depth when not moving forward, a reduction of 30% in auto depth power when moving forward at 50% thrust, and a reduction of 60% auto depth power when moving forward at 100% thrust.

- Advanced Button: This button sets up the PID control loop for the Auto Depth routine. See section *19.3 Auto Depth PID* for more information.

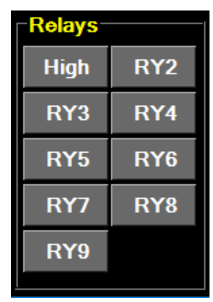
16.6.7. Hardware Tab



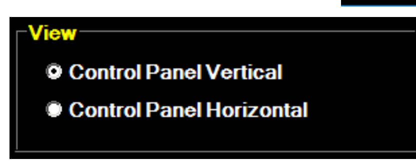
The Hardware tab contains settings for various hardware configurations.

The ROV Model selection specifies the type of ROV being used. Depending on this selection, certain configuration options that apply to that specific model will be available. Different configuration settings are stored for each of the vehicle types in this list, so a topside unit could be used for several different ROV's as long as the proper ROV Model is selected for the ROV that is currently being used.

The option for Auto Connect enables immediate connection when DiveLog starts and the ROV is powered. If Auto Connect is unchecked, then the ON/OFF buttons on the main ROV Pilot window will normally be OFF, and must be set to ON before the connection to the ROV will be established (including the video and sonar connections). Auto Connect **must** be unchecked when there are multiple computers that will be operating a single, network-enabled ROV. Ensure **only** the controlling computer's Control is set ON, turning the current controller to OFF **before** handing over control to another computer. Always avoid having more than one computer with it's ROV Control in the ON state, as this will result in connection issues.



The Accessory Relays table allows the user to customize the text that appears on each relay button, as well as set the button action to momentary or toggle. When set to momentary, the button will only stay active when the button is held down. Uncheck the Accessory Relays checkbox at the top to hide the relays on the main window.



The View options will change the main control panel from a vertical orientation to a horizontal orientation. Depending on the Active Screens used and the screen real-estate, either orientation may suit the screen layout better.

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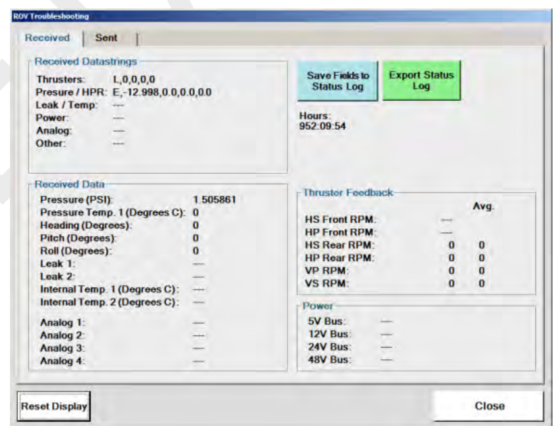
The value labelled “Depth Averaging” is used to apply a rolling average to the pressure/depth sensor on the ROV. Depending on the total range of the depth sensor used in the ROV, the displayed depth on the main Navigation View of DiveLog may appear bouncy without averaging. If this is the case, then increase the number of samples to smooth out the readings. Set this value to one to turn off the depth averaging.

The ROV HPR Config button opens up the Heading Pitch Roll Configuration window. On this window several of the heading, pitch, and roll parameters can be adjusted and the eight point compass calibration can be performed (important for getting the most accurate compass readings). See section *14.3 Heading Pitch Roll (HPR) Configuration* for more information.

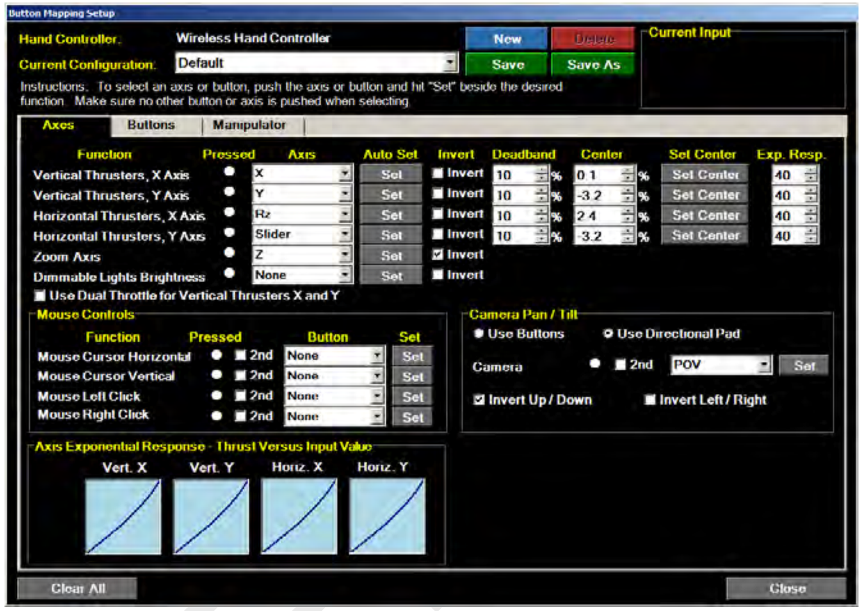
The ROV Depth Config button opens up the Depth Configuration window. On this window, the depth can be “zeroed”, and the model of the depth sensor can be configured. See section *14.4 Depth Configuration* for more information.

The Troubleshooting button opens up a window that provides information on the status values being sent from the ROV, as well as the control values being sent to the ROV from DiveLog (see image, right).



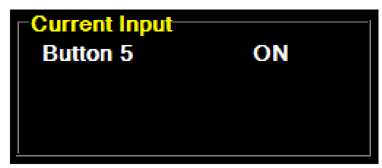
If there appears to be trouble with the ROV connection or any sensor values from the ROV, this window can be referred to gain detailed status information (see image, right).

16.7. Hand Controller Button Mapping Setup



Clicking "Configure" on the Hand Controller tab of the ROV Configuration window will open the Button Mapping Setup window. This window allows viewing or changing the function that each button on the hand controller performs. This window also allows choosing between different button mapping configurations or creating new ones.

If there are multiple hand controller setups, the current one can be selected by choosing it in the drop-down box at the top of the window. Using the buttons at the top, hand controller setups can be created, saved with a new name, or deleted.



At the top right of the window, a box indicates what buttons are currently being pressed. This helps in identifying buttons, and can also help to make sure additional buttons or axes are not pressed before auto setting a function (depending on the hand controller, some buttons or axes do not spring back to the off position when released).

The "Axes" tab shows all of the functions that use an analog axis, and also has displays for setting up mouse operation, manipulator operation, and camera pan/tilt operation.

The "Buttons" tab shows all functions that are controlled with a button or toggle switch.

The "Manipulator" tab provides various control options for the one, two, four, or five function manipulator.

Note: When the Setup Button Mapping window is open, the Hand Controller values will only be displayed on the window, and will not be used to control the ROV or any of its functions.

16.7.1. *Viewing the Button/Function Pairs*

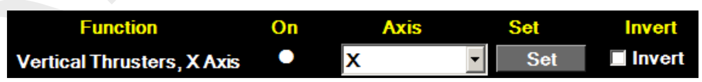
This form consists of a number of lists. In general, the ROV control functions are listed along the left side of each list. Beside the function is a dot indicating whether the axis/button is currently pressed, and then a dropdown list off all possible axes and buttons on the hand controller.

The button or axis associated with each function will be listed in the dropdown box, but it is not always immediately apparent which button/axis on the hand controller it is referring to. To easily view which function is associated with buttons/axes, simply press the button or move the axis to its extents and the dot beside the associated function will light up red.

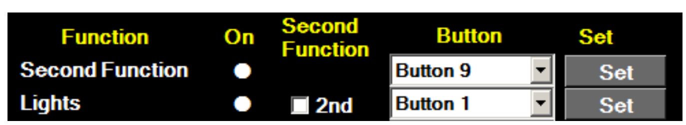
To view the second function of a button, hold down the "Second Function" button, then press the desired button. If the button has a second function assigned then the dot will light up beside that function.

16.7.2. *Editing the Setup*

For each function that requires a stick axis to control it, there will be a dropdown box to select an axis on the hand controller, as well as a checkbox that allows inverting the axis.



To automatically set the desired axis, push the stick/input all of the way along the proper axis (either in the left/right direction, or the forward/back direction), and then press the "Set" button to the right of the function name. The selection in the dropdown box will automatically be set to the pressed axis.



For each function that requires a button to control it, there will be a dropdown box to select the button, and a checkbox to select whether or not it is a second function of that button.

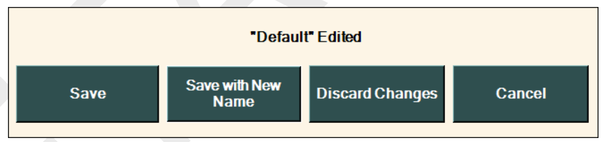
All functions in the list may be set to be either a button's primary function or secondary function. If that functions "2nd" checkbox is checked, that function will be performed only if the "Second Function" button is pressed, similar to holding a SHIFT key on a keyboard to use the key's alternate character. The "Second Function" is always the first in the list, and should must be set to allow for second functions to be performed.

To automatically set a desired button, hold down the button and then press the "Set" button to the right of the function name. The selection in the dropdown box will automatically be set to the pressed button. To set a button as a second function, perform this same procedure, and then check the “2nd" checkbox.

On certain button functions, there is an additional option to specify whether the button is a toggle button or a momentary button. In general, most buttons on hand controllers are momentary, meaning they will automatically release when the button is no longer pressed. More advanced hand controllers will have buttons that act as toggle switches: when they are switched one way, they will stay in the “on” state until manually switched back. These types of switches must be specified as “Toggle” in the button mapping setup to function properly.

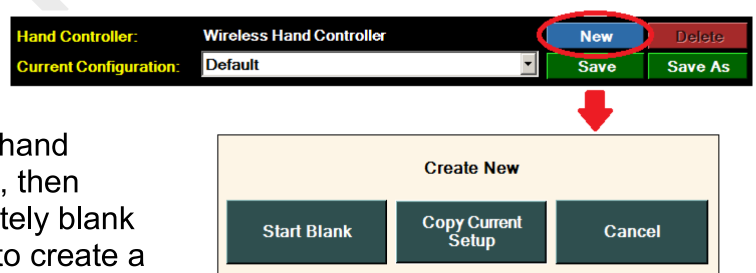
16.7.3.   Saving a Hand Controller Setup

If a hand controller setup is edited, click the “Save” or “Save As” button at the bottom. “Save As” will allow the user to enter a new name for the hand controller setup so that the previous setup will not be overwritten.



If the current setup has been modified and the user clicks “Close” or a different setup is selected from the list at the top, the user will be given a prompt to save changes to the setup. Select “Save” to update the current setup, select “Save with New Name” to save the edited setup as a separate setup, click “Discard Changes” to exit without saving the changes and click “Cancel” to continue editing the current setup.

16.7.4.   Creating a New Setup

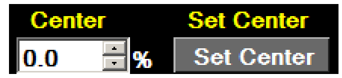


It is useful to create a new setup if you want to edit the default setup, or if a different hand controller is being used on the system. To create a new hand controller setup, click the “New” button, then select either “Start Blank” for a completely blank setup, or select “Copy Current Setup” to create a setup with a new name, but using all of the pre-configured button mapping of the current setup.

16.7.5.   Settings for Thruster Control Axes

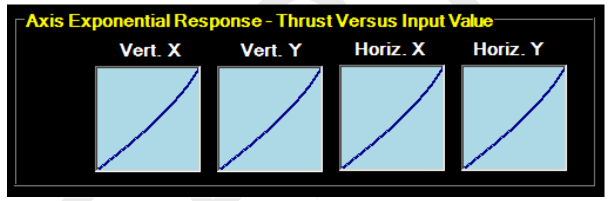
The four axes that control thruster speeds have some additional settings to set the deadband, the center, and the joystick exponential response.

When the control sticks return to the center, they may not spring back to the exact center point each time. The deadband values ensure that no control values will be sent to the thruster when the control sticks are at rest by creating a tolerance around the center point. Keep the deadband values low, but if you notice that the ROV thrusters sometimes turn when the control sticks are in their center position, increase these values for the appropriate axis.



Depending on the hand controller, the center of the sticks may not always produce a control value of zero. If you notice this, when the sticks are at rest, click the “Set Center” button to set the proper center point for the sticks.

The Joystick Exponential Response is used to give finer control to each thruster. By applying an exponential response to the control values for each thruster, the precision of control for slower thrust values is enhanced while precision of control is reduced at the top end. I.e. finer ROV control at slow speeds will be enhanced as the exponential response is increased.

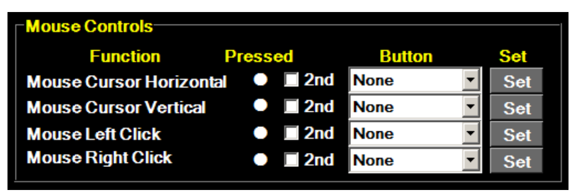


For hand controllers that use a dual throttle such as the Shark Marine ProStick, check the box labelled “Use Dual Throttle for Vertical Thrusters X and Y”. This will allow controlling vertical thrust as well as sideways “crab” movement with the dual throttle control.

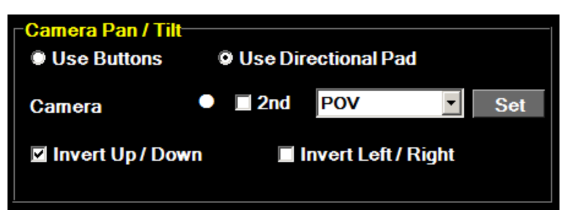
If the stick control seems too sensitive when turning the ROV (using the X axis of the horizontal thrusters control stick), reduce the “Turn Sensitivity” percent, which will effectively reduce the amount of power used to turn the ROV.

16.7.6.   Settings for Mouse Controls

If the hand controller contains controls that lend themselves well to mouse operation, then mouse controls can be set. The horizontal and vertical mouse movements are set as two analog axes, and the left click and right click are set as two buttons.



16.7.7.   Settings for Camera Pan / Tilt



There are two ways to control the camera pan/tilt platform: by using buttons or by using a directional pad (or “hat”). Choose the control type, then assign the appropriate buttons. If “Use Directional Pad” is selected, then only one button needs to be set (listed as POV in the drop-down list), otherwise four individual buttons must be set.

To swap the left/right or the up/down input for the directional pad ("hat"), click the "Invert Tilt" or the "Invert Pan" boxes.

16.7.8. *Manipulator Functions*

If a one or two function manipulator is used, then only buttons in the "Jaw and Wrist" box must be specified. A directional pad (or "hat") control can be used to control the jaw and wrist, or individual buttons can be used. If "Use Buttons" is selected, then a different button will be assigned to each of the four functions. If "Use Directional Pad" is selected, then a directional pad ("hat") input must be specified (listed as POV in the drop-down list).

To swap the left/right or the up/down of the directional pad ("hat"), click the "Invert Open/Close" or the "Invert Left/Right" boxes.

If the four or five function manipulator is used, then three control options are available: the directional pad ("hat"), or axes, or individual buttons. A combination of axes and buttons may also be used for the different arm functions.

A button or toggle switch should be set for enabling the hydraulic pump when equipped with a four or five function manipulator. If a toggle switch on the hand controller is used (i.e. when switched, it remains in the "on" state), then the "Toggle" box should be checked.

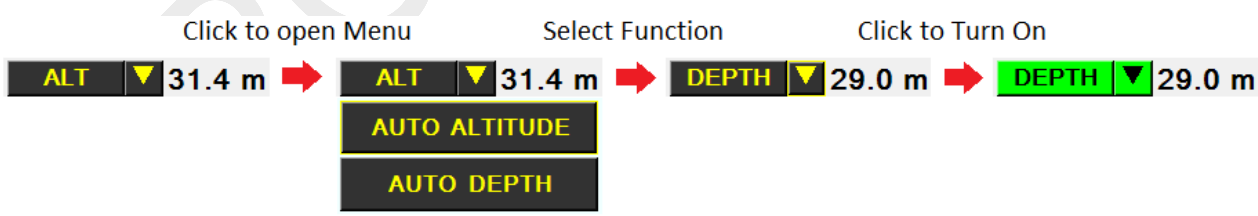
17. MAKO Diver Delivery System

The MAKO Diver Delivery System (DDS) can be connected to the Navigator to provide the MAKO with intelligent functions and control. To enable the MAKO control functionality in DiveLog, turn on the MAKO Diver Delivery System, on the System Setup window in DiveLog (see section 13.3.1 Active Vehicles).

When the MAKO is enabled in DiveLog, the MAKO controls will be visible along the top of the main DiveLog screen. The buttons along the top are as follows:

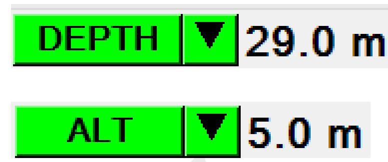
- Auto Depth or Auto Altitude: Used for controlling the vehicle's vertical position.
- Auto Route / Target Goto, Auto Heading, or Station Keeping: Used for automatic control of the vehicle's heading (and forward thrust when station keeping).
- Auto Speed or Thrust Hold: Used for controlling the forward thrust.
- MAKO Options: Opens the MAKO Options window, where many of the vehicle settings can be adjusted.

The first three buttons turn a particular function ON or OFF. When the function is ON, the button will be highlighted green. The function of each of these three buttons can be changed by selecting the function in a drop down menu. The drop down menu is opened by clicking the down arrow to the right of each button.



The MAKO Options button will open up the options window. See section *17.5 MAKO Options* for more information.

17.1. Auto Depth and Auto Altitude

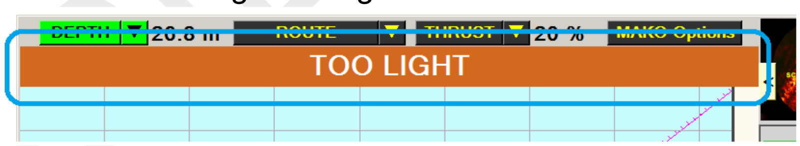


The Auto Depth and Auto Altitude functions automatically hold a constant depth, or a constant altitude off bottom. The depth/altitude set-point is displayed to the right of the button. When the Auto Depth / Auto Altitude is on, if the vertical thruster control stick is used to drive up or down, this value will automatically be set to the current depth or altitude once the control stick is released. The set-point can also be changed manually by clicking on the number.

When either Auto Depth or Auto Altitude is ON in DiveLog, the “Auto Depth” light on the MAKO DDS Control Box will also be ON. If the “Auto Depth” button on the MAKO DDS Control Box is pressed, this will turn ON or OFF the function in DiveLog.

NOTE: For Auto Altitude to function, an optional altimeter or Doppler unit must be connected.

When the Auto Depth or Auto Altitude is running, DiveLog will periodically perform a check of the amount of thrust that is being used. If DiveLog detects that a lot of thrust is consistently being used in one direction or the other, it could be because the buoyancy of the operator or other load on the vehicle is causing a strong vertical force that the Auto Depth routine is fighting against. If this is the case, DiveLog will show the message “TOO LIGHT” or “TOO HEAVY” to indicate that the operator should perform a buoyancy adjustment to reduce the amount of power being used. If the buoyancy of the vehicle is too light or too heavy, it may also cause the vehicle to pitch too greatly, which may affect operation of devices such as the Doppler or SONAR.

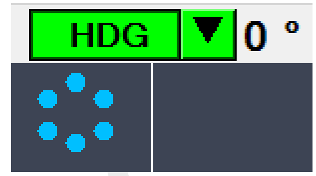


17.2. Auto Heading, Goto Route / Target, Station Keeping

Auto Heading, Goto Route / Target, and Station Keeping all automatically adjust the heading (turn the vehicle) when turned on. While Auto Heading simply points towards a given heading, the other two functions have more complex behaviour. See below for details.

NOTE: It is highly recommended that the Navigator Delta controlling the MAKO is fitted with the optional high accuracy motion reference unit (MRU) for responsive and accurate heading corrections.

17.2.1. *Auto Heading*



The Auto Heading will turn to correct the vehicle's heading until the compass heading (displayed on the Navigation View in DiveLog) matches the set-point, which is displayed beside the "HDG" button. To set the set-point to the current heading, click and hold the "HDG" button for one second (see image, right).

While Auto Heading is on, the driver of the vehicle can still use the horizontal control stick to change the heading of the vehicle. Once the stick is released or pushed straight forward, the heading control values from DiveLog will resume guiding the vehicle along the proper heading.

17.2.2. *Goto Route / Target*

When the Goto Route / Target is turned on, DiveLog will control the heading of the vehicle to point towards the current Goto in DiveLog, which can be either a target or route point (see sections *12.7 Tracking a Target* and *20.6 Routes*). To have the vehicle drive to the Goto point, turn on Thrust Hold or Auto Speed.

Depending on the Goto type, there are a few different options. A point "arrival distance" or "standoff distance" can be set, which sets the distance from the point that DiveLog will consider that it has arrived at the point. For routes there is also a setting to continue to the next point, or stop at each point. For more information see section *17.5 MAKO Options*.

NOTE: **If Auto Speed or Thrust Hold is turned ON while Goto Route / Target is ON, the vehicle will travel at the specified speed/thrust until it arrives as the Goto point. At this time it may toggle off the Auto Speed / Thrust Hold, or perform Station Keeping depending on the setting.**

17.2.3. *Station Keeping*

When turned on, Station Keeping will control the vehicle to automatically remain close to the current location. When station keeping turns on, it turns on the Auto Depth function to keep the vehicle at the same vertical position. Unlike Auto Heading and Goto Route/Target, station keeping will use forward thrust (as well as turning thrust) to remain near to the position, especially if there is a water current. There are some settings to configure how station keeping will operate; see section *17.5 MAKO Options* for more information.

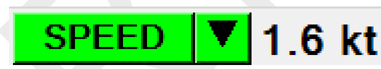
NOTE 1: **For station keeping, a position source must be connected and valid, such as a GPS or DNS.**

NOTE 2: When turning station keeping ON, Auto Speed or Thrust Hold will turn OFF (if previously ON). Forward thrust is only used if required by the station keeping function to remain close to the proper point.

17.3. Auto Speed and Thrust Hold

Auto Speed and Thrust Hold both control the forward thrust of the vehicle. See below for details.

17.3.1. Auto Speed



When turned on, the Auto Speed function will control the forward thrust of the vehicle. DiveLog will determine the proper level of thrust to remain at the set speed in knots. The desired speed is set by clicking on the value displayed beside the “Speed” button.

Auto Speed is especially useful when combined with the other auto functions. Turn on Auto Speed as well as Goto Route / Target to have the vehicle automatically traverse a pre-set route.

Auto Speed will be toggled OFF by the software if the user pulls back on the horizontal control stick of the Mako. This is a safety feature so that the vehicle does not continue forward if the user notices a collision risk and pulls back the stick to stop.

NOTE: For Auto Speed, a position source must be connected and valid, such as a GPS or DNS. If the position source goes invalid, Auto Speed will continue with the same thrust level as it waits for the position to become valid again.

17.3.2. Thrust Hold

The Thrust Hold button performs the same function as the Thrust Hold button on the MAKO DDS Control Box. This function sets the forward thrust to a specified percentage.

Just as with Auto Speed, Thrust Hold can be used in conjunction with Goto Route / Target to have the vehicle automatically traverse a pre-set route.

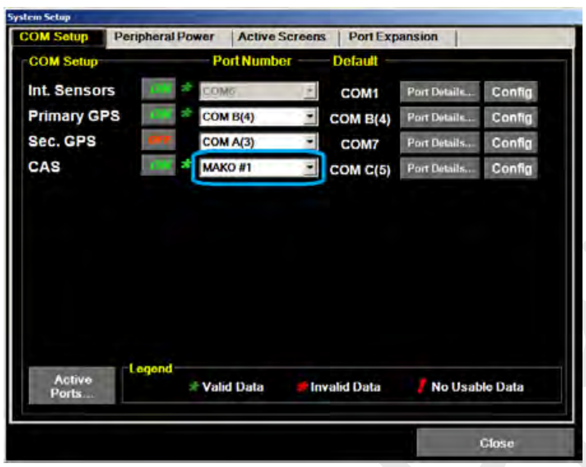
Thrust Hold will be toggled OFF by the software if the operator pulls back on the horizontal control stick of the MAKO.

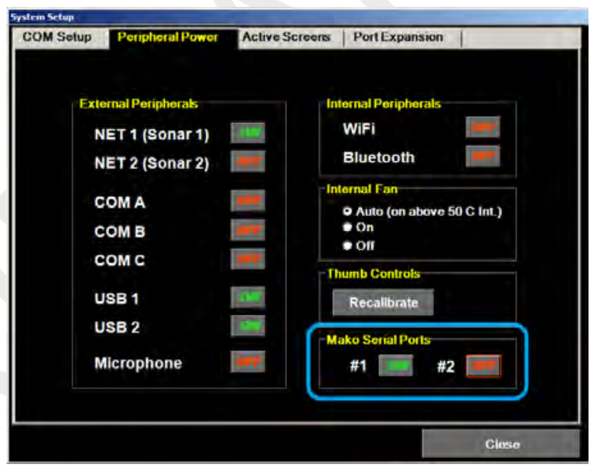
17.4. MAKO COM Ports

The MAKO control box has one or two serial ports that can be used to plug in a serial device such as a GPS or a Collision Avoidance Sonar. The serial ports on the MAKO behave in the same way as the serial (COM) ports on the Navigator, and include power toggling functionality.

To set the device COM port, on the System Setup window specify MAKO #1 or MAKO #2 for the Port Number (see image, lower left).

To toggle the power to the device, on the Peripheral Power tab of the System Setup window, press the ON/OFF buttons under Mako Serial Ports (see image, lower right).





Note: **For the COM Port communication and power toggling to function, the MAKO must be connected to the Navigator and powered up.**

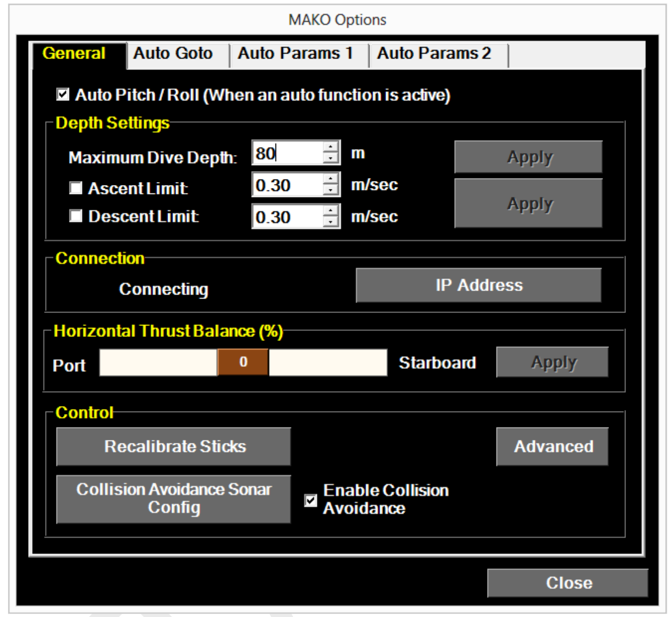
17.5. MAKO Options

The Mako Options window is reached by clicking the "Mako Options" button at the top of the main window of DiveLog when the MAKO is enabled.

NOTE: **Some settings on this window have an "Apply" button, which indicates that it is a setting that is saved to the memory in the MAKO DDS itself. There must be an active link with the vehicle to set these settings. The apply button must be clicked (and the vehicle connected) before the setting will take effect.**

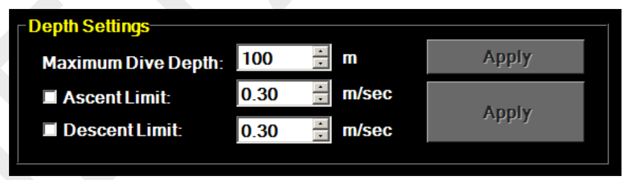
The Mako Options window has several tabs of useful setup options.

17.5.1. General Tab



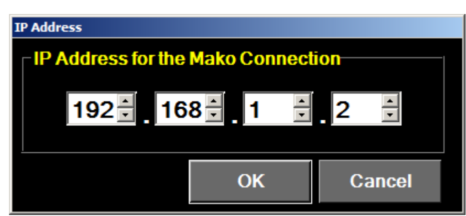
The first checkbox on the "General" tab enables or disables Auto Pitch / Roll. When this box is checked, if DiveLog is connected to the MAKO DDS, and at least one other auto function is active (such as Auto Depth, Auto Heading, et cetera), DiveLog will control the vertical thrusters to compensate if the pitch or roll of the vehicle is deviating from a level orientation.

NOTE: For the pitch correction, the vehicle must be configured with four vertical thrusters, rather than the standard two.



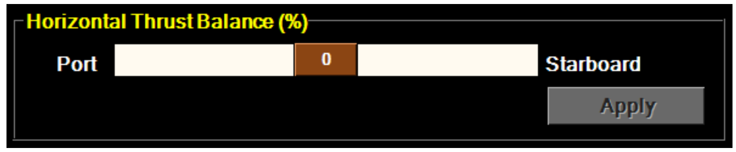
In the "Depth Settings" box, there are several settings:

- Maximum Dive Depth: If the vehicle is driven deeper than this depth setting (either by user stick control or by control of an automatic software function), then DiveLog will display a warning to the operator that the maximum depth has been exceeded.
- Ascent Limit: When the ascent limit is enabled, the MAKO DDS will produce a counter thrust if the ascent rate is greater than the set rate. By default, the ascent limit is always enabled on the vehicle, and limits the ascent to 0.3 m/sec or 1 ft/sec. DiveLog can override this setting by unchecking the box or entering a different value here.
- Descent Limit: When the descent limit is enabled, the MAKO DDS will produce a counter thrust if the descent rate is greater than the set rate. By default, the descent limit is always disabled on the vehicle. DiveLog can override this setting by entering a value here and checking the box.



In the "Connection" box, the status of the Ethernet connection to the Mako is displayed. The "IP Address" button allows setting the IP address of the vehicle (i.e. the IP address that DiveLog will connect to. The default IP address of the vehicle is **192.168.1.2**. This number should always be displayed here unless there is a special setup.

This slider allows setting the Horizontal Thrust Balance percent. This is used to adjust the power that goes to horizontal port thrusters versus the horizontal starboard thrusters.



When the control stick is pushed directly forward, depending on imbalances in drag and thrusters between the port side and the starboard side, the vehicle may make a slight turn (large arc) to the left or right. This slider bar compensates for this. Slide the bar to the right to give more power to the starboard thrusters, and slide it to the left to give more power to the port thrusters.

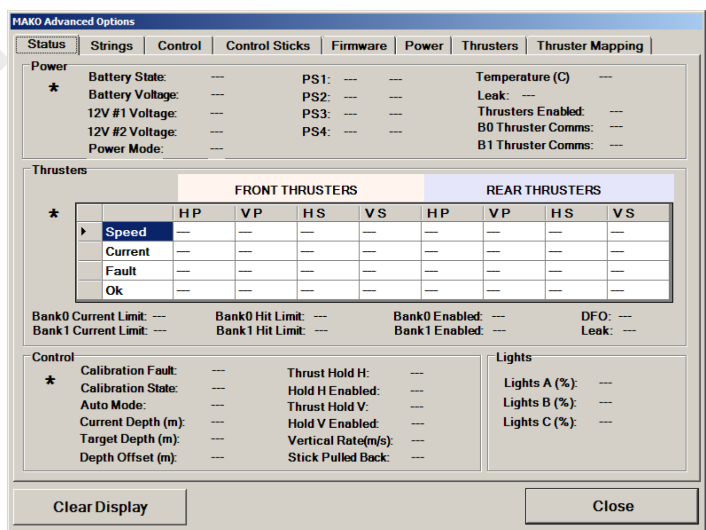
The “Control” box allows the user to change settings for two MAKO peripherals, as follows:

Recalibrate Sticks: This button will command the vehicle to perform a full calibration of the stick controls (this may take about a minute or longer). Be sure that the operator does not touch the sticks during this process.

Collision Avoidance Sonar: These options allows enabling and setting parameters for a collision avoidance sonar, if one is installed. To enable automatic collision avoidance, check the checkbox labeled “Enable Collison Avoidance”. When the “Collision Avoidance Sonar Config” button is pressed, the Collision Avoidance Sonar Configuration window is opened. For details, see section *15.16 Collision Avoidance Sonar*.

The Advanced button in this box opens the MAKO Advanced Options window, used to troubleshoot and monitor MAKO internal circuitry.

MAKO Advanced Options



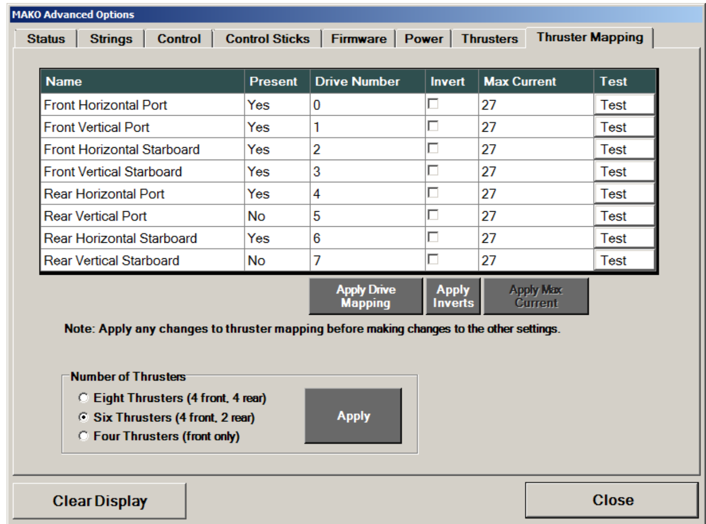
This window is opened from the General tab of the Mako Options window. This window should normally only be used under advice from technical staff at Shark Marine Technologies Inc.

The tabs on this window each display various status and setup information. The status information may be used to help troubleshoot hardware problems.

All settings on this window will have been set at the factory, and there is generally no need to change them.

The only settings that may need to be updated are the settings on the last tab: Thruster Mapping. This tab sets up the thruster configuration for the MAKO, and specifies which drive in the MAKO Thruster Driver Box is driving which thruster.

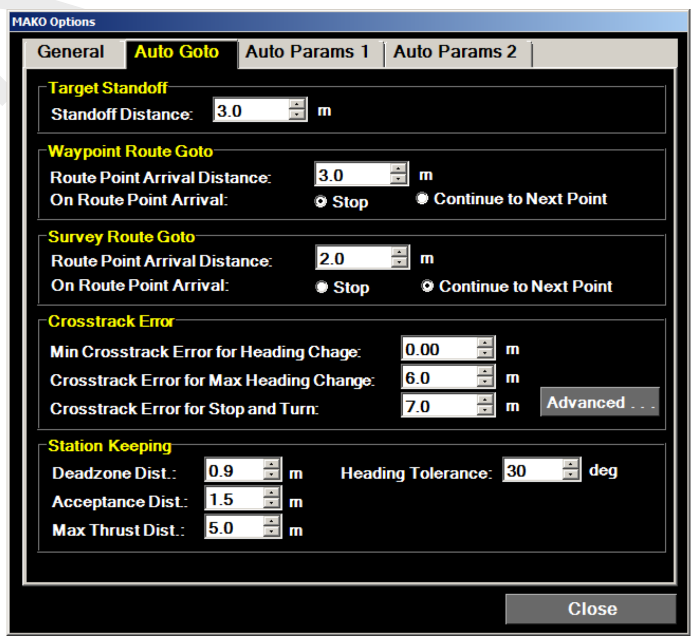
It is beyond the scope of this manual to set up drive mapping. In the case that it appears that an incorrect thruster is turning when a thumb stick is pressed in a particular direction, contact Shark Marine Technologies before changing the drive mapping.



The “Test” button on the right side of the table can be used to test each drive/thruster and helps when the need arises to troubleshoot drive or thruster problems. If the MAKO is ON and connected to DiveLog, then pressing the “Test” button will command an individual thruster to run at 10% power for 1 second.

The “Invert” column of checkboxes is used to invert the direction of rotation of the thruster. This should normally not be necessary to change, but there are certain cases where this is desirable, usually when a field repair is being done. For example, this may be necessary if a thruster is replaced with a thruster that is wired the opposite way, or with a thruster that has a prop with the opposite sweep. After setting the “Invert” checkbox, click the button “Apply Inverts” to enable the change.

17.5.2. Auto Goto Tab



These settings configure how DiveLog’s Goto Route / Target, and Station Keeping functions will operate.

- Target Goto:
  - o Target Standoff Distance: This applies when using a Target or Target Route as the Goto in DiveLog, and the Goto Route / Target function is turned ON, and Auto Speed or Thrust Hold is also turned ON. When the vehicle gets to a point with this distance from the target, DiveLog will stop travelling forward towards the target, and will start performing station keeping to remain about the set distance from the target.

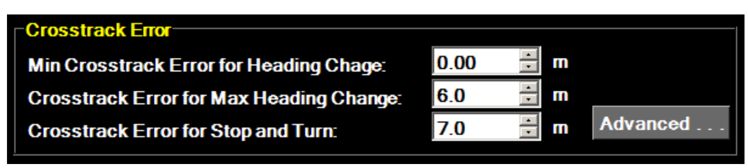
- Waypoint Route Goto: These settings apply when using a Waypoint Route as the Goto in DiveLog and Goto Route / Target is turned ON.

  - Route Point Arrival Distance: Determines the distance from the Goto route point that DiveLog will consider that it has arrived at the point, and will either perform the stop or continue function.
  - On Route Point Arrival: Determines what the vehicle will do when it has arrived at the Goto route point.
    - Stop: If Auto Speed or Thrust Hold is turned ON, it will toggle OFF. The route point is not incremented, but can be manually incremented by the user when they are ready to proceed.
    - Continue to Next Point: The route point will be incremented to the next point in the route. The heading will turn towards the next point. At the last point in the route, the vehicle will perform station keeping.

- Survey Route Goto: These settings apply when using a Survey Route as the Goto in DiveLog and Goto Route / Target is turned ON.

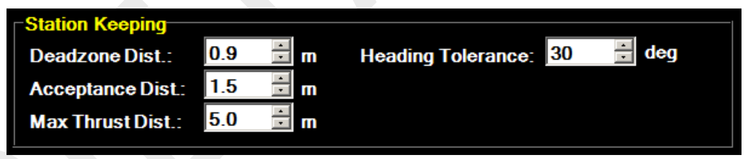
  - Route Point Arrival Distance: Determines the distance from the Goto route point that DiveLog will consider that it has arrived at the point, and will either perform the stop or continue function.
  - On Route Point Arrival: Determines what the vehicle will do when it has arrived at the Goto route point.
    - Stop: If Auto Speed or Thrust Hold is turned ON, it will toggle OFF. The route point is not incremented, but can be manually incremented by the user when they are ready to proceed.
    - Continue to Next Point: The route point will be incremented to the next point in the route. If Auto Speed or Thrust Hold is turned ON, the forward thrust will stop to allow the vehicle heading to turn to the proper direction. When the heading is correct for the next point, the forward thrust will resume. This action is done to eliminate overshoot, and make sure the vehicle remains as close as possible to the proper line start point when following a survey grid. At the last point in the route, the vehicle will perform station keeping.

- Crosstrack Error: These settings apply when using any type of route as the Goto in DiveLog and Goto Route / Target is turned ON.



  - Min Crosstrack Error for Heading Change: This value determines how far to the right or left of the route line will cause the vehicle to start to turn to get closer to the route line. To follow a route line more accurately, reduce this value.

- Crosstrack Error for Max Heading Change: This value determines how far to the right or left of the route line the vehicle must be to have the vehicle head entirely back to the route line itself, rather than the Goto point. To follow a route line more accurately, reduce this value, but if this value is too low then changes in heading may be too abrupt when the position gets closer or further away from the route line. When following a route, if the crosstrack error is between the min and max values, the vehicle heading will be somewhere between the two extremes, allowing the vehicle to correct itself to get back to the line as well as keep heading towards the Goto point at the end of the route line.
- Crosstrack Error for Stop and Turn: At this distance the vehicle will check that it is going in the correct direction, and will cut thrust and turn towards the route if the direction is wrong. This prevents the vehicle from performing a large arcing turn if it was heading in the wrong direction (such as when a route point is manually incremented or due to a loss of a valid position).
- Advanced Button: This button sets up the PID control loop for the Crosstrack Error Correction (Route Following correction). See section *19.4 Crosstrack Error (Route Following) PID* for more information.



• Station Keeping: These settings apply when using the "Station Keeping" auto function, such as when at the end of a route, using the route "loiter" function, standing off from a target, or using the main station keeping function.
  - Deadzone Dist.: Within this radius from the station keeping position, neither forward thrust will be used, nor will the heading be adjusted. This value should be small, but if too small then the vehicle may try to turn too much if the position from the source is bouncing.
  - Acceptance Dist.: This value determines how far from the station keeping position the vehicle may drift before it will provide some forward thrust to get closer. If the vehicle is within this distance, then no forward thrust will be used, but the heading will be adjusted to point towards the station keeping point.
  - Max Thrust Dist.: When the vehicle is between the Acceptance Distance and the Maximum Thrust Distance, then a varying (proportional) amount of thrust will be used to get closer to the station keeping position. Outside the Maximum Thrust Distance, full thrust will be used to get closer to the point.

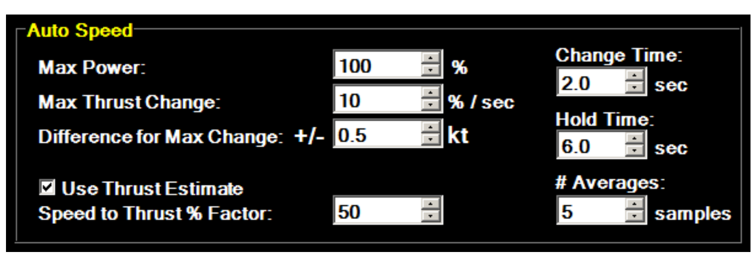
17.5.3. Auto Params 1 Tab

Auto Heading

The Auto Heading settings determine the strength of heading corrections (used in Auto Heading, Goto Route / Target, and Station Keeping).

- Min Power: Applies a dead-band, so thrust below this percent will not be used.
- Max Power: The maximum amount of power that will be used if the current heading is far away from the proper heading.
- Steer Forward Bias and Steer Reverse Bias: These setting are used because thrusters generally do not give as much power in reverse as they do going forward. Set these percentages to reduce forward power and increase reverse power to give more effective turning, and to reduce the amount of forward movement when turning on the spot. Click “Apply” to set these values (so the Mako Hardware settings get updated).
- Advanced Settings when Stopped: This button sets up the PID control loop for the Auto Heading when the vehicle is not moving forward. See section *19.2 Auto Heading PID* for more information. The settings are different than the settings for when the vehicle is moving, since turning dynamics are different in these two states.
- Advanced Settings when Moving: This button sets up the PID control loop for the Auto Heading when the vehicle is moving forward. See section *19.2 Auto Heading PID* for more information.

Auto Speed



The Auto Speed settings determine the strength of a speed correction (used when Auto Speed is turned on). The auto speed routine works as a “Change and Hold” cycle, where DiveLog changes the thrust then holds the new thrust for a period of time. DiveLog will first compare the actual speed provided by the positioning sensor (such as GPS or DNS) to the speed setpoint. If they do not match, then DiveLog will increase or decrease thrust for a period of time, known as the Change Time. DiveLog will then keep the thrust constant for a “Hold Time” to allow the vehicle to accelerate or decelerate, and for the speed to stabilize with the new level of thrust. The cycle then repeats as DiveLog will compare the speed and perform the adjustment, then wait for the actual speed change to occur.

- Max Power: The maximum amount of power that will be used by the auto speed routine.
- Max Thrust Change: If the current speed is very different from the speed set-point (i.e. at or beyond the setting for “Difference for Max Change”), then this is the increase in thrust that will be used. Reduce this value to have the thrust respond slower to a change in speed.
- Difference for Max Change: Sets how far the speed must be from the set-point for the maximum change in power to be used. At a difference in speed below this value, a proportional change in thrust (less than “Max Thrust Change”) will be used.
- Use Thrust Estimate: Turns on the thrust estimate feature. When the vehicle is starting from a stopped state, DiveLog will estimate the proper thrust to get to the given speed.
- Speed to Thrust % Factor: Used to estimate the proper thrust to get to a given speed. This value is multiplied against the speed setpoint to get a thrust percent. For example, if the speed setpoint is 1.0 knots, then 1.0 * factor of 50 = 50% thrust to be used.
- Change Time: The amount of time that DiveLog will adjust the thrust while performing the “Change and Hold” cycle.
- Hold Time: The amount of time that DiveLog will hold the thrust constant while performing the “Change and Hold” cycle.
- # Averages: Since the speed measurement from the positioning sensor can be “bouncy”, the auto speed routine will average a number of speed readings to smooth out the changes. Do not increase this value too high, as it will delay the changes to the thrust.

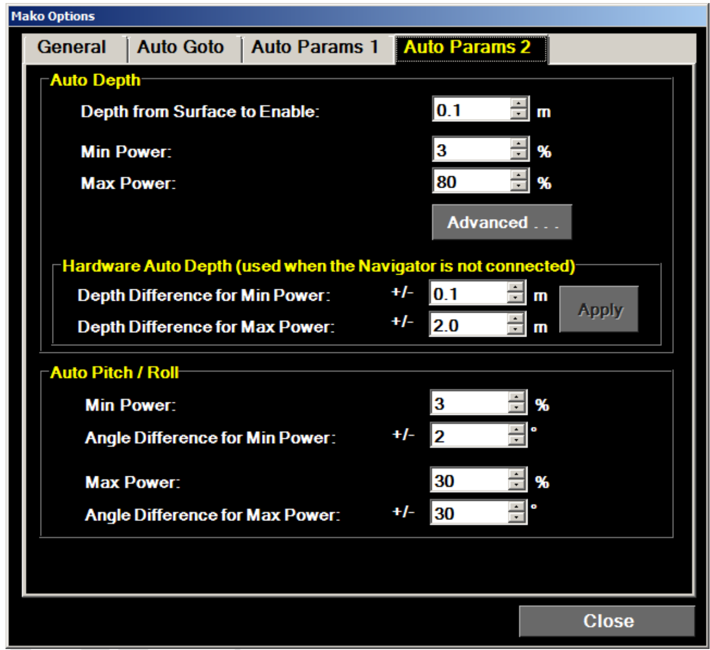
Stopping

Stopping settings are used when the vehicle is following a route and needs to stop when arriving at a point. These settings should allow the vehicle to stop as closely to the route point as possible.

- Stop Time: The amount of time that reverse thrust will be applied to stop when travelling at 1 knot. If travelling slower than 1 knot, the stop time will be reduce proportionally, and if travelling faster than 1 knot, the stop time will be increased proportionally.
- Stop Power: The percent power of reverse thrust will be applied to stop when travelling at 1 knot. If travelling slower than 1 knot, the stop power will be reduced proportionally, and if travelling faster than 1 knot, the stop power will be increased proportionally.

17.5.4. *Auto Params 2 Tab*

Auto Depth



The Auto Depth settings determine the strength of a depth correction (used in Auto Depth, and Auto Altitude).

- Depth from Surface to Enable: Right at the surface, no depth correction will be performed. This value determines how deep the unit must be to perform depth corrections.
- Min Power: Applies a dead-band, so thrust below this percent will not be used.
- Max Power: The maximum amount of power that will be used if the current value is far away from the set-point.
- Advanced Button: This button sets up the PID control loop for the Auto Depth routine. See section *19.3 Auto Depth PID* for more information.

Hardware Auto Depth (used when the Navigator is not connected)

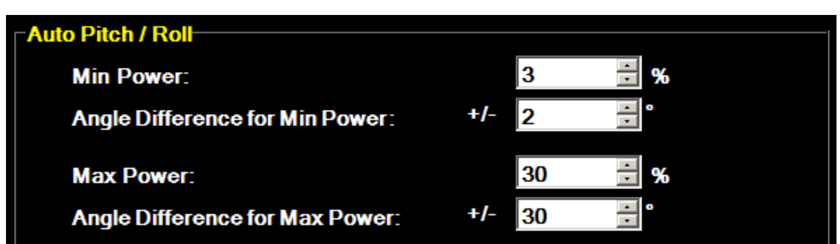
Aside from the Auto Depth that is controlled by DiveLog on the Navigator, the MAKO also has a hardware based auto depth function that will operate when the Navigator is disconnected. There are two settings that specifically apply to the hardware auto depth, as follows:

- Depth Difference for Min Power: The difference between the current depth and the set-point when the correction starts to be applied, i.e. the thrusters start to turn on to correct.
- Depth Difference for Max Power: The difference between the current depth and the set-point that the maximum amount of power that will be used to correct.

Click Apply when these values are changed to update the hardware (the MAKO must be connected and powered up).

Auto Pitch/Roll

The Auto Pitch/Roll settings determine the strength of a pitch or roll correction (used



when Auto Pitch/Roll is checked on the General Tab).

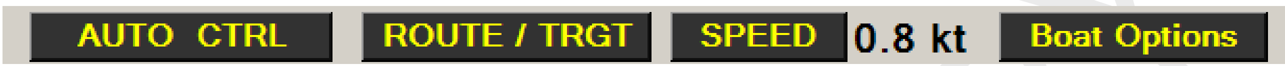
Note: Auto pitch is only available on ROV's with special thruster configuration.

The settings are as follows:
- Min Power: How much power will be used when the correction starts to be applied, i.e. the thrusters turn on slowly to correct.
- Angle Difference for Min Power: How far the current pitch/roll value must be away from level before a correction is applied.
- Max Power: The maximum amount of power that will be used if the current value is very far away from the set-point (specifically, when the pitch/roll is equal to or greater than the "angle difference for max power").
- Angle Difference for Max Power: How far the pitch/roll must be from level before maximum power is used to correct. If the pitch/roll is somewhere between the "angle difference for min power" and the "angle difference for max power", then a percentage of power between the "min power" and "max power" will be used.

18. DiveLog Automated Survey Boat

The DiveLog Automated Survey Boat (D.A.S. Boat) feature is enabled by selecting "D.A.S. Boat" on the Active Screens tab of the System Setup window (see *13.3.1* Active Vehicles for more information).

When the D.A.S Boat is enabled, an "Auto Controls Bar" will be displayed at the top of the Primary Screen of the main DiveLog window.



The D.A.S. Boat may be controlled with the hand controller, but turning on the Auto controls in DiveLog will enable automatic control of the boats speed and heading.

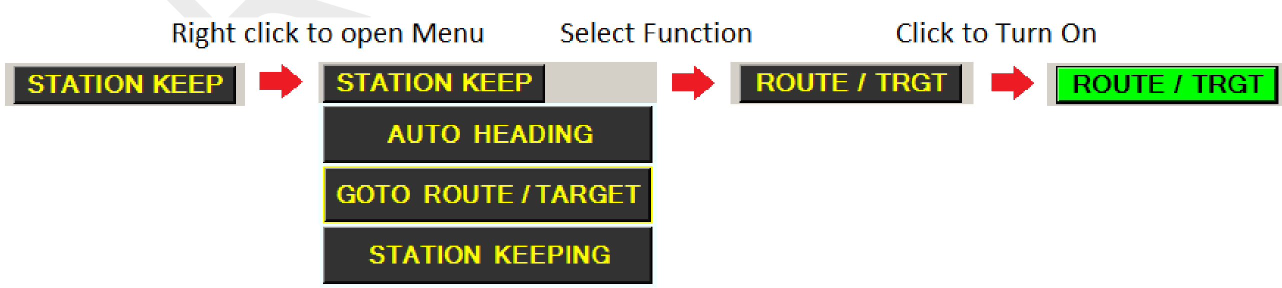
Note: To allow automatic control of the boat by DiveLog, the auto control switch must be switched to "Auto" on the hand controller.

18.1. Auto Function Controls

The buttons along the top of the screen function as follows:

- Auto Ctrl (Control): Used to turn on general control of the boat by DiveLog.
- Auto Route / Target Goto, Auto Heading, or Station Keeping: Used for automatic control of the vehicle's heading.
- Auto Speed or Thrust Hold: Used for controlling the forward thrust of the boat.
- Boat Options: Accesses the window for various information and setup parameters.

The first three buttons turn on or off a particular function by clicking the button. When the function is on/active, the button will be highlighted green. The function of the second and third of these three buttons can be changed by selecting the function in a drop down menu. The drop down menu is opened by right clicking the button or letting the mouse hover over the button for one second.



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18.2. Auto Control

The AUTO CTRL (Auto Control) button turns on DiveLog's control of the boat. When on, if no other auto controls are turned on then DiveLog will be actively communicating with the boat, but will not send any thrust commands. When this is on, turning on one or both of the other auto functions will then cause the boat to move.

NOTE: While the boat is powered, this button should be ON to give DiveLog control of the boat if the hand controller is not turned on or being used. Leaving the boat powered with neither the hand controller on, nor DiveLog control on may cause the boat to perform random thrust or servo movements.

18.3. Auto Heading, Goto Route / Target, Station Keeping

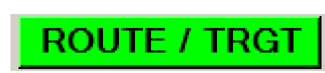
Auto Heading, Goto Route / Target, and Station Keeping all automatically adjust the heading (turn the boat) when turned on. While Auto Heading simply points towards a given heading, the other two functions have more complex behaviour. See below for details.

18.3.1. Auto Heading

The Auto Heading will turn to correct the boat's heading until the compass heading (displayed on the Navigation View in DiveLog) matches the set-point, which is displayed beside the "HDG" button. To set the set-point to the current heading, click and hold the "HDG" button for one second (see image, right).

If Auto Speed or Thrust Hold is used, then the boat will travel along the given heading. If neither Auto Speed or Thrust Hold is used, then the boat will point itself along the given heading, but will not produce forward thrust.

18.3.2. Goto Route / Target



When the Goto Route / Target is turned on, DiveLog will control the heading of the vehicle to point towards the current Goto in DiveLog, which can be either a target or route point (see sections *12.7 Tracking a Target* and *20.6 Routes*). To have the vehicle drive to the Goto point, turn on Thrust Hold or Auto Speed (there must be a position from the boat GPS for Auto Speed).

Depending on the Goto type, there are a few different options. A point "arrival distance" or "standoff distance" can be set, which sets the distance from the point that DiveLog will consider that the boat has arrived at the point. For routes there is also a setting to continue to the next point, or stop at each point. See *18.5.3 Auto Goto Tab* on the Configuration window for more information.

NOTE: **If Auto Speed is turned ON while Goto Route / Target is ON, the vehicle will travel at the Auto Speed value until it arrives as the Goto point. At this time it may toggle off the Auto Speed, or reduce the forward thrust depending on the proper action.**

18.3.3. Station Keeping

When turned on, Station Keeping will control the boat to automatically remain close to the current location. Unlike Auto Heading and Goto Route/Target, station keeping will turn on forward thrust (as well as turning thrust) to remain near to the position, especially if there is a current in the water. There are some settings to configure how station keeping will operate; see *18.5.3 Auto Goto Tab* on the Configuration window for more information.

NOTE 1: **For station keeping, the boat must have a valid a position from the GPS.**

NOTE 2: **If Auto Speed is ON when Station Keeping is turned ON, the thrust needed to perform the station keeping will override the Auto Speed thrust, i.e. the boat will not move at the auto speed value.**

18.4. Auto Speed and Thrust Hold

Auto Speed and Thrust Hold both control the forward thrust of the boat. See below for details.

18.4.1. Auto Speed

When turned on, the Auto Speed function will control the forward thrust of the vehicle. DiveLog will attempt to determine the proper level of thrust to remain at the set speed in knots. The desired speed is set by clicking on the speed value displayed beside the “Speed” button.

Auto Speed is especially useful when combined with the other auto functions. Turn on Auto Speed as well as Goto Route / Target to have the vehicle automatically traverse a pre-set route.

NOTE: **For Auto Speed, DiveLog must be receiving a valid position from the boat’s GPS. If the position source goes invalid, Auto Speed will continue with the same thrust level as it waits for the position to become valid again.**

18.4.2. *Thrust Hold*

The Thrust Hold button sets a certain percentage of horizontal forward thrust. Thrust Hold will produce a more stable level of thrust than Auto Speed, but will not compensate for wind or current in the water so the overall speed may or may not be as consistent as Auto Speed, depending on the conditions.

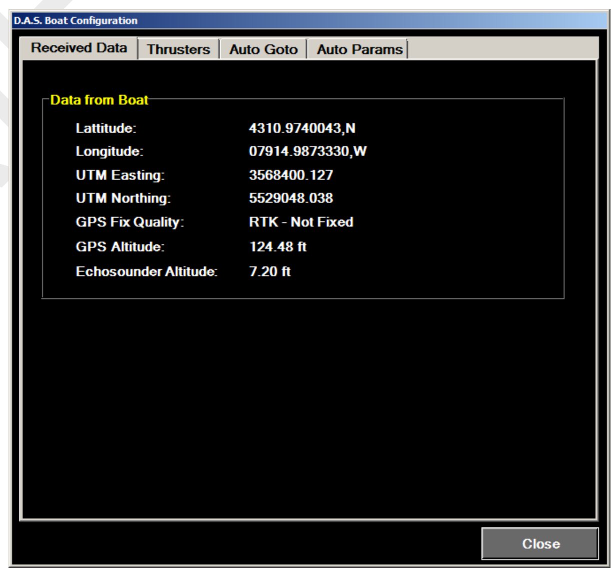
Like Auto Speed, Auto Thrust is useful when combined with the other auto functions. Turn on Auto Thrust as well as Goto Route / Target to have the vehicle automatically traverse a pre-set route.

18.5. D.A.S. Boat Configuration

The D.A.S. Boat Configuration window is opened by clicking the Boat Options button on the Auto Controls Bar at the top of DiveLog's main screen. The configurations window is divided into four tabs that each contain various setup parameters.

18.5.1. *Received Data Tab*

The Received Data tab shows a few pieces of that the boat is transmitting over the wireless link.



Position of the boat in latitude and longitude as well as UTM is displayed. The quality of the position fix is also displayed. This is important, as the boat's position will not be at it's optimal accuracy until the GPS Fix Quality reads "RTK – Fixed".

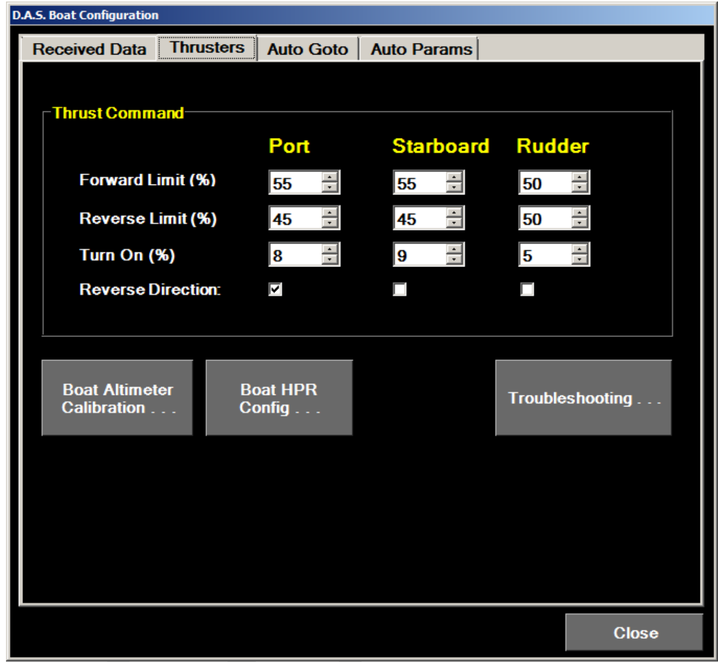
The GPS altitude (altitude above mean sea level) as well as the echosounder altitude (altitude above the sediment) are also displayed.

18.5.2. *Thrusters Tab*

The Thrusters tab contains various setup parameters for each of the port, starboard, and rudder (thuster angle) servo.

The Thrust Command box sets the thruster limits, turn on percent, and reverses the direction of the thrust command value.

The Forward Limit percent defines the maximum thrust power that will be sent to each thruster in the forward direction. The Reverse Limit percent is the same for the reverse direction. Keeping this value at a reasonable percentage will reduce the current (power) drawn by each thruster and extend battery life. The reverse limit should also be kept low because the thrusters will draw in air if they spin too fast in reverse.



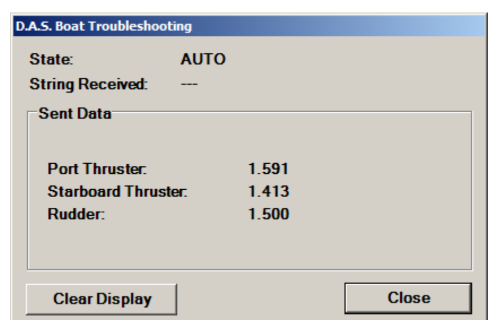
The Turn On Percent specifies the actual commanded thrust percent used when DiveLog wants to use 1% thrust (since friction will prevent the prop from turning at a very low percentage of power). This value is important for accurate control at low thruster speeds.

Note: Since the two thrusters on the boat have counter-rotating propellers, one thruster (usually the port) must be reversed.

The button “Boat Altimeter Calibration…” opens the window used to calibrate the echosounder. See section *15.8 Altitude Calibration* for more information.

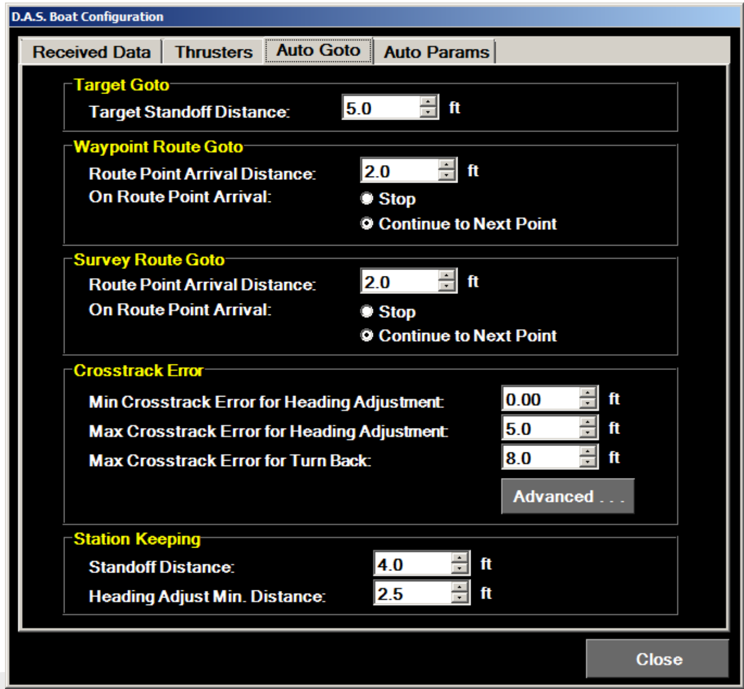
The “Boat HPR Config…” button opens up the Heading Pitch Roll Configuration window. On this window, several of the heading, pitch, and roll parameters can be adjusted and the eight point compass calibration can be performed (important for the most accurate compass readings). See section *14.3 Heading Pitch Roll (HPR) Configuration* for more information).

The Troubleshooting button opens up a window that provides information on the control communications to the boat (see image, right). If there appears to be trouble with the boat connection, this window can be referred to in order to view the status and control values being sent to the boat.



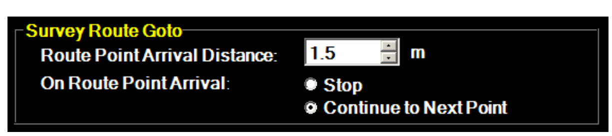
18.5.3. *Auto Goto Tab*

These settings configure how DiveLog's Goto Route / Target, and Station Keeping functions will control the boat.



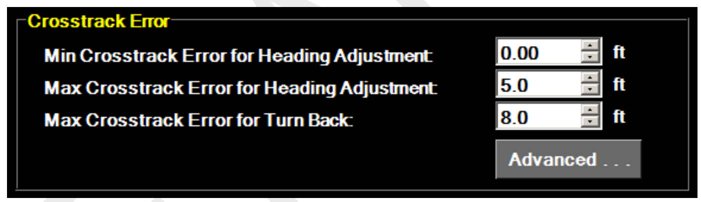
- Target Goto:
  - Target Standoff Distance: This applies when using a Target or Target Route as the Goto in DiveLog, and the Goto Route / Target function is turned ON, and Auto Speed is also turned ON. When the boat gets to a point which is this distance from the target, DiveLog will stop moving the boat forward towards the target, and will start performing station keeping to remain about the set distance from the target.

- Waypoint Route Goto: These settings apply when using a Waypoint Route as the Goto in DiveLog and Goto Route / Target is turned ON.
  - Route Point Arrival Distance: Determines the distance from the Goto route point that DiveLog will consider that the boat has arrived at the point, and will either perform the stop or continue function.
  - On Route Point Arrival: Determines what the boat will do when it has arrived at the Goto route point.
    - Stop: If Auto Speed or Thrust Hold is turned ON, it will toggle OFF. The route point is not incremented, but can be manually incremented by the user when they are ready to proceed.
    - Continue to Next Point: The route point will be incremented to the next point in the route. If Auto Speed or Thrust Hold is turned ON, the forward thrust will stop to allow the vehicle heading to turn to the proper direction. When the heading is correct for the next point, the forward thrust will resume. At the last point in the route, the vehicle will perform station keeping.



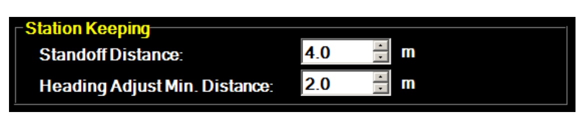
- Survey Route Goto: These settings apply when using a Survey Route as the Goto in DiveLog and Goto Route / Target is turned ON.

- Route Point Arrival Distance: Determines the distance from the Goto route point that DiveLog will consider that the boat has arrived at the point, and will either perform the stop or continue function.
- On Route Point Arrival: Determines what the boat will do when it has arrived at the Goto route point.
  - Stop: If Auto Speed or Thrust Hold is turned ON, it will toggle OFF. The route point is not incremented, but can be manually incremented by the user when they are ready to proceed.
  - Continue to Next Point: The route point will be incremented to the next point in the route. If Auto Speed or Thrust Hold is turned ON, the forward thrust will stop to allow the vehicle heading to turn to the proper direction. When the heading is correct for the next point, the forward thrust will resume. At the last point in the route, the vehicle will perform station keeping.



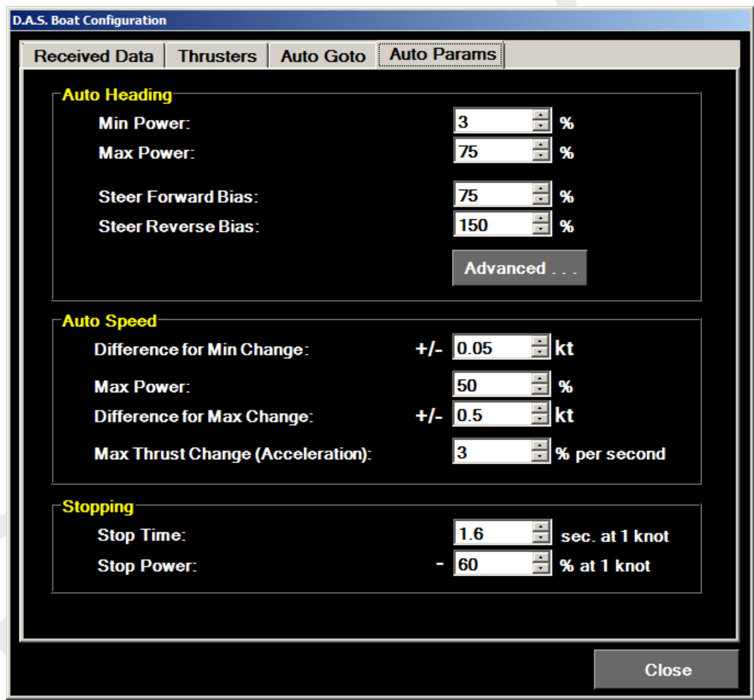
- Crosstrack Error: These settings apply when using any type of route as the Goto in DiveLog and Goto Route / Target is turned ON.
  - Min Crosstrack Error for Heading Adjustment: This value determines how far to the right or left of the route line will cause the vehicle to start to turn to get closer to the route line. To follow a route line more accurately, reduce this value.
  - Max Crosstrack Error for Heading Adjustment: This value determines how far to the right or left of the route line will cause the vehicle to head entirely back to the route line itself, rather than the Goto point. To follow a route line more accurately, reduce this value, but this value must be greater than the “Min Crosstrack Error for Heading Adjustment”. When following a route, if the crosstrack error is between the min and max values, the vehicle heading will be somewhere between the two extremes, causing the vehicle to correct itself to get back to the line as well as keep heading towards the Goto point at the end of the route line.
  - Max Crosstrack Error for Turn Back: If the boat is equal to this distance away from the route line, the boat will stop and adjust its heading to get back to the route line, the resume forward speed when pointed in the correct direction (provided that Auto Speed or Thrust Hold is on).
  - Advanced: This button sets up the PID control loop for the Crosstrack Error Correction (Route Following). See section *19.4 Crosstrack Error (Route Following) PID* for more information.

- Station Keeping: These settings apply when using the “Station Keeping” auto function.
  - Standoff Distance: This value determines how far from the initial position the boat may drift before it will provide some forward (or reverse) thrust to get closer. If the vehicle is within this distance, then no forward thrust will be used.



- Heading Adjust Min. Distance: This value determines how far from the initial position the boat must drift before the heading will be corrected to turn towards the point. This value should be small, but if too small then the boat may spin too much when close to the station keeping point (to try to maintain a heading towards the station keeping point).

18.5.4. Auto Params Tab



There are three groups of parameters for controlling the auto functions:

- Auto Heading: Determines the strength for the heading correction used by the auto functions (Auto Heading, Goto Route / Target, Station Keeping).
- Auto Speed: Determines the strength for the Auto Speed routine.
- Stopping: Determines the power used to stop the boat when arriving at a route point.

Auto Heading

The “min power” refers to how much power will be used when the correction starts to be applied, i.e. it starts to turn on to correct.

The “max power” indicates the maximum amount of power that will be used if the current heading is very far away from the set-point.

Steer Forward Bias and Steer Reverse Bias: When the boat is turning, the thruster on one side will be given increased power, while the thruster on the other side will be given reduced power (or power in reverse if the vehicle is stopped). Since the thrusters do not generally produce as much thrust when they are going in reverse, set these percentages to reduce forward power and increase reverse power to give more effective turning.

The Advanced button sets up the PID control loop for the Auto Heading. See section *19.2 Auto Heading PID* for more information.

Auto Speed

Difference for Min. Change sets how far from the speed setpoint the current speed must be before a correction is applied.

Max Power: Determines the maximum thrust that will be used when auto speed is turned on.

Difference for Max Change and Max Thrust Change together determine a proportional change in thrust when the speed is not at the setpoint. If the difference between the current speed and the speed setpoint is greater than this number, then the thrust will change by this given percentage each second until the speed matches.

Stopping

When arriving at a route point, the boat needs to stop otherwise it will coat past the intended point. This is done by reversing thrust for a period of time. The Stop Time and Stop Power determine how long and at what level of reverse thrust the boat will use to stop. These values entered specify the time and power when the current speed is one know (as it arrives at the route point). If the speed is faster or slower, then a corresponding increase or decrease in the stop time and power will be used.

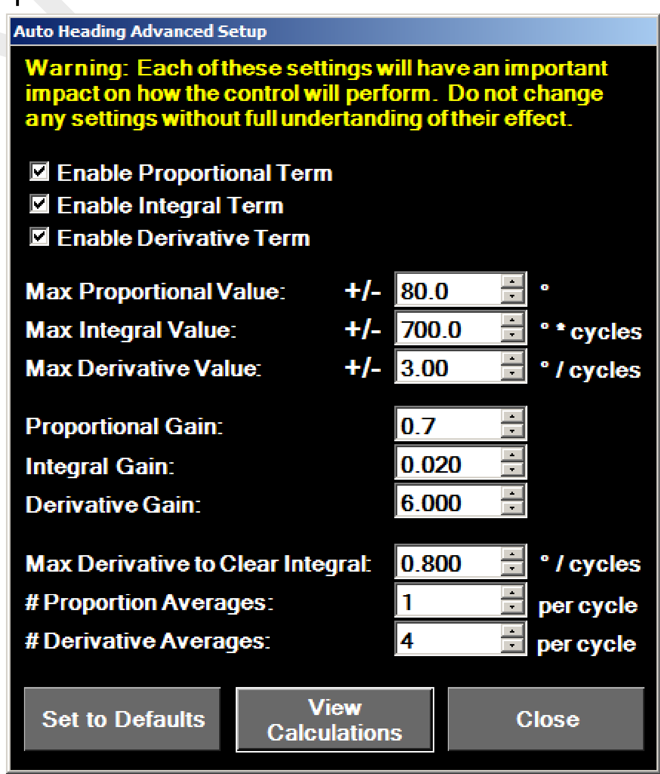
19. Auto Function PID Control Setup

Three of the vehicle control routines utilize a PID (Proportional – Integral –Derivative) control loop: Auto Heading, Auto Depth, and Crosstrack Error Correction (route following). This type of control loop uses sensor feedback combined with a mathematical calculation that considers the magnitude of the offset from the setpoint (proportional control), the rate of change of the difference from the setpoint (derivative control), and the cumulative difference from the setpoint (integral control). This section of the manual will give guidelines to setting up each of these three PID control loops if they are not functioning accurately. If the operation of the control is good, then it is recommended that the user does not change any PID settings, since setup can sometimes be tricky and/or time consuming.

Note: These control values have been tuned by Shark Marine technical staff during field trials, and should not be changed without a full understanding of how these parameters will affect control of the vehicle.

Each Advanced Setup window will include settings for the proportional, integral, and derivative term of the control loop calculation. Settings are as follows:

- Enable: When checked, the term will be used in the final thrust calculation. Uncheck this box when setting up the control to isolate the effect of each term, or if the term is not needed in the control loop
- Max Value: This sets an upper limit on the value, and applies to the value BEFORE gain is applied.
- Gain: The gain is a multiplier for the term that scales the value to an appropriate number to be used as a thrust percent.

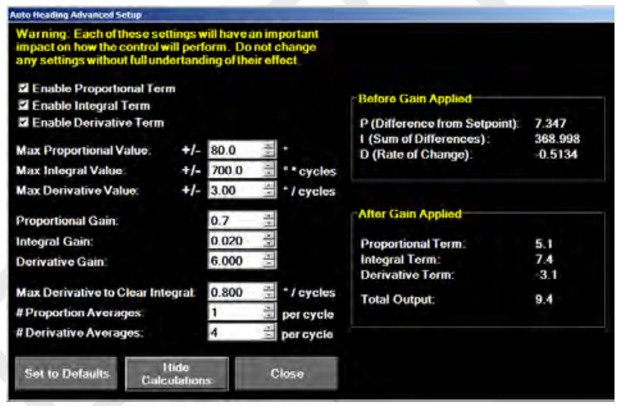


The "Max Derivative to Clear Integral" is used to clear/reset the integral term when there is a high derivative (rate of change) value. In general, the integral is useful to correct a steady state error when close to the set-point. When thrusting to get close to the set-point, the integral should be cleared to avoid it's influence on the system (otherwise it may cause overshoot past the set-point). The value "Max Derivative to Clear Integral" sets when to clear the integral (I.e. at what derivative / rate of change value).

The “# Proportion Averages” sets the number of samples of averaging that that will be applied to the proportional value (i.e. the difference from the set-point).

The “# Derivative Averages” sets the number of samples of averaging that that will be applied to the derivative value (i.e. the rate of change of the difference from the set-point).

The “Set to Defaults” button sets all values back to initial values. The initial values will be the values set by the factory for the vehicle type, and will not be specifically tuned to customizations of the vehicle.



The “View Calculations” button expands the window to show the PID calculations, which may aid in setting the PID values.

- P, I, and D raw values are displayed, before gain is applied.
- P, I, and D terms are displayed (with gain applied), which are added to result in the total output.
- Total output is displayed, which is the force value that will command a change in thrust.

19.1. Guidelines for Setting Up the PID

Note: These control values have been tuned by Shark Marine technical staff during field trials, and should not be changed without a full understanding of how these parameters will affect control of the vehicle.

Follow these general steps to set up the PID parameters.

- Uncheck “Enable Integral Term” and “Enable Derivative Term” so that only the proportional term is active.
- Set the Proportional Gain so that the vehicle is correcting at the appropriate speed/thrust. Note, there will likely be an overshoot past the set-point.
- Enable the Derivative Term and set the Derivative Gain so that the overshoot is minimized. If the Derivative Gain is too high they you may notice that too much power is lost during the correction.
- Enable the Integral Term, and set the gain only high enough so that a steady state error is corrected after a short period of time. Note that a steady state error will only normally occur if an external force is pushing the vehicle away from the set-point.
- The Max Derivative to Clear Integral must be set properly to prevent integral wind-up, where the integral term slowly builds up and causes an unwanted thrust. Take note of the D value (Rate of Change) before gain is applied during a rapid correction

(click Show Calculations to see the value). Set the Max Derivative to Clear Integral lower than the rate of change during the rapid correction.

19.2. Auto Heading PID

The parameters on the Auto Heading Advanced Setup will configure the dynamics of the auto heading function. The Auto Heading routine is used in the following cases:

- Auto Heading is turned on
- Goto Route / Target is turned on: DiveLog will calculate the proper heading to get to the route point or target and use the auto heading to correct the vehicles heading.
- Station Keeping is turned on: DiveLog will calculate the proper heading to stay at the proper location and use the auto heading to correct.

The auto heading routine will use the current heading sensor value and compare it to the heading set-point, and calculate the turning force that should be applied.

The Proportional Value represents the difference, in degrees, between the current heading and the set-point.

The Integral Value represents a cumulative difference between the current heading and the set-point. If a force is causing the vehicle to turn in one direction, then the integral value will build up after a few seconds and result in a turning force to counteract the external force.

The Derivative value represents the rate of change of the heading. I.e. how quickly the vehicle is turning towards or away from the proper heading.

See section *19 Auto Function PID Control Setup* and *19.1 Guidelines for Setting Up the PID* above for a general description of the setup window.

19.3. Auto Depth PID

The parameters on the Auto Depth Advanced Setup will configure the dynamics of the auto depth function. The Auto Depth routine is used when Auto Depth is turned on, or Auto Altitude is turned on.

The auto depth routine will use the current depth sensor value and compare it to the depth set-point, and calculate the vertical thrust that should be applied.

The Proportional Value represents the difference, in meters or feet, between the current depth and the set-point.

The Integral Value represents a cumulative difference between the current depth and the set-point. If a force is consistently causing the vehicle to float or sink, then the integral value will build up in a few seconds and result in a vertical thrust to counteract the external force.

The Derivative value represents the rate of change of the depth. I.e. how quickly the vehicle is moving upwards or downwards, either towards or away from the target depth.

See section *19 Auto Function PID Control Setup* and *19.1 Guidelines for Setting Up the PID* above for a general description of the setup window.

19.4. Crosstrack Error (Route Following) PID

The parameters on the Route Crosstrack Advanced Setup will configure the dynamics of the crosstrack correction function. The crosstrack correction routine is used when the auto function “Goto Route / Target” is active, and a Goto Route is set. The crosstrack correction routine calculates a heading set-point that the auto heading routine then use to correct the vehicle’s heading.

The crosstrack correction routine will look at the vehicle’s perpendicular (sideways) distance to the route line (in the same way that the Route Crosstrack panel shows the sideways offset from the route; see section *20.6 Routes*). The crosstrack correction routine uses this distance to calculate a change to the heading that should be followed. In general, if the crosstrack error distance is zero, then the heading will be directly towards the end point of the current route segment. If the crosstrack error distance is large (meaning the vehicle is far away from the intended route line), then the proper heading will be to travel perpendicular to the route line (to head straight to the route line, rather than the end point). At positions near the route line, the heading will be adjusted as needed to put the vehicle on the proper course. A valid position from one of the position sources must be available for the crosstrack correction to function.

The Proportional Value represents the perpendicular difference, in meters or feet, between the route line and the current position.

The Integral Value represents a cumulative difference between the route line and the current position. If a force such as water current is consistently causing the vehicle to be pushed off the route line, then the integral value will build up in a few seconds and result in a heading offset to counteract the sideways force.
S
The Derivative value represents the rate of change of the crosstrack error. I.e. how quickly the vehicle is moving towards or away from the route line.

See section *19 Auto Function PID Control Setup* and *19.1 Guidelines for Setting Up the PID* above for a general description of the setup window.

20. Track Screen

20.1. Track Overview

The “Track Screen” provides a bird-eye view of the data in the project, including information on where files were recorded, areas of coverage, and target position. The image is always geodetically referenced, and any point may have its corresponding geodetic latitude and longitude displayed with a tool-tip. The image also provides a quick way to access additional information by clicking or moving the cursor over targets or tracks.

The image of the Track Screen is drawn with a Universal Transverse-Mercator (UTM) projection, and WGS-84 datum. The UTM Zone is auto-set using the location of the currently displayed map or from the first geodetic position used in a project (such as target, route, realtime GPS, et cetera).

The image on the Track Screen is always drawn north up. Since a UTM grid is used, lines running at a true zero degree bearing may appear not perfectly vertical since the UTM grid itself is slightly angled depending on the location.

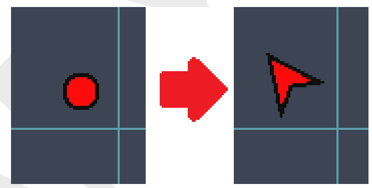
The Track Screen will show real-time positions and tracks as well as past recorded tracks for each different file type saved in the current project. Possible displayed data includes:

- current position and heading with course over ground projection line,
- towfish position,
- target positions,
- tracks for recorded data,
- routes,
- search boundary,
- long baseline station positions,
- coverage areas for sonar files,
- and more depending on accessories used with the system.

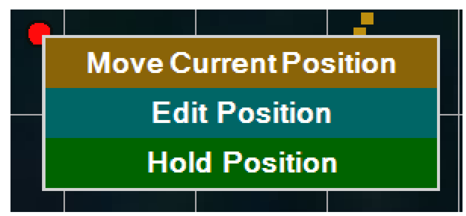
By default, the Track Screen will display a dark gray. A map or chart can be displayed in the background by importing a chart to the project or by manually geo-referencing an image. The Track Screen supports displaying both raster and vector chart types. See section *20.5 Managing Maps* for more information.

When a project is loaded, tracks for all recorded files are loaded and displayed on the Track Screen, although display of different tracks can be turned off.

20.1.1. Current Position on the Track Screen Image

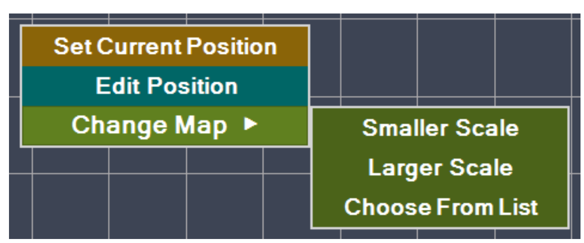


If there is currently a valid GPS position, then that position will be displayed on the track screen as a red icon. If the system has a valid magnetic compass heading, then the icon will appear as a chevron indicating the current heading, otherwise it will appear as a dot. Moving the mouse cursor over the icon will display the latitude and longitude co-ordinates of the current position (if the cursor info box is checked). The display format of the latitude and longitude will be as follows: first two/three digits are degrees, the next two digits are minutes, and the last four digits are decimals of minutes (this is the same format that is transmitted by a standard NMEA GPS device). The icon may also show a projection line indicating the course over ground (see section *20.4.8 Projection Line* below for more information).



To set the current position from the track screen, right click the position dot or chevron, select “Move Current Position”, and use the crosshairs to select the desired position on the Track Screen. The new position will remain valid for a few seconds. To enter the position as latitude and longitude coordinates, select the “Edit Position” option. These functions are useful for seeding the start position of the Doppler Navigation System.

A third option will allow you to hold the current position. This is useful when your position is known, but you have no position source to continuously validate it. You can stop holding the position by clicking Cancel Hold Position in the same menu, or using the enter position window. See section *3.4.3 Position Sources* for more information.



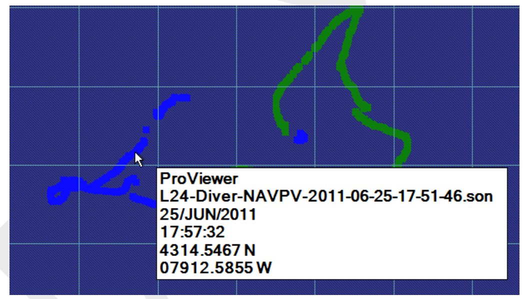
Right clicking on a different part of the image will present similar options, as well as an option to change the map, which allows switching to a smaller or larger scale map or choosing from a list of all maps in the project.

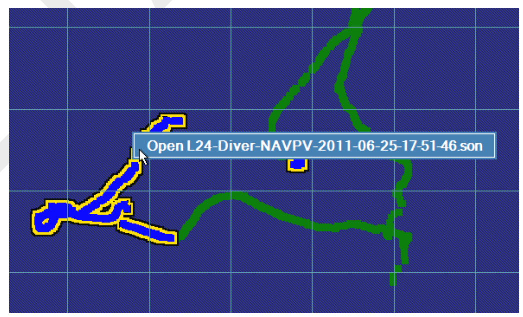
To see how various items will appear on the track image, refer to section *20.4.9 Track Legend*.

20.1.2. Tracks on the Track Screen Image

As the GPS position changes, the red icon will move on the Track Screen, and a track will be left behind the current position as a series of consecutive dots for each position, connected by thin lines. At most zoom levels; the track dots will blend together to create a thick continuous line.

Similar to the real-time current position and track, playback current position and tracks will appear as an icon with a track made up of track dots. For each file type, the playback position and track will appear in a different color depending on the file type.



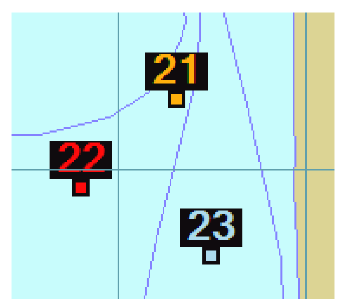


If “Cursor Info” is turned on (on the main controls at the bottom of the Track Screen), then moving the cursor over a track will show a tooltip that will display:

- Track type (I.e. the Active Screen that the track belongs to)
- The file name that corresponds to the track
- The date of the track
- The time of the individual track point
- The position of the individual track point

For recorded tracks, right clicking the track will bring up an option to open the recorded file (such as a sonar file). Playback of the file will start at the point that was right clicked, making it is easy to jump to a point in the file just by right-clicking the corresponding part of the track.

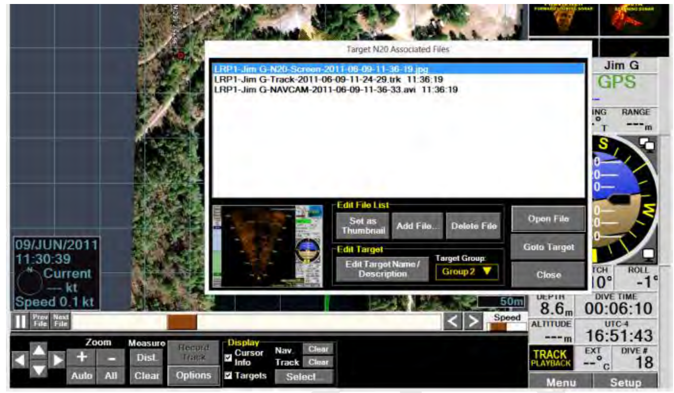
20.1.3. Targets on the Track Screen Image



Targets will be drawn as a dot representing the target point, and a label above the dot with the target number or name. The color of the drawn target will be different depending on the group of the target. Group 1 targets are red, group 2 targets are yellow, and group 3 targets are blue.

If “Cursor Info” is turned on (on the Track Screen controls), and the mouse cursor is placed over the target dot or label, then the target’s icon, name, position co-ordinates, depth (if available), and description are displayed in the mouse tool-tip.

Right clicking on the target will bring up the list of associated files for that target. This acts as a shortcut for opening files associated with the targets displayed on the Track Screen. See section *12.6.3 Target Associated Files* for more information. The target name and/or description can also be modified by clicking the button “Edit Target Name/Description”, and the target group can be changed.

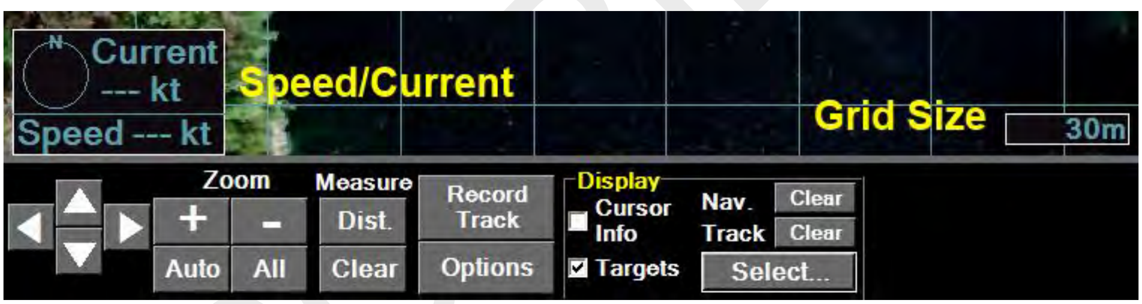


20.1.4. The Navigation Track

The Navigation Track is a track that appears as a grey path on the Track Screen. The Navigation Track is never recorded, and is used to show the unit’s recent path while on the surface. The Navigation track can be hidden or shown with a button on the Track Screen control panel.

20.1.5. Track Overlays

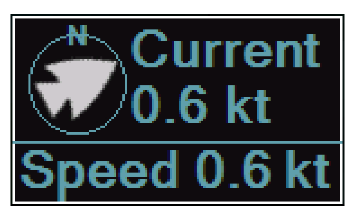
There are two main overlays on the track screen:



Grid Size

This overlay displays the current distance between grid lines on the Track screen. It is displayed only when the grid is visible.

Speed/Current



This overlay displays the sensed speed of the system (supplied from the current position source) and either the sensed water current or the manually set water current. If the speed or current does not have a valid value, the overlay will resemble the image above. The image to the right shows an active speed/current overlay. The direction of the arrow shows the heading of the displayed water current. The speed displays the calculated SOG (speed over ground) value. This value is calculated using distance between GPS positions, using a specified delay time, which can be changed from the Track Options window (see section *20.4.13 Positioning*).

The speed/current overlay also allows you to access two dropdown menus used for setting current (see section *20.8.2 Water Current*), and enabling and configuring Dead Reckoning mode (see section *20.8.1 Dead Reckoning*).

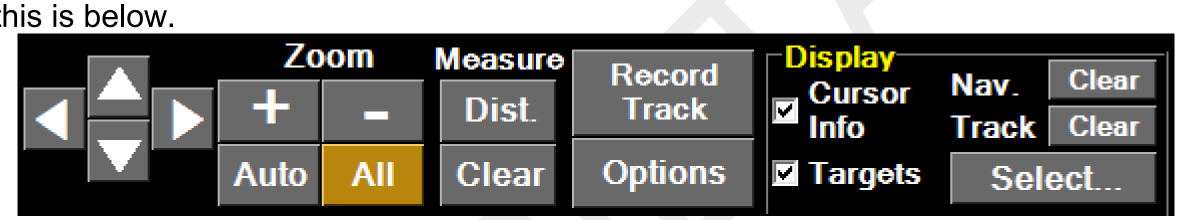
20.2. Track Controls

20.2.1. Moving the Image (Arrow Buttons)

To control the view of the track, there are four arrow buttons, and four zoom buttons, as seen below. Pressing any of the four arrow buttons will move the view in that direction in an amount equal to one eighth of the screen size. I.e., when the "▲" button is pressed, the view will move up, and all tracks visible will move downward in the view.

While scrolling with the arrow keys is taking place, a temporary image will be drawn on the Track Screen and a detailed redraw is done when scrolling is complete. Scrolling the image can also be done by clicking and dragging, or a single click will re-center the image at the click position.

When any of the arrow keys are pressed the zoom mode is toggled to "Free Mode". More on this is below.



20.2.2. Zoom Buttons and Zoom Modes

There are four zoom buttons provided. The "Zoom Auto" button and the "Zoom All" button toggle the zoom mode to one of three possible zoom modes, as follows:

Zoom Auto: "Zoom Auto" repositions the view so that the most current and active point on the track is positioned in the center of the view. Also, the zoom level is set so that the new track points fit nicely within the view. Another feature of the Zoom Auto mode is auto-centring. As data points are added to the track, the track will make its way toward a side of the view. Once the track gets close to the edge of the view, the view will shift to centre the most recent position.

Zoom All: "Zoom All" mode will zoom out to the extents of the tracks to fit everything within the view. This allows a quick view of the entire current track or the entire project data (depending on the "Show Tracks" selection, more on that below). Zoom All mode will also automatically keep all data in view. When Zoom All mode is on, if new track data is off the edge of the view, the view will shift and zoom out to keep all tracks and targets in view.

Free Mode: "Free Mode" is the active mode when one of the arrow buttons is used, or when one of the two above zoom modes are turned off. Free Mode allows the user to move around to view any part of the projects track map. Unlike the above two zoom modes, in Free Mode, the view will never shift or change from the current view (although track data will still be updated).

When Zoom Auto mode is on or Zoom All mode is on, the corresponding button will be highlighted. Pressing one of the highlighted zoom buttons will turn that zoom mode off and "Free Mode" will be active, but the current view and zoom level will be retained.

20.2.3. Zooming In and Out

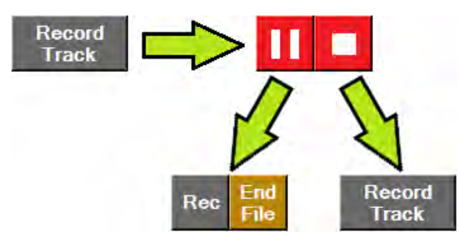
The two buttons "Zoom In" and "Zoom Out" allow the view to be narrowed, or broadened, respectively. In "Zoom Auto" mode, pressing either zoom in or zoom out will change the view, but keep "Zoom Auto" mode on, i.e. the map will still auto-center. If the zoom mode is "Zoom Full", then the mode will be changed to "Free Mode" when zooming in or out.

While zooming in or out, a temporary image will be drawn on the Track Screen to give a fast indication of the new scale, and a detailed redraw is done when zooming is complete. Zooming in or out can also be done by positioning the mouse over the image and rotating the mouse wheel (if using a mouse with a mouse wheel). When zooming in or out with the mouse wheel, the view will also re-center to the position of the mouse cursor.

20.2.4. Distance Measuring Tool

The distance between any two points on the track can be measured by clicking the Measure Distance button then clicking two points on the track display. The distance from the first point to the second point, as well as its bearing will then is displayed on the track.

20.2.5. Record Track



The track appears as a green path on the Track Screen and acts as a log of the positions and sensor data for each operation. For operations on the surface, the track can be started by clicking the Record Track button. The record button on the Track Screen will change into two red buttons while the track is being recorded. The left red button will pause the track file to allow continuation of the same file later. The right red button stops recording and ends the file. If the pause button is clicked, the buttons will change to "Rec" to resume recording, and "End File" to finalize the file. If the stop button or the "End File" button is pressed the buttons will change back to the "Record Track" button and a new file will be created the next time it is pressed.

When a file is being recorded with an Active Screen, the track will automatically start to record and continue recording as long as the Active Screen file is being recorded. Recording of the track cannot be paused or stopped while the Active Screen file is being recorded.

If DiveLog is controlling a vehicle or running on a Navigator, the track is also automatically recorded when the depth of the unit descends below the Start Dive Depth (set on the Depth Configuration window). Since the track acts as a log of the dive, recording cannot be stopped when a dive is underway. When the depth ascends to the surface, the track will stop recording (unless a file is being recording with a different Active Screen). The track file will be automatically continued if the dive resumes within ten minutes, but the "End File" button can be clicked while on the surface to force a new track file to be created during the next descent.

Note: If the Doppler Navigation System is being used and the unit returns to the surface, the track will continue to record to wait for a fix from a GPS device (for up to ten seconds).

When the Track Screen is toggled to a secondary display while the track is recording, a small recording indicator will be present in the corner of the secondary window.

For details on the track file format, see section *20.7.2 Track File Description*.

20.2.6. Options Button

Clicking the "Options" button opens up the Options window. See section *20.4 Track Options* .

20.2.7. Display Options

These controls determine how items are displayed on the Track Screen.

There are two checkboxes for additional display options on the track controls. The "Cursor Info" checkbox turns on or off the display of the cursor tool tip, which provides context sensitive additional information over different parts of the Track Screen image. The "Targets" checkbox turns on or off the displaying of all targets on the Track Screen.

Nav: The "Clear" button beside "Nav" will hide the current Navigation track (the grey track) up to the current point. This is useful for hiding the pre-dive portion of a track so that just the useful mission portion of the track is displayed. Click the button again to show the entire Navigation track. Note that the Navigation track is not recorded and this button only affects the currently displayed data.

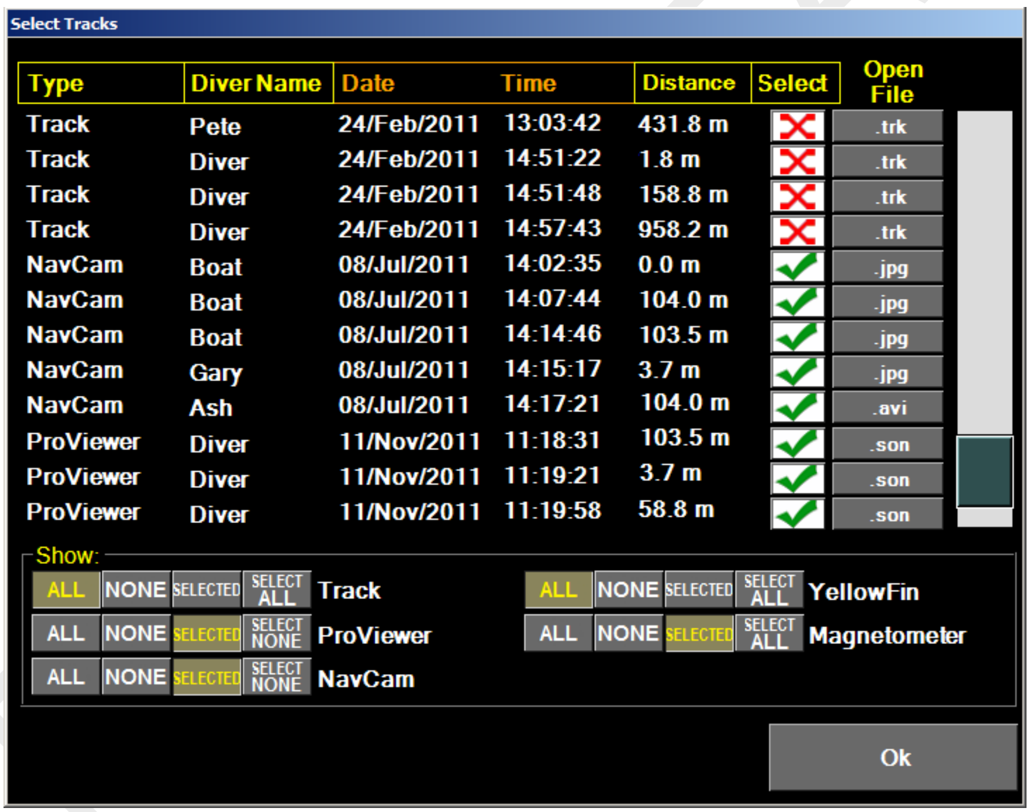
Track: The "Clear" button beside "Track" will hide the current recording track(s) up to the current point. This is useful for cleaning up the display if there are is a long track being recorded. Click the button again to show the entire track.

Note that this will not delete or stop recording the track, and only affects the current display on the Track Screen.

Select...: This button opens the window for selecting which past tracks are displayed. See section *20.3 Selecting Project Tracks* for more information.

20.3. Selecting Project Tracks

The Select Tracks window will open up when the Select button on the Track Screen control panel is clicked. This window provides a listing of all recorded tracks in the current project. The following information is displayed for each track: Type of track (primary track, Forward-Looking Sonar file track, Magnetometer file track, etc…), operator name, date track was created, time track was created, total distance, and whether it is selected to be displayed or not.

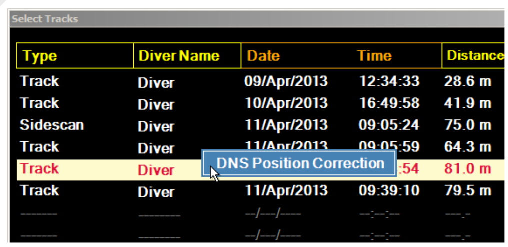


By default, the most recent tracks will be displayed at the bottom of the list. Clicking one of the headings at the top (Type, Diver/Operator Name, Date/Time, Select) will sort the list based on that column.

The button in the right-most column is for opening the file associated with the track. The text on the button will denote the file type (file extension) of the recorded file. For example, if the type of the track is Forward-Looking sonar, then the button will read “.son” to indicate that the button will open the sonar file.

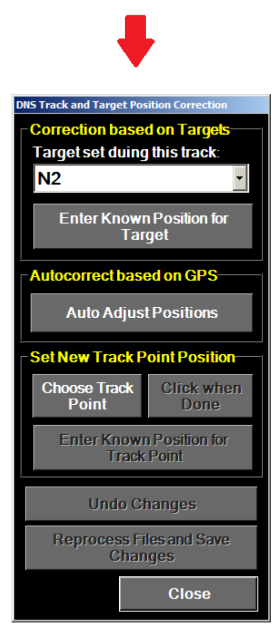
Buttons at the bottom left of the window allow showing all, none, or selected for each type of track. These settings will be retained for the next time the project is used. The settings have the following effect:

- ALL: Regardless of which tracks are selected, all tracks of that track type will be shown.
- NONE: Regardless of which tracks are selected, no past tracks of that track type will be shown. A current recording track will still be displayed and a track open for playback will still be displayed unless the track is hidden on the Track Playback Control Panel (see section *20.7.4 Track Playback Control Panel*).
- SELECTED: The show/hide status for each track is set by the entry in the “Select” column of the list. In the “Select” column of the table, the button with a green checkmark or a red x indicates if that particular track is selected. Note that a track being played back will still be shown even if hidden with this method.
- SELECT ALL/NONE: A quick way to select or deselect all tracks of that type.



20.3.1. *DNS Track and Target Correction*

This feature is used to perform a correction to rectify inaccuracies that may occur when using the Doppler Navigation System (DNS). The location data contained in Track files, recorded files, and targets can be adjusted during post-processing if they were recorded when the Doppler Navigation System was being used as the position source.



When a correction is made, the track will be adjusted as well as the position of any targets set while the track was recorded. Sonar files (and other recorded files) will also be re-processed to adjust the recorded positions and headings for the data.

To initiate this process, use the Select Tracks window (opened by clicking the Select button on the Track Screen controls). Find the desired track to be corrected in the list, and right click the track to bring up the option “DNS Position Correction”. If the selected track has DNS points, the “DNS Track and Target Position Correction” window will be launched (see image, right).

Note: Only tracks of type “Track” can be selected for DNS correction. Any recorded files that overlap these tracks (i.e. were recorded at the same time) will also be corrected together with the main track.

The correction can be done in three ways:

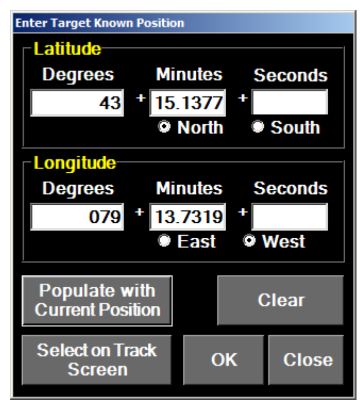
- Correction based on a target that was set while the file was recorded, and has a known proper location.
- Correction based on subsequent points in the track that are from another more trusted position source such as a GPS.
- Correction by selecting one of the DNS track points and specifying a new location for that point.

All types of corrections can be done to the same track, and multiple corrections can be done to the same track.

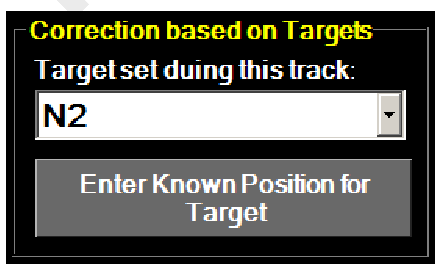
When the adjustment is made, DiveLog will calculate a rotation and stretch factor for a DNS track segment. A single track may have multiple DNS segments if different position sources were used while the track was recorded, or if multiple corrections are made on the track.

When an adjustment is made, any targets set along the adjusted track segment will also have their positions adjusted to the calculated proper location.

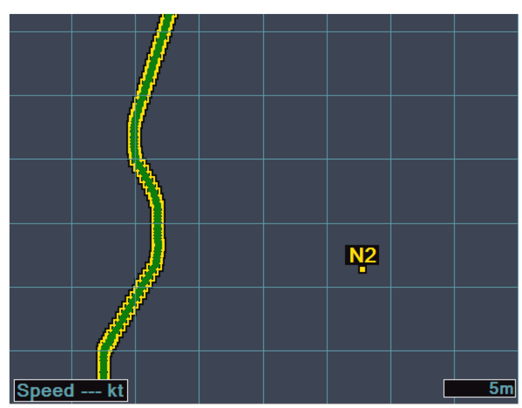
Note: While performing DNS Track correction, files should not be opened or recorded with any Active Screen. Doing so may cancel the DNS changes.



Correction based on Targets



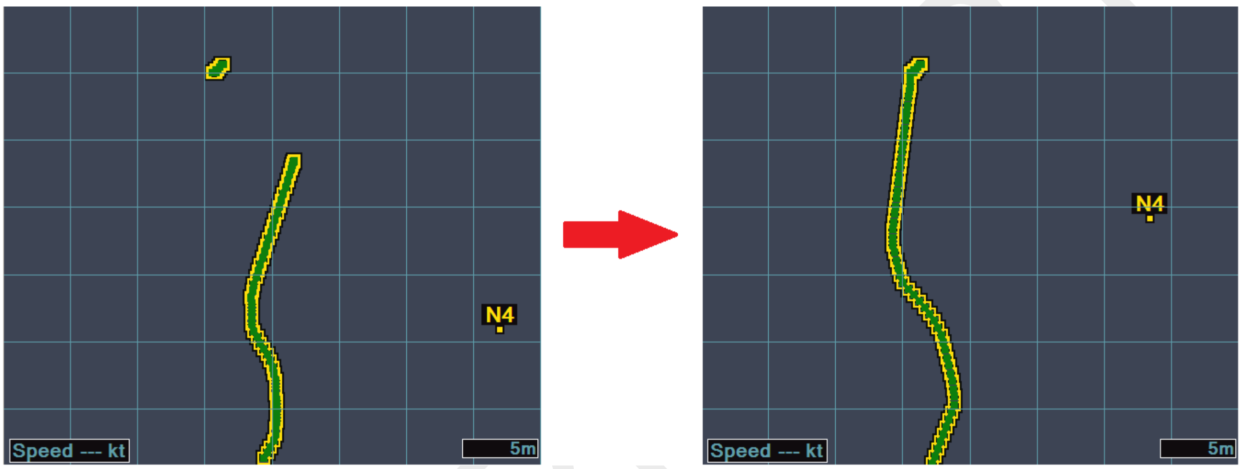
If one or more targets was set by the operator when the DNS track was recorded (or set using the recorded file) then a correction based on targets can be used. For this to be done, a “Known” (precise) position must be available for the target that is different than the position originally set for the target.



To perform the correction, select the target from the drop-down list. This list will only contain targets that were set while the track was recorded. Once the target is selected from the list, click the Enter Known Position for Target button to bring up the standard position entry window. The known position can be entered in degrees with decimals, or degree and minutes, or degrees and minutes and seconds. The known position can also be selected by clicking on the Track Screen image if the target is on a map. Once the position is entered the adjustment to tracks and targets will be made.

When correction based on targets is performed, DiveLog will determine the proper location for the point where the target was set based on the distance and bearing of the target's set position and known position. The positions for that DNS segment will be corrected to put the target at the proper location.

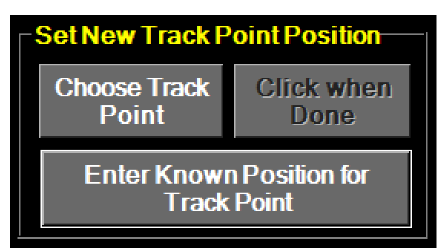
Autocorrect based on GPS



The autocorrect function will correct the DNS portions of the track as long as they are followed by a position from another position source such as GPS, LBL, or a manually set position. When the Auto Adjust Positions button is pressed, the entire track will be scanned for DNS segments that end with a different position source, and all such segments will be adjusted.

When autocorrect based on GPS is performed, DiveLog will determine the proper end point for the track segment based on the distance and bearing of the last DNS point before the other position source took over. The DNS track segment will then be stretched and rotated to connect to the proper end point.

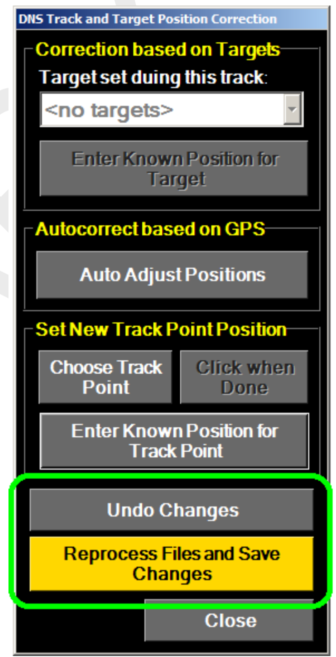
Set New Track Point Position



This correction method should be used when a DNS track point has a known correct location, such as when a landmark or other visual reference is used to determine the proper location. Choose the track point that should be adjusted by clicking the button, and clicking the track point on the Track Screen. Then click the button to enter the known position, which can be manually entered, or be selected by clicking anywhere on the Track Screen image.

Undo Changes / Reprocess Files

When corrections are done, the locations of the tracks, sonar coverage map, and targets on the Track Screen image will be updated to reflect the new positions. However, files are not yet saved at this point. If the changes are not desirable, click the Undo Changes to revert back to the previously saved files.



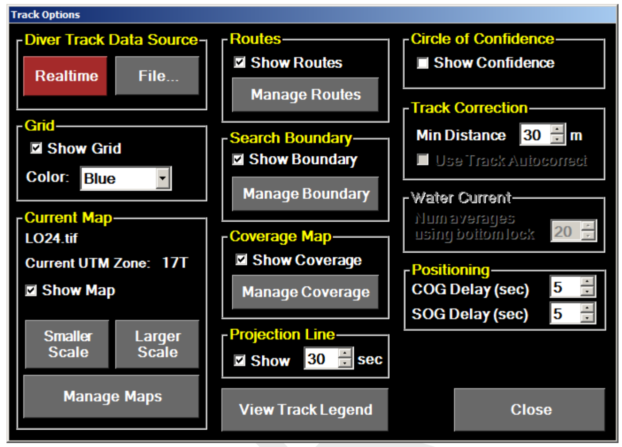
If the changes appear to be good, the changes must be finalized by clicking the “Reprocess Files and Save Changes” button. When this is done, track files along with the corresponding recorded sonar files and targets will all be saved.

The reprocessing of recorded files (such as sonar files) will work similarly for all different types of recorded files even though these files may differ greatly in structure. Generally, DiveLog will load the recorded file in the background, and update the position and heading data for each ping in the file, then resave the entire file with the new data. This may take a short while depending on the amount of data in the file. Afterwards when the file is played back, any positioning information displayed on the screen while the file plays will reflect the updated/corrected data. For example, when a Forward-Looking Sonar file is played after correction, targets drawn on the image will be placed at the updated locations.

Note: After the “Reprocess Files and Save Changes” button is pressed, the previous set of adjustments will be saved and the original files are overwritten. Undo cannot be done after this point. To preserve original files, before performing DNS track corrections either export the entire project or copy the entire project folder in Windows to another location as a backup.

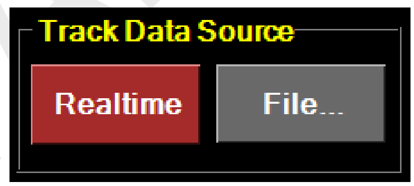
Note: If video files recorded with the NavCam active screen are reprocessed, video overlay reflecting the position will NOT be altered/updated.

20.4. Track Options Window



The “Options” button on the track controls opens up the “Track Options” window. This window allows the user to toggle the data source for the Track Screen. This window also allows changing of grid settings, setting up the map image, specifying the search boundary, managing routes, and shows the legend for the track. Each of these options is described below.

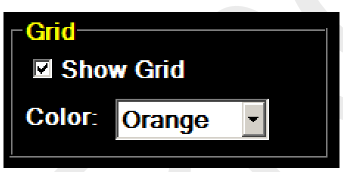
20.4.1. Track Data Source



The Track Data Source box allows the user to toggle the data source between Realtime and File mode. This setting only sets realtime or playback of the track files; regardless of this setting, the real-time position will still be displayed on the Track Screen.

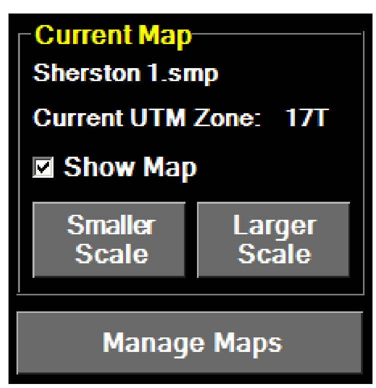
Click “File...” to toggle the track to playback mode. This will open up an interface that will allow selecting past recorded tracks for playback. A list of all track files from the current project will be displayed. Click “Realtime” to return to realtime mode for recording tracks. If a dive is started (by exceeding the “start dive depth”) while the data source is set to “File...”, the data source will automatically toggle back to realtime and the track will start recording. Note that the source of the realtime position may be from any of the various positioning devices such as GPS, Long Baseline, DNS, et cetera.

20.4.2. Grid Options



The grid on the track image can be toggled on or off by checking or un-checking the checkbox next to “Grid On”. The grid color can also be changed to a number of different choices based on user preference.

20.4.3. Current Map



The Current Map box shows the name of the currently selected map and provides controls for changing the currently displayed map.

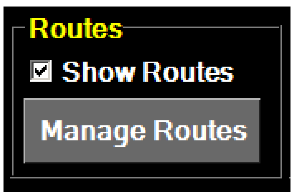
The current UTM Zone being used for positioning on the Track Screen is displayed. This zone value is automatically set from the location of the current map or from the first geodetic data point.

The checkbox “Show Map” either shows or hides the map on the Track Screen.

The buttons “Smaller Scale” and “Larger Scale” will switch to a smaller scale or larger scale map of the current location respectively, if such a map has been added to the project.

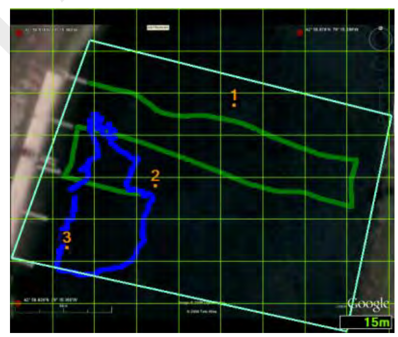
The button “Manage Maps” brings up the Manage Maps window, which displays a list of all maps in the project. With this window, a specific map can be selected as the current map and other map functions can be performed. See section *20.5 Managing Maps*.

20.4.4. Routes

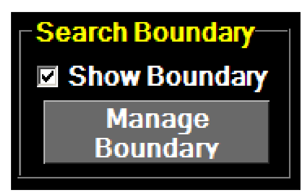


The checkbox “Show Routes” on the Track Setup window chooses between hiding and displaying all route lines on the track screen. The button “Manage Routes” brings up the Manage Routes window. See section *20.6 Routes* for more information.

20.4.5. Search Boundary



The Search Boundary feature displays a boundary on the track screen, as a light green box. The boundary may be set up as the limits of the search area, or to highlight an important region. The boundary is purely for visual reference on the track screen, and has no effect on collected data inside or outside the boundary. Each project may have one search boundary, but the search boundary can be changed as the project progresses. The search boundary consists of any number of geodetic coordinates, which are connected by a continuous line.



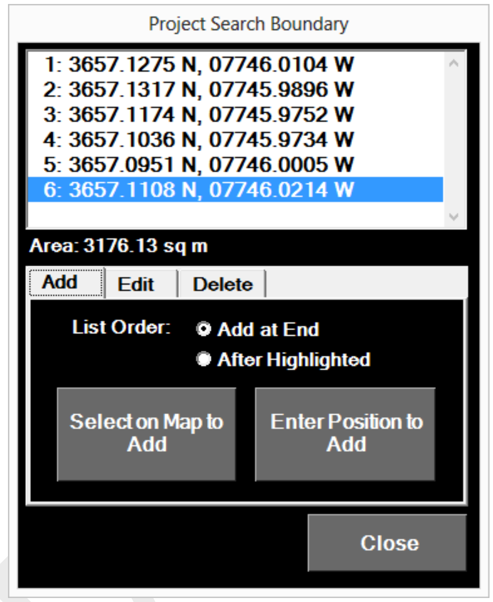
The checkbox “Show Search Boundary” on the Track Setup window chooses between hiding and displaying the search boundary line on the track screen. The button “Manage Boundary” brings up the Project Search Boundary window.

20.4.6. Setting/Editing a Search Boundary

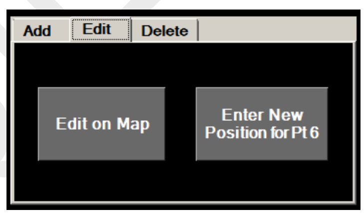
On the Project Search Boundary window, each point along the search boundary is displayed in a list, with each consecutive point connecting on the Track Screen image to form the boundary. The last point is also linked to the first so that a continuous shape is created. While the Project Search Boundary window is open, the currently selected point in the list will be highlighted on the track screen with a white dot. The area of the boundary will be shown once 3 points are selected.

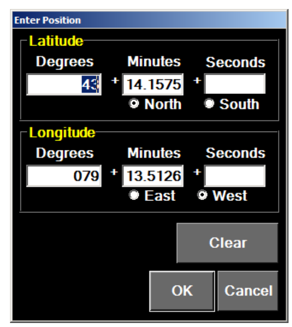
There are two ways to enter boundary points:

1. Click “Select on Map to Add” to enter a point with the mouse by clicking on the track screen image.
2. Click “Enter Position to Add” will allow the user to manually enter the geodetic position (in one of the three formats: degrees, or degree/minutes, or degrees/minutes/seconds).

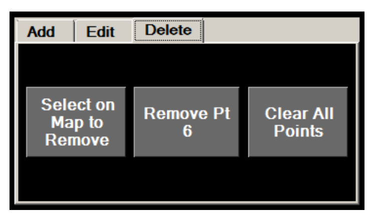


The order of the points is important, since the order determines which points will be connected by a line on the Track Screen image. Select “Add at End” when specifying additional consecutive points on the boundary. Select “After Highlighted” to add a point between two existing points. In this case select a point on the list (which will be highlighted on the Track Screen), and specify the new next point.



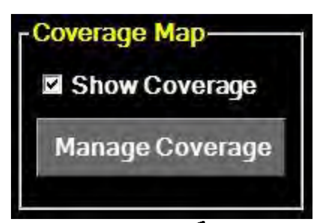


To edit points, toggle to the “Edit” tab. Clicking “Edit on Map” will allow any point on the Track Screen to be selected by clicking it with the mouse, then clicking on the image to select the new position. Alternatively, select the appropriate point in the list on the Project Search Boundary window to change the position by clicking “Enter New Position for Pt #”. This will allow the position to be manually edited with the standard Enter Position window (see image, right).

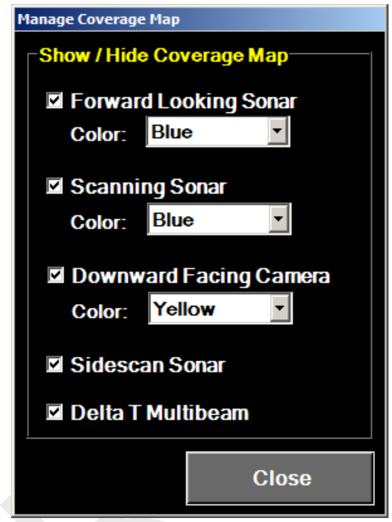


To remove a point, toggle to the “Delete” tab. Clicking “Select on Map to Remove” will allow using the Track Screen image to click any point to remove it. Alternatively, select the appropriate point in the list and click “Remove Pt #” to remove it. When a point is removed the points before and after that point will become connected on the Track Screen image. To clear the entire search boundary, click “Clear All Points”.

20.4.7. Coverage Map



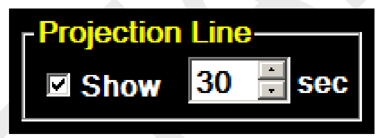
This box on the Options window sets the display settings for device coverage mapping. The “Manage Coverage” button brings up the Manage Coverage Map window. There are settings for the coverage maps for the following sensors:

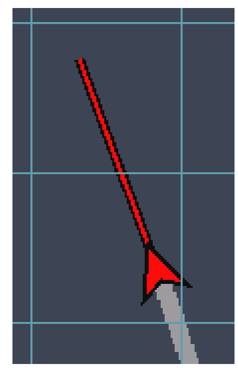


- Forward-Looking Sonar
- Scanning Sonar
- Downward Facing Camera
- Sidescan Sonar
- DeltaT Multibeam

Check or uncheck the box to show or hide the coverage map of that type. The color of the coverage map can also be set, depending on the sonar/sensor type. Note that the coverage map may not be visible on the secondary screen when the Track Screen is toggled to secondary.

20.4.8. Projection Line

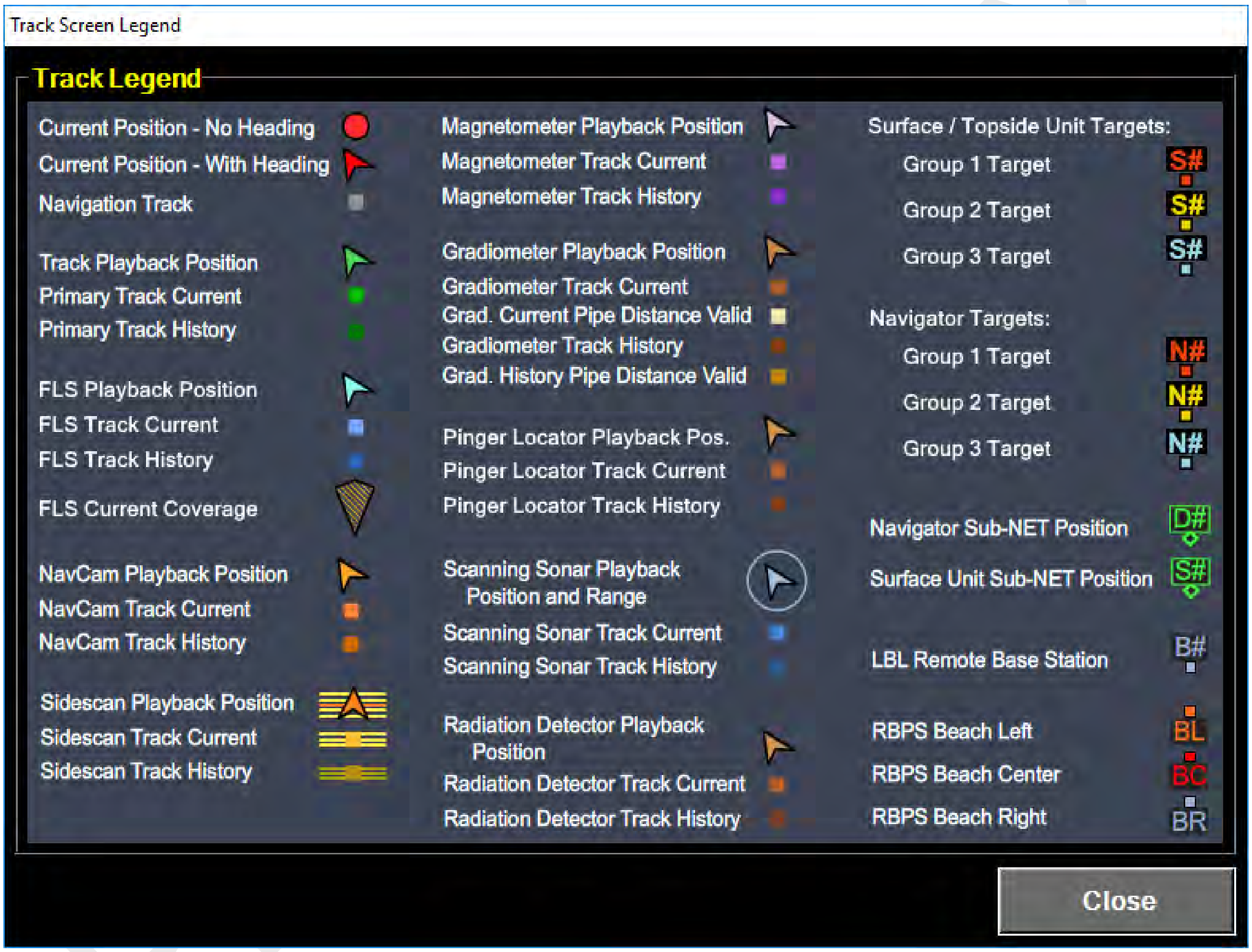




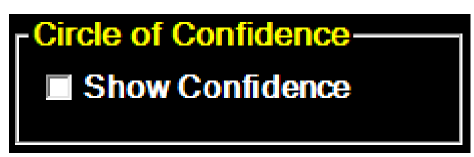
The Projection Line feature extends a line from the position icon to show the current direction of travel (course over ground). The length of the line represents the current speed, and the tip of the line indicates where the position will be in the time specified on the options form (if the current speed and course over ground remain constant). Note that the direction of the projection line may not match the compass heading, especially if there is a current in the water.

20.4.9. *Track Legend*

The Track Legend window can be opened by clicking the "View Track Legend" button. This window indicates how each object will be shown on the Track Screen image. Use this for reference if you are unsure about what each color on the Track Screen image relates to. For more information about the various tracks, see section *20.7 Tracks*.

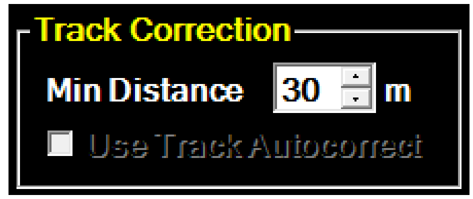


20.4.10. *Circle of Confidence*



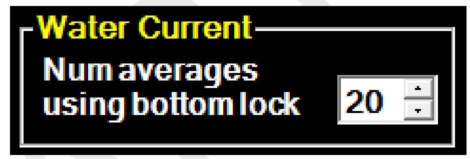
This box on the Options window allows the showing and hiding the Circle of Confidence track display. For more information on the Circle of Confidence see section *20.9 Circle of Confidence* for details.

20.4.11. Track Correction



This box allows the changing of the minimum distance for a DNS (or other soft position fix) track segment to be corrected, when performing post processing track correction (see section *20.3.1 DNS Track and Target Correction* for details). The option to “Use Track Autocorrect” is a feature that is currently in development and will be enabled in future versions of DiveLog.

20.4.12. Water Current

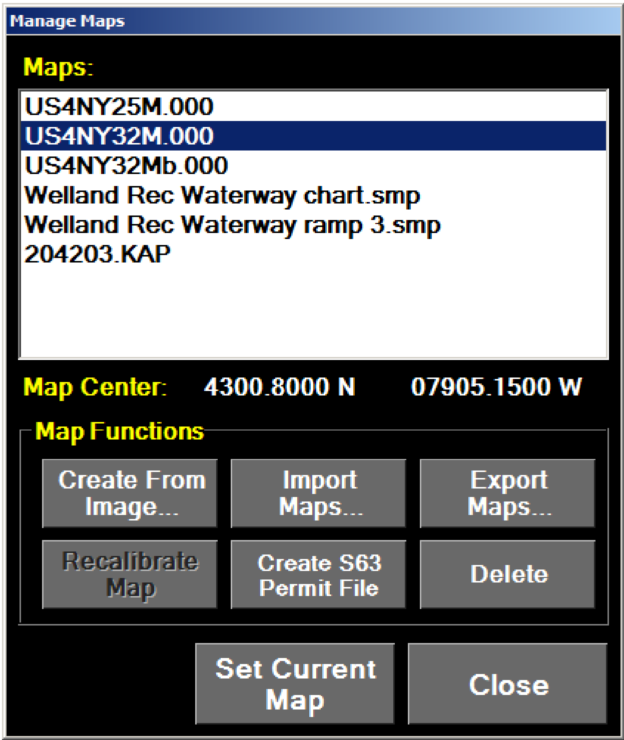


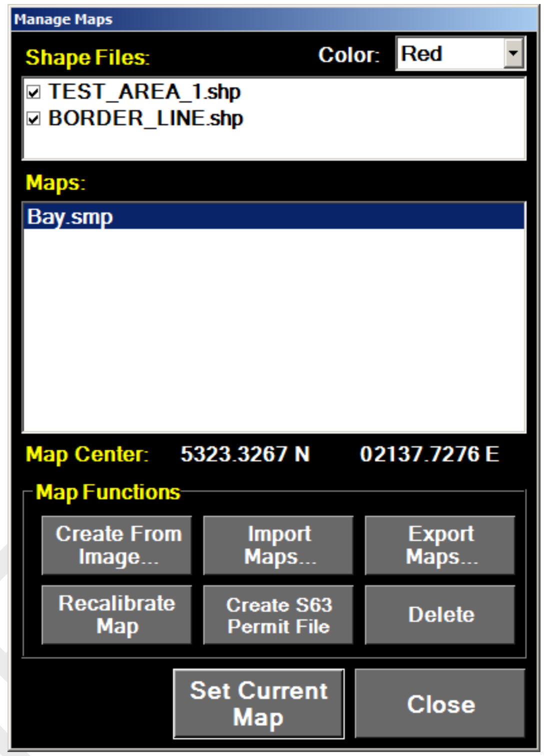
This box allows changing of the number of values to average when calculating current based on a DNS bottom lock. This feature is currently in development and will be enabled in future versions of DiveLog.

20.4.13. Positioning

This box allows setting the delay time for both vectored COG (course over ground) and vectored SOG (speed over ground). This delay determines the length of time over which your COG and SOG are calculated. For example, if your COG delay is set to 4 seconds, DiveLog will calculated each new course over ground value using your current position and your position 4 seconds prior. The longer this delay is, the more stable the reading will be, but it will be less responsive to rapid changes. Likewise, if the SOG delay is set to four seconds, then the speed will be calculated by using the distance travelled over the last four seconds.

20.5. Managing Maps

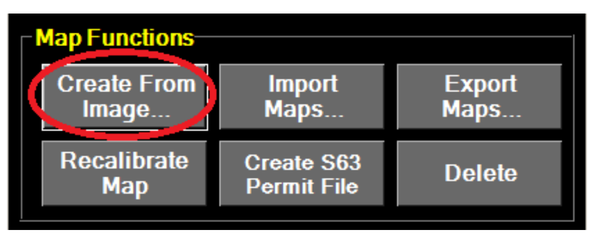




The Manage Maps button on the Track Options window brings up the Manage Maps window. This window provides a list of all maps in the project, and provides the ability to add and remove maps from the project.

A list of the current maps for the project is displayed (see image, upper left). Select a map by clicking the item in the list to highlight it. The center point of the selected map will be displayed in latitude and longitude co-ordinates.

If ESRI Shapefiles have been added to the project, they will be displayed as a separate list at the top of the window (see image, upper right). Shapefile maps will be drawn as an overlay on top of the current map. Multiple Shapefiles can be used simultaneously. To show or hide a Shapefile map, select or deselect the checkbox beside the map name. The color used to draw all Shapefiles can be specified by using the dropdown box “Color:” at the upper right of the window.



The Create New button allows the creation of a new map from an image file. Either a Shark Map or a GeoTiff can be created. Both of these map types are created in exactly the same way: an image is loaded and then three calibration points are set. See section *20.5.1 Creating a New Map* for more information.

The Recalibrate Map button is used for re-calibrating either a Shark Map or a GeoTiff. This is done in the same way as creating a new map, but the previously entered calibration points can be changed. See section *20.5.2 Recalibrating a Map* for more information.

The Import Maps button allows bringing one or more maps into the project from a location on the file system or different DiveLog project. See section ***Error! Reference source not found. Error! Reference source not found.*** for more information and a listing of supported map types.

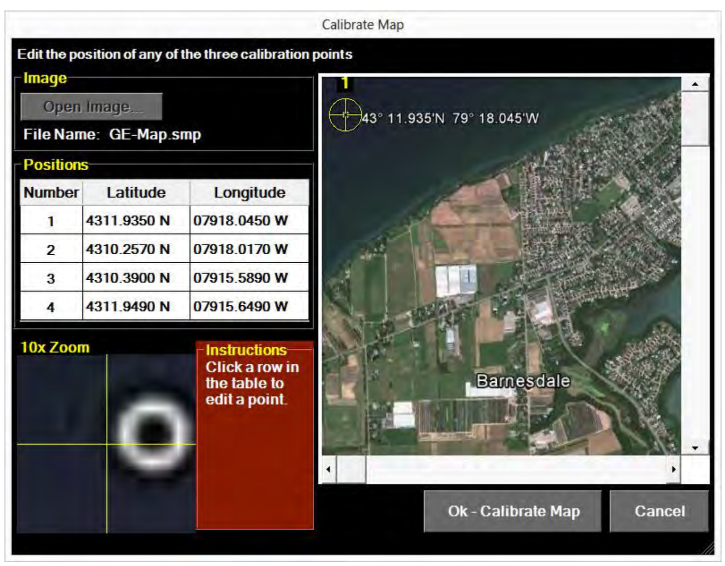
The Export Maps button allows copying the maps in the project to a different location. See section ***Error! Reference source not found. Error! Reference source not found.*** for more information.

The Delete button removes the highlighted map from the current project and deletes the map file(s). If the same map exists in other projects, those other projects will not be affected.

The Create S63 Permit File button is used to generate the system identifier required when S63 charts are to be used. Clicking this button will create a text file containing a system identifier that must be given to the chart provider. See section *20.5.4 Using S63 Charts* for more information.

To choose a map from the list to be used as the current map on the Track Screen, double click the map in the list, or else highlight the map and click the Set Current Map button. If you do not wish to change the current map, click the Close button when done with this window.

20.5.1. Creating a New Map



A new map can be created with the Calibrate Map window, accessed with the “Create from Image” button on the Manage Maps window. The “Recalibrate Map” button on the Manage Maps window also opens this window, but the image and points will be filled in from the selected map. The Calibrate Map window allows the user to set or edit geo-referencing information for an image. Any image can be used to create a map as long as three points on the image correspond to known geodetic positions.

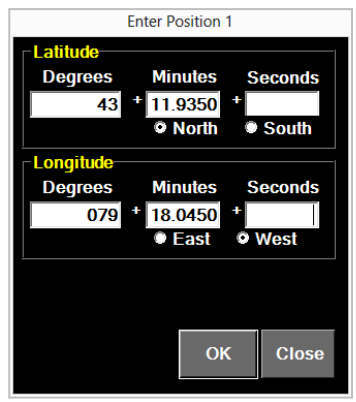
Two types of maps can be created or recalibrated with this window: A Shark Map (.smp) and a GeoTiff (.tif). If a new map is created, the user will be prompted to save it as one of these two types when the image calibration is complete. Both of these file types consist of a bitmap/raster image with geodetic calibration information. Both types can also later be re-calibrated with this window (using the Recalibrate Map button on the Manage Maps window).

To calibrate a map image, first load an image by clicking the Open Image button. The file format of the image can be ".bmp", ".jpg", or ".tif". If the desired map image is in another file format, use an image editing program to convert it to one of these file types. Once the image file is loaded, the image will be displayed and used for setting the calibration points.

Positions

Number	Latitude	Longitude
1	4311.9350 N	07918.0450 W
2	4310.2570 N	07918.0170 W
3	4310.3900 N	07915.5890 W
4	4311.9490 N	07915.6490 W

To geo-reference the image, the user must know the geodetic co-ordinates for at least three, preferably four, points on the image. For greatest accuracy of the map calibration, use four points as far away from each-other as possible. A good rule of thumb is to set calibration points in each corner of the image. An image can be obtained from any commonly available mapping program, as long as the program is able to provide geodetic co-ordinates of points on the map. Google Earth is commonly used for this task (see section *20.5.3 Creating a Map Image in Google Earth*)



Both Shark Maps and GeoTiff are calibrated in exactly the same way. Shark Maps will preserve the original calibration points and image orientation if the map is ever re-calibrated. GeoTiffs, once calibrated, will convert the calibration points to points at the four corners of the image, and rotate the saved image to north up.

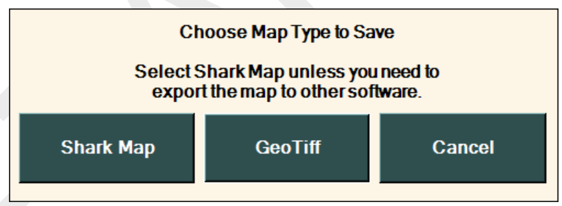
The Positions table (see image, upper right) gives a list of the calibration points. For each of the points, the latitude and longitude is displayed.

To specify each of the points, click on a row in the table and enter the geodetic position in one of the three formats: degrees, or degree/minutes, or degrees/minutes/seconds (see image, middle right). If you know the positions in decimal degrees, then enter the numbers in the degrees box, and leave the minutes and seconds boxes blank. If you know the positions in degrees and minutes (with decimals of minutes), then enter those two numbers in the degrees and minutes boxes, and leave the seconds box blank. If you know the position in degree, minutes, and seconds, then fill in all three boxes.

Once the geodetic position is entered, the pixel location must be specified on the map. After clicking Ok on the “Enter Position” window, the cursor will become a target crosshair indicating that a point must be clicked on the image. If required, use the scrollbars to move the map image so that the proper point is visible. Then click the exact point on the map using the zoom window to help accurately line up the pixel location. The location of each clicked point will be shown on the map image with a numbered crosshair symbol (see image, lower right).

When calibrating an image for the first time, all positions will be blank. After the first point is entered, the next points will be auto-filled with the latitude and longitude of the previously entered point. This makes it quicker to enter the consecutive points since most likely only the minutes will need to be edited for each point.

Once the three or four points are entered, click Ok - Calibrate Map. A prompt will ask the user to select the file type that the map should be saved as. The following is a description of the two types:



- Shark Map (.smp file): The file contains the original image and the original 3 geo-reference points. This file type is recommended due to the preservation of the original data and the ease of re-calibration.
- GeoTiff (.tif file). When saved, the 3 geo-reference points are converted to corner points of the image, and the image itself will be may be stretched and rotated if necessary. This map file type is commonly supported, so save as a GeoTiff if you plan to export the map for use in other software.

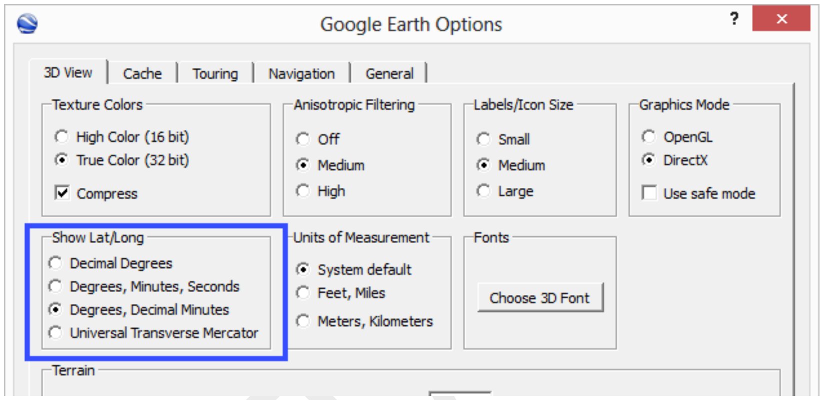
After selecting the file type, the image will be geodetically calibrated and saved in the current project.

20.5.2. Recalibrating a Map

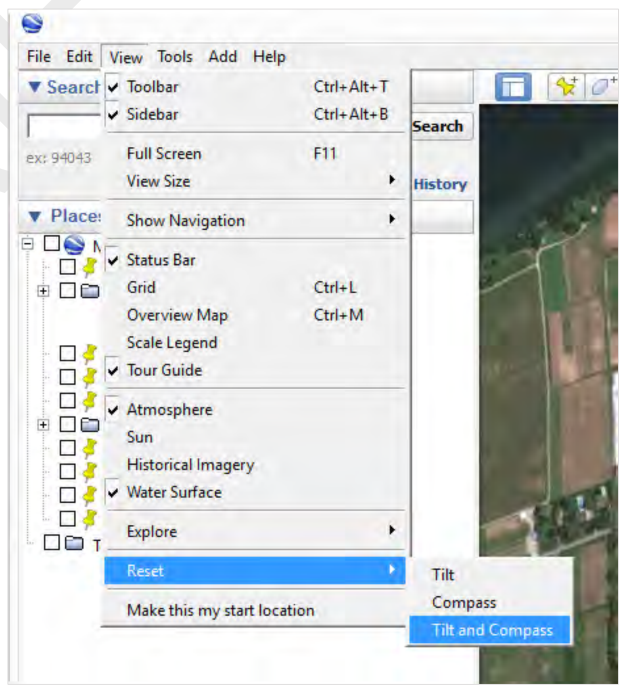
When recalibrating a map image, the same Map Calibration window is used as when creating a map. The map image will be displayed, and the current calibration points will be displayed in the list. The latitude/longitude and/or the pixel location of any of the calibration points can be changed the same way as creating a new map (see section *20.5.1 Creating a New Map* for details). When done editing the points, click the Ok - Calibrate Map button to update the map file.

20.5.3. *Creating a Map Image in Google Earth*

The follow steps can be taken to capture a map in Google Earth that can be calibrated easily in DiveLog:



1. Ensure that Google Earth is set to display coordinates in the format “Degrees, Decimal Minutes”, to correspond with the format displayed in DiveLog. Open the Options window as shown to the right, and check the indicated checkbox in the Show Lat/Long box.



2. Pan and zoom the map to the area you would like to use as a map. Be sure to leave space around your target working area for the calibration points.

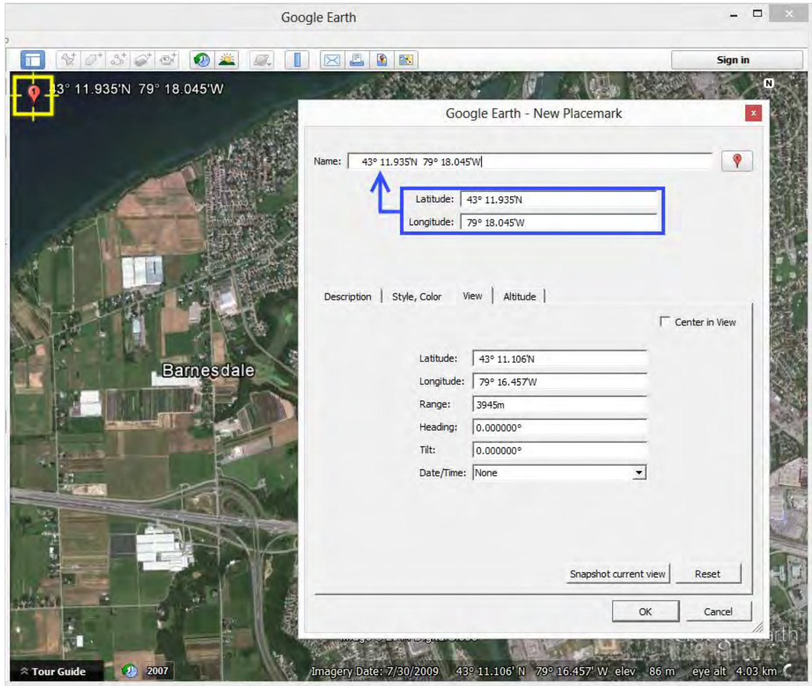
3. Set the tilt and compass to 0 degrees using the menu option View > Reset > Tilt and Compass and shown to the right.

4. Use the Add Placemark button  to add a new placemark to the map. These placemarks will be used to mark reference points on the map for calibration in DiveLog.

5. Drag the placemark icon into a corner of the map.

6. Right click on the placemark to use the options menu to copy the latitude and longitude into the placemark name, as shown below.

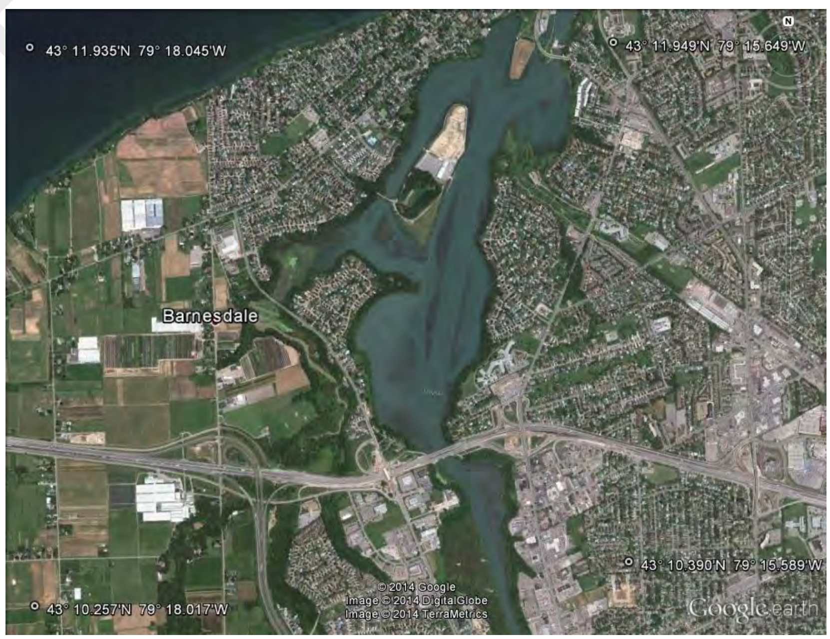
7. Use the button to the right of the Name textbox to open the Icon selection screen. Choose the ◉ icon, as this is the easiest to mark in DiveLog. Then, use the “Style, Color” tab to change the size of the text and icon to 0.8.



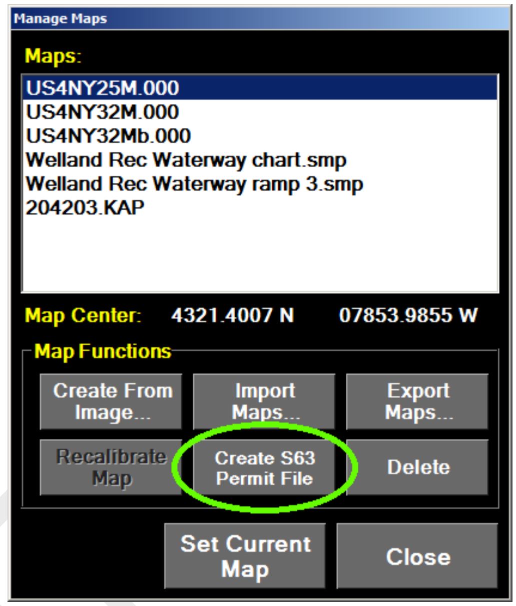
8. Repeat steps 4-6 for each of the four corners of the map, ensuring the text beside each icon is visible. Be sure not to move any placemarks after the placemark name has been set with the position. If you have moved a placemark, repeat step 6 to re-set the placemark name.

9. Once all four placemarks are set, make sure the tilt and compass are reset (View > Reset > Tilt and Compass), then save the image by using the menu option File > Save > Save Image…

The final image should resemble the one to the right, with a placemark in each corner and the Lat/Long position beside each one.



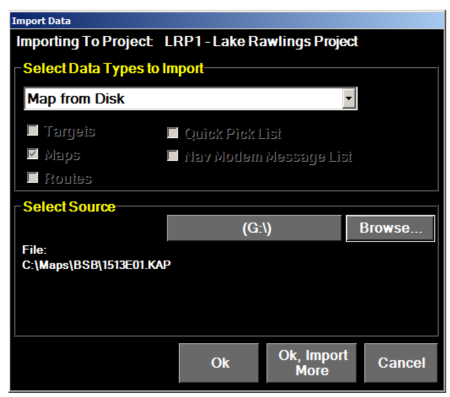
20.5.4. Using S63 Charts



To use S63 Encrypted charts with DiveLog, the S63 charts must be encrypted specifically for the system. DiveLog will create a permit file which contains a system identifier. This permit file must be provided to chart providers to create the encrypted S63 chart.

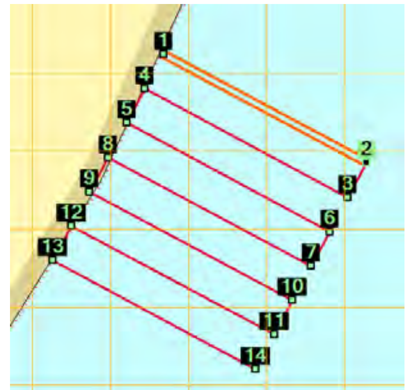
To create the permit file, click the “Options” button on the Track Screen to open up the Track Setup. Click the Manage Maps button to open the Manage Maps window. On the Manage maps window, click the button “Create S63 Permit File”. This will open up a save dialog to save the permit file. The permit file can be saved anywhere, but should be a location that can be exported, such as a removable USB flash memory device.

This permit file must then be provided to chart providers. The chart file will then be supplied with a permit file specific to that chart. After the S63 chart is provided, it must be imported into the DiveLog project along with its permit file. Note that this permit file will be different from the one created by DiveLog, and will allow DiveLog to read the chart file.



To import the chart into DiveLog, on the Import Data from, select “Map from Disk” (See section *9 Importing Data* for more information on importing maps). Click “Browse...” and select the chart (it should have .000 for the file extension). A prompt will come up asking if the map is an S63 chart, to which the answer is Yes. If the permit file is called permit.txt and is in the same directory as the .000 file then it will be found automatically. Otherwise you will be prompted to select the permit file for that chart. The chart and permit file will be copied to the DiveLog project. After this point the chart may be used as any other chart in DiveLog and the permit file will be used automatically.

20.6. Routes

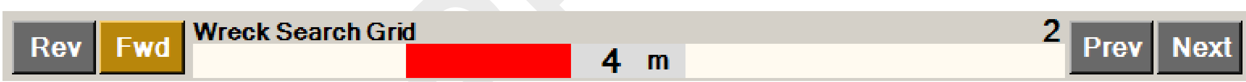


The “Routes” feature allows the operator to follow a pre-defined path for the mission. Routes will be displayed as a series of red connected lines on the Track Screen. Routes are project specific and must be added or imported to any new project. There may by any number of routes in a project, and the routes may consist of any number of points (geodetic coordinates).

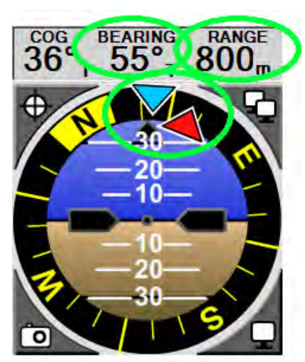
There are four different types of routes:

- Waypoint route: A simple list of arbitrary waypoints,
- Target route: Created by selecting targets from the Track (Map) Screen in a user-specified order to create a route for verification and collecting data on pre-set target positions,
- Survey route: Allows setting up a lawnmower grid to create a survey or search area,
- RBPS route: The route used with the Rapid Beach Programming System. This type of route is only created and used with the RBPS Active Screen.

A route can be set as the “Goto Route”. When a Goto route is set, the Route Crosstrack control panel will be displayed along the top of DiveLog. For the active route, the route points will be highlighted on the track screen with green labels. Other routes in the project will appear as red lines without point labels.

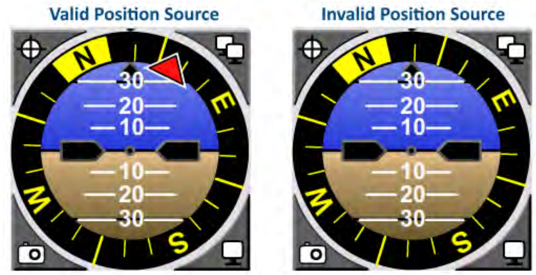


The Route Crosstrack panel has controls for incrementing and decrementing the current route point with the “Next” and “Prev” buttons. The “Rev” and “Fwd” buttons set the direction of the route that will be followed. The current route point will have its label highlighted on the Track Screen, and the name of the route point will be shown at the top right of the control panel. The current route segment (the line leading up to the current point) will be highlighted with a double line on the Track Screen.

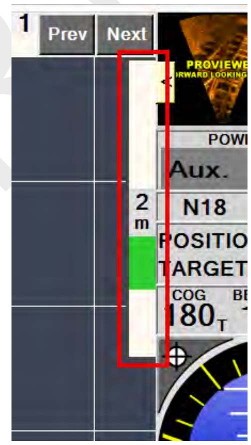


Values for bearing and range to the route point are displayed on the Navigation view (in the same way as a target Goto). The bearing to the current route point will be displayed on the compass as a red triangle (see image, right). The course over ground will be displayed as a blue triangle. Line up the red and blue triangles for the most optimal path to the next route point when a water current influencing your direction of travel.

The triangle indicating the bearing to the route point will blink if the current position source becomes invalid. After 20 seconds of an invalid position, this indicator will disappear.



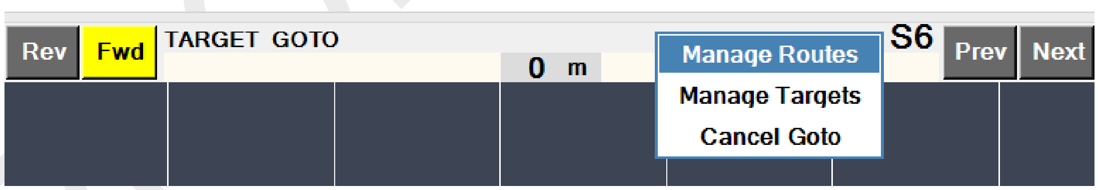
The crosstrack error distance will be displayed in the center of the crosstrack bar. If the current position is drifting too far to the left, a red bar will appear and grow depending on the crosstrack error. If the current position is drifting too far to the right, a green bar will indicate the error.



If depth information is available to DiveLog, and the current route has a target depth, a depth crosstrack bar will be shown. This bar works in the same way as the standard crosstrack bar, but shows your distance from the current target depth. A green bar below the middle rectangle indicates you are below your target depth, and a red bar above the middle indicates you are above the target depth.

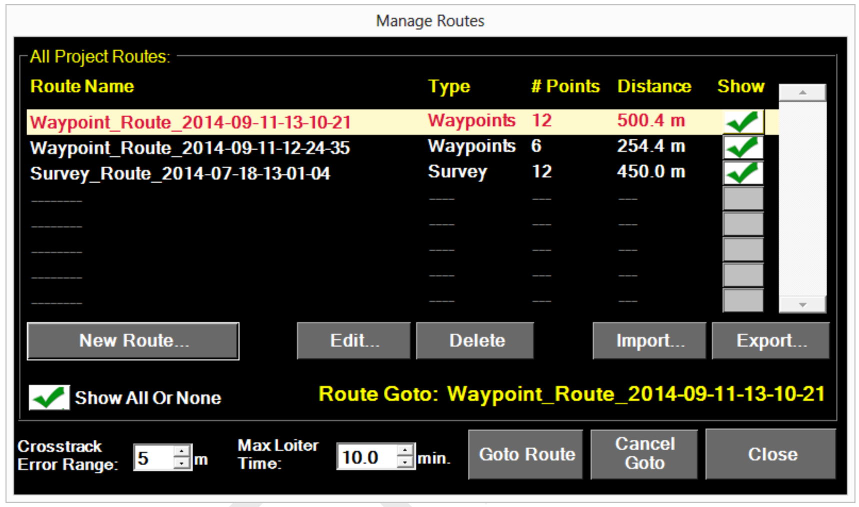
While following a route, the operator must use the “Prev” and “Next” buttons to increment the route point when they reach the next segment of a route. This must be done so that the crosstrack error refers to the proper route segment. If following the route backwards (descending order of the route points), then click “Rev” to reverse the route. Reversing the route does not change the route or its points, but it causes the “Next” button to decrement the route point rather than increment it. Also, the current segment of the route will then be correct with respect to the point that the operator is heading towards.

You can also quickly cancel the current route, or access target or route options by clicking on the route control panel and selecting an option from the dropdown menu as seen below.



20.6.1. *Managing Routes*

The Manage Routes window shows a list of all routes in the current project.



The following information is displayed for each route: route name, type, number of points, total distance, and show/hide status. Clicking one of the headings at the top (Route Name, Type, # Points, Distance, Show) will sort the list based on that category.

In the "Show" column, a button shows whether a route is displayed or not by displaying a green checkmark or a red x. Clicking the button will toggle the display setting. All "Show" settings will be saved for the next time the project is used.

The "New Route…" button creates a new route with no points. When a new route is created, the "Edit Route" window will come up, which allows setting of the route name and points. See below.

Click on a row on the list to highlight it. Once highlighted, the route can be edited or deleted. The "Edit…" button will open the "Edit Route" window (see below), and allow setting or editing points for that route. The "Delete" button will ask for confirmation, and then permanently delete the route from the project.

The "Import…" button, and the "Export…" button allows importing or exporting routes. See sections ***Error! Reference source not found. Error! Reference source not found.*** and ***Error! Reference source not found. Error! Reference source not found.*** for more information.

The button "Goto Route" sets the route to be currently followed, and turns on the Route Crosstrack bar on the main screen of DiveLog. The route must be highlighted in the list before clicking this button. The current route Goto is shown in yellow text at the bottom right. The route Goto and the current Goto point on the route will be saved when DiveLog is closed. The "Cancel Goto" turns off the route Goto, and the Route Crosstrack bar on the main screen will disappear.

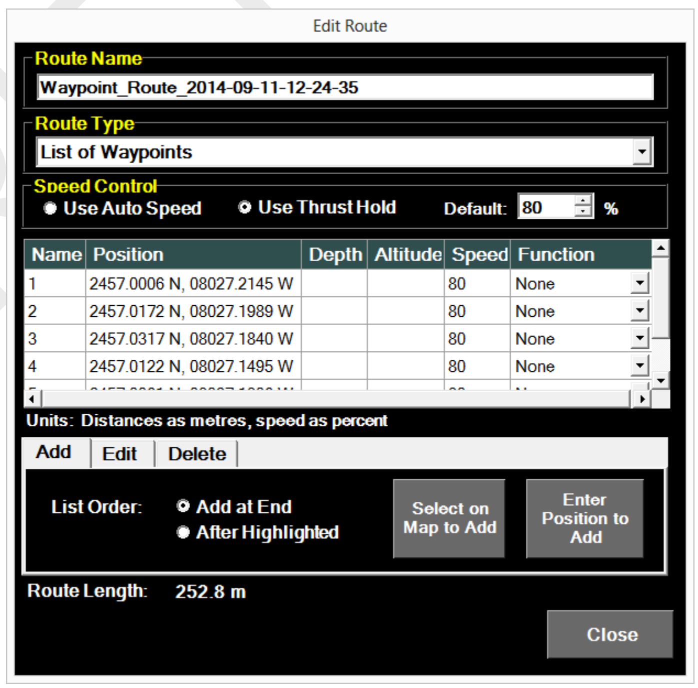
The setting for the crosstrack error range is at the bottom left corner of this window. This value determines the maximum error that will be displayed with the red and green bars on the Crosstrack bar on the main screen. If the crosstrack error distance is equal to or greater than this value, then the red or green bar will be at its maximum length.

The Max Loiter Time setting determines how long a vehicle will wait, during autonomous route following, for a “Continue” command from the user before automatically continuing to the next point.

20.6.2. Edit Route Window

The Edit Route window is used for creating and editing a Waypoint Route, Target Route, or Survey Route. The Route Type selection specifies one of these three types. Always specify the route type as the first step. Once points are added to the route, the type cannot be changed. The window will reconfigure for each different route type.

The first item shown on the Edit Route window is the route name. The route name will be part of the file name when the route is saved to the project, so certain reserved characters will not be permitted. A route name will be auto-generated by DiveLog but can be changed at any time.



The next control after the route type is Speed Control. When using a vehicle, this control allows you to set the thrust control method to either Auto Speed or Thrust Hold, and the default speed value for the points.

The table shows a list of all of the route points. Clicking an item in the list will highlight the point on the Track Screen image.

Towards the bottom of the window, the total length (distance) of the route is displayed. This value is the sum of the distance of each route segment, and will change as points are added or modified. It allows creation of routes to a specific length.

20.6.3. Setting Route Point Properties

Any route point, regardless of route type, have four properties the user may set:

Depth: This is the target depth for this route point. When route following, this depth will be used for the segment leading up to this point. Note: If Altitude is also set, then this depth becomes the *maximum* depth the route follower should go.

Altitude: The altitude the diver or vehicle should be at when it arrives at this point, unless this altitude would be beyond the maximum depth.

Speed: Speed route follower should use to get from this point to the next.

Function: The additional action of the route follower at this point. The possible functions are as follows:

None:	Continue normal auto depth or altitude auto operation.
Ramp to Depth:	Perform a linear movement from the previous to the current target depth or altitude.
Get GPS Fix:	Move to the surface until a GPS fix is secured, then goes back to the proper depth and continues to the next point.
Loiter:	Stop at this point and wait (during automatic route following, the vehicle will perform a station keeping function). Resumes to the next point when the user clicks a continue button, or until the set time limit (on the Manage Routes window) expires.

20.6.4. Creating and Editing Waypoint Routes

There are two ways to enter route points:

1. Geodetic lat/long positions can be manually entered by clicking “Enter Position”. Latitude and Longitude can each be entered in one of the three formats: decimal degrees, or degrees and decimal minutes, or degrees/minutes/seconds.

2. Points can be specified by clicking on the Track Screen image. To quickly add a series of points, click “Select on Map to Add”. This will allow you to choose one or more points with the mouse cursor. If the Track Screen is not the primary mode, click on its secondary image to bring it up. A button titled “Click When Done” will appear at the bottom of the Edit Route window. When done selecting the points, click this button.

The order of the points is important, since the order determines which points will be connected by a line on the track screen. Select “Add at End” when specifying the next point on the route. Select “After Highlighted” to add a point between two existing points (right after the highlighted point in the list).

To edit points on the map, click “Edit on Map”. Then click a point on the Track Screen to select it. Once selected, click another point on the Track Screen to specify the new location for that point.

If editing a single point, highlight the point of interest in the list to select it and then click “Enter New Position for: #”.

Removing points can be done in two ways. Clicking “Select on Map to Remove” will allow you to simply click route points on the map to delete them. Alternatively, highlight the point in the list and click “Remove: #”. When a point is removed the points before and after that point will become connected.

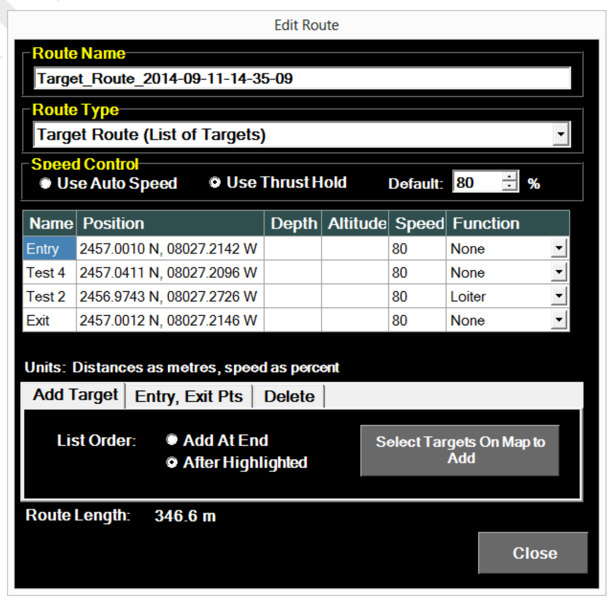
To clear all points in a route, click “Clear All Points”.

To remove the entire route and delete the route file from the project, click “Delete This Route”.

20.6.5. Creating and Editing Target Routes

Target routes consist of a series of target positions plus optional entry and exit points. A target route is created by adding pre-existing targets by selecting them on the Track Screen.

To add targets, first select “Add at End” or “After Highlighted” to specify the location in the list of points that new points will appear. Then click “Select Targets on Map to Add”. This will allow using the mouse cursor to point and click on the Track Screen to choose the targets. When done, click “Click When Done”.



Entry and exit points can also be specified. The entry point will always be the first point in the route, and the exit point will always be the last point in the route. Like points in a waypoint list, the entry point and exit point can be selected by clicking anywhere on the Track Screen (with the “Select Pt on Map” button, or the position can be manually entered (by clicking “Enter New Position for ...“).

Points can be removed under the “Delete” tab. Removing can be done by selecting the points on the Track Screen, or by highlighting them in the list and clicking “Remove: ...”.

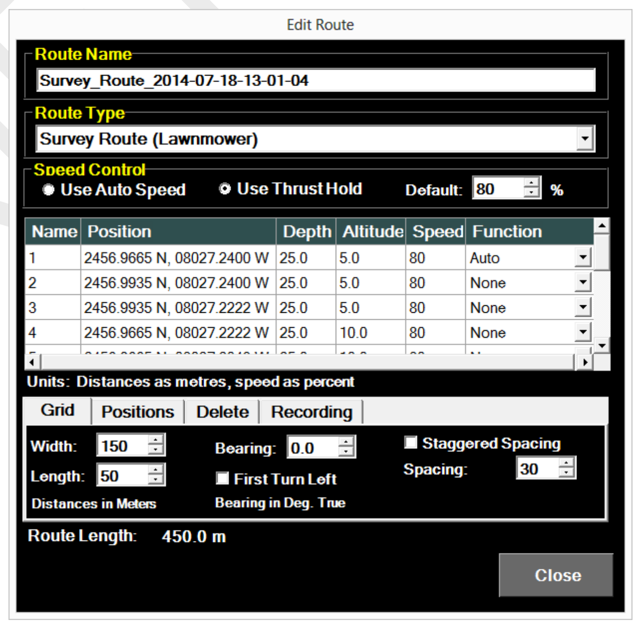
When a target route is created or edited, the points added to the route are the current location of the specified target. If the position of a target is subsequently changed, the route will not be affected (and the route point will be the old position of the target). If desired, to update a route in the event of a target changing position, the point in the route should be deleted and re-added.

When a target point is removed from the list (or the target route is deleted), the target itself will not be deleted or modified in any way. These controls will only affect the route, and not the targets that the route is based on.

20.6.6. Creating and Editing Survey Routes

Survey routes are used to create lawnmower path or search grid for systematic covering of an area.

Rather than adding each point, the grid parameters are specified to create the route. None of the points in the list can be manually edited other than the start point, the entry point, and the exit point.



The survey grid parameters are as follows:

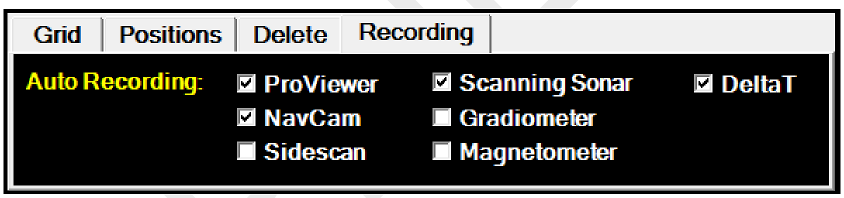
- Width: the total width of the search area.
- Length: the length of each line that will be run in the survey grid.
- Bearing: the direction of the first line (and thus specifies the angle of the entire grid).
- First Turn Left: specifies whether the survey grid will progress to the left of the first line, or the right.
- Staggered Spacing: Uncheck this box if the distance between each line should be uniform. Check this box if the spacing between odd and even lines should be different.
- Spacing: For uniform spacing; the distance between each line.
- Odd Spacing: For staggered spacing; the distance after every odd numbered line that the next line will start.
- Even Spacing: For staggered spacing: the distance after every even numbered line that the next line will start.

All values will default to the last values used for a survey grid.

On the “Positions” tab, three points may be specified: the entry point, the grid start point, and the exit point. The entry point and exit point are optional. The survey grid will appear on the Track Screen as soon as the “Grid Start Point” is specified. Modifying any of the points or grid parameters will immediately update the image on the Track Screen so that the survey route can be viewed.

The entry point, start point, and exit point can each be specified by clicking on the Track Screen image or by manually entering the position.

The Recording tab allows you to set which active screens will start recording during each length leg of the survey. During automatic route following, when the vehicle arrives at the first route point, all selected screens will automatically begin running and recording (if the required device is available and properly configured). Recording will be toggled off at the end of each route line (so no recording is done on the connecting lines), and will toggle on at the beginning of each subsequent route line.



20.7. Tracks Files

20.7.1. Playback of a Track

Recorded tracks can be played back on the Track Screen. In order to play back, the data source for the Track Screen must be toggled from Realtime to File. To do this, open the Options window (click Options on the control panel at the bottom of the Track Screen), and click “File...”. This will enable the user to open a “.trk” file from the current project.

When the Track Screen is in File mode, playback controls will be displayed. As the track plays, the playback position will be highlighted on the Track Screen with an icon (a large green dot or chevron). Like playback of other files in DiveLog, recorded sensor and navigation data will be played back on the Navigation View panel on the main screen of DiveLog.

Note: Tracks for files recorded with a different Active Screen will be played automatically when the file is played back.

20.7.2. Track File Description

The track file contains all basic sensor data, Goto information (route/waypoint information), and other relevant dive information. The following is a list of data stored in each line of the track file:

- header denoting type of track point,
- position latitude (decimal degrees),
- position longitude (decimal degrees),
- position valid (true/false),
- position source (GPS, long baseline, DNS, etc...),
- date (dd/mmm/yyyy),
- time (hh:mm:ss.mmm),
- speed (meters/second) (from GPS or other position source),
- speed valid (true/false),
- course over ground (degrees) (i.e. true heading from the GPS),
- course over ground valid (true/false),
- dive number,
- diver/operator name,
- magnetic heading (degrees),
- pitch (degrees),
- roll (degrees),
- heading/pitch/roll valid (true/false),
- depth (meters),
- depth valid (true/false),

- altitude (meters) (external altimeter must be connected),
- altitude valid (true/false),
- surface interval (hh:mm:ss),
- dive time (hh:mm:ss),
- internal temperature (degrees Celsius),
- internal temperature valid (true/false),
- external temperature (degrees Celsius) (must have altimeter or other external temp source),
- external temperature valid (true/false),
- Goto point type (target, route point, etc),
- Goto latitude (decimal degrees),
- Goto longitude (decimal degrees),
- Goto position valid (true/false),
- Goto number,
- Goto name,
- Goto depth (meters),
- Goto depth valid (true/false),
- Goto target group,
- Goto cross-track error (meters),
- Goto cross-track error valid (true/false),
- Goto file name

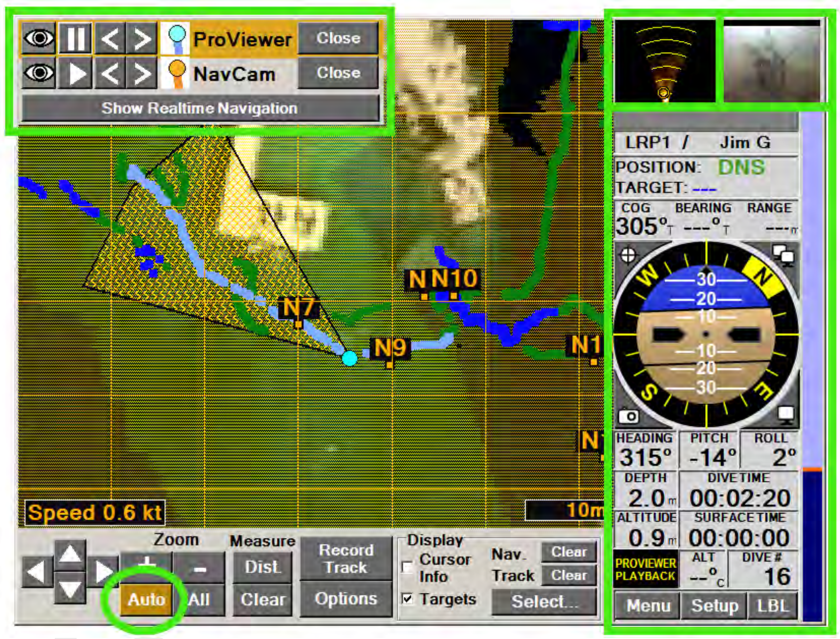
20.7.3. Tracks Paired With Recorded Active Screen Files

Most types of files recorded with an Active Screen such as sonar files, magnetometer files, NavCam files, etc, automatically record a track file simultaneously. The track file will be kept in the same directory as the main file that it accompanies (such as in the "FLS" directory in the folder for the current project). The name of the track file will be the same as the name of the main file, with the only difference being the file extension ".trk". The purpose of the track file is to track the locations of each recorded file, and record additional data that may not be recorded in the main file.

When a project is loaded, all of the track files (including those paired with other recorded files) are loaded into memory and will be displayed on the Track Screen. This offers a quick view of the areas that have recorded data, and what types of files are recorded. The track paths displayed on the Track Screen are different colors based on the type of file they represent.

20.7.4. Track Playback Control Panel

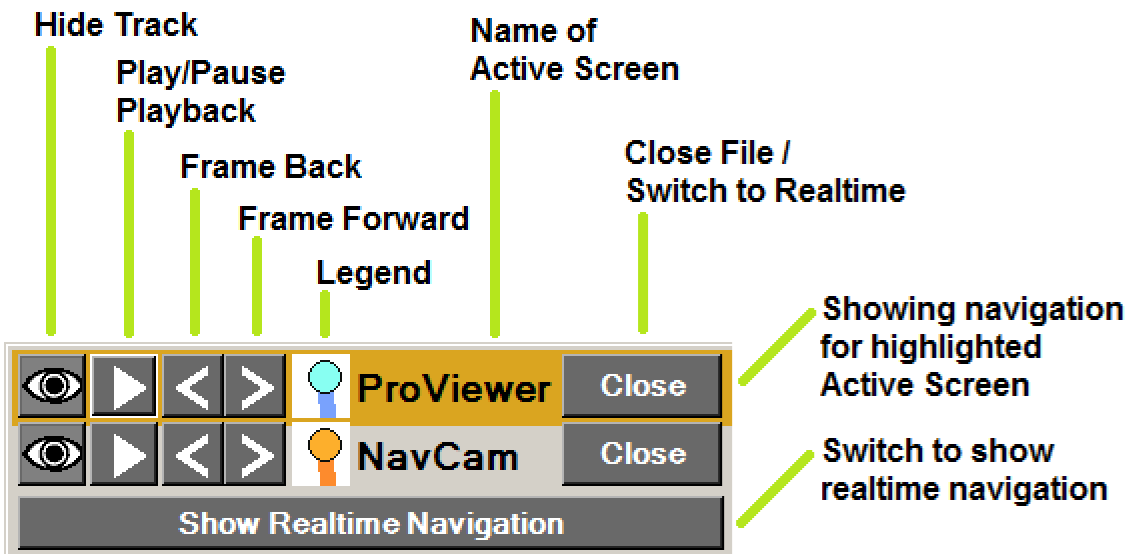
When a recorded file such as a sonar file or NavCam file is played back through its Active Screen, the display on the Track Screen will also play back data. When a file is playing, the track for that file will become highlighted on the Track Screen and an icon (dot or chevron) will show the current position of the playback file data. This makes it very intuitive to see the current geodetic position of the data displayed on the playing Active Screen.



While a file is playing, Navigation information for the playback file will be shown on the Track Screen. This means two things:

- If "Auto" mode is set for the Track Screen zoom, then the Track Screen view will automatically shift to keep the playback position in view if the playback position goes off the screen.
- If the Track Screen is the Primary Screen (and the playing Active Screen is secondary), the Navigation View on the right hand side will display and play back the data for the file rather than show realtime data.

The playback control panel at the top left of the Track Screen allows controlling of the files that are playing in the other Active Screens (while looking at the track playback). The row that is highlighted orange shows which playback file is showing navigation information on the Track Screen. If multiple files are open by different Active Screens, clicking a different row in the list will change the Track Screen to show navigation information for that file. By clicking the button "Show Realtime Navigation", the "Auto" scroll and Navigation View display for the Track Screen will return to show realtime data. See image below for a description of the playback control panel.



The controls in each row of the playback control panel perform the following actions:

- Eye: Highlight or stop highlighting the track for the current file (default is highlighted).
- Play/Pause: Commands the listed Active Screen to play or pause playback of the loaded file.
- Frame Back: Commands the listed Active Screen to step back a frame of the loaded file.
- Frame Forward: Commands the listed Active Screen to step forward a frame of the loaded file.
- Legend: Shows how the track for the listed Active Screen will appear on the Track Screen Image.
- Name: Shows the name of the Active Screen that this row of controls is for. Clicking on the name will also switch the Track Screen to show navigation for that Active Screen.
- Close: If realtime mode is enabled (DiveLog is running on a Navigator or Survey system), then this button commands the listed Active Screen to close the file and toggle the data source back to realtime. If realtime mode is not enabled (Mission Planning or View Only mode), then this button will just close the file.
- Highlighted Row: Indicates which playing Active Screen is showing Navigation the Track Screen.

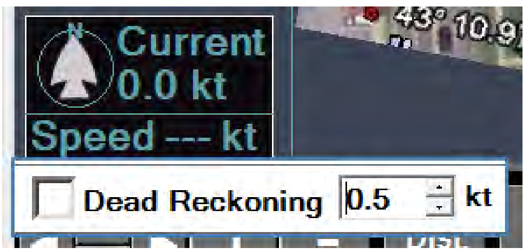
Note that when a file is played, other playing files will automatically pause, and Track Screen will show navigation for the new playing file.

20.8. Dead Reckoning and Water Current

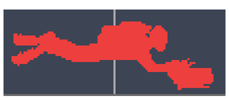
In situations where no speed sensors are available, DiveLog offers a feature to track position using a pre-set speed and water current. This “assisted dead reckoning” is similar to traditional dead reckoning, but heading is known and used to track position given a statically set speed. A water current may be set to account for movement caused by current.

20.8.1. Dead Reckoning

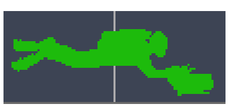
To turn on Dead Reckoning mode, click the speed section of the Track overlay (see section *20.1.5 Track Overlays*) to open the dead reckoning drop down menu. This menu allows you to enable or disable dead reckoning mode. Checking the checkbox shown below will start dead reckoning mode if there **is not** a valid position source and there **is** a valid HPR source.



A graphic overlay of a swimming diver is displayed any time dead reckoning is enabled. The diver is shown in one of several states.



If the diver is red, swimming is currently **paused** and no distance will be covered. The red diver icon will flash to indicate that dead reckoning is active but not swimming (stationary).




If the diver is alternating between light and dark green, swimming is **active** and distance will be covered equal to the combination of the entered speed and water current.

To switch between swimming and stationary, click the green/red diver graphic. This should be done each time the operator stops swimming and starts swimming.

When another position source (such as a GPS) becomes valid, the dead recon mode will

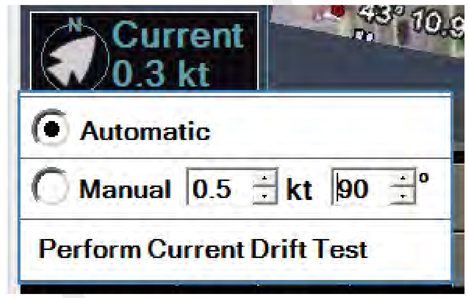
become inactive, and the icon will become gray. If that position source becomes invalid again, dead recon mode will become active again, but in a stationary state. Click the icon to start swimming again.

It is important to note that while using dead reckoning mode, DiveLog will assume the operator is swimming at the exact speed set. The more that the operator deviates from this speed, the more inaccurate the final position will be. To maintain accuracy, the swimming should be done in the same direction as the compass heading. For example, swimming forward when the Navigator is pointed to the side would result in incorrect movement of the dead reckoning position in DiveLog. The accuracy of the water current value will also have an effect on final position accuracy.

20.8.2. *Water Current*

Water Current is a measure of the speed and direction a body of water is travelling with reference to ground. It is important to know the water current when using dead reckoning mode, as the speed and direction a diver is swimming is relative to the water. This means that relative to the ground, the diver may be moving at a difference speed and in a different direction based on current.

To determine the water current, 3 options can be used:

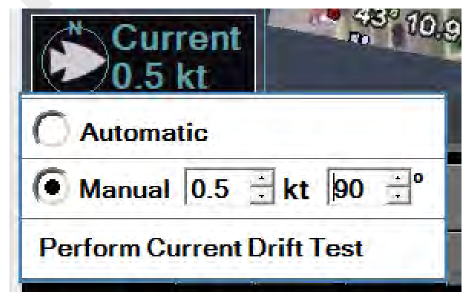


Automatic Current

Checking the Automatic Current radio button will allow current to be set using the DNS (Note: this feature is not currently available with the standard DNS unit).

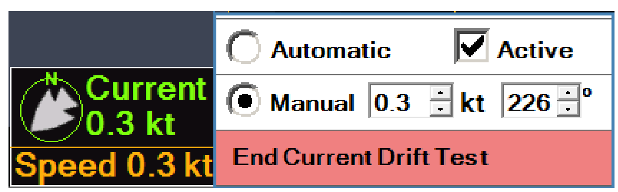
Manual Current

Checking the Manual radio button will allow the user to set the speed and direction of the current. This current will be used in all dead reckoning calculations until the current is changed back to automatic.



Current Drift Test

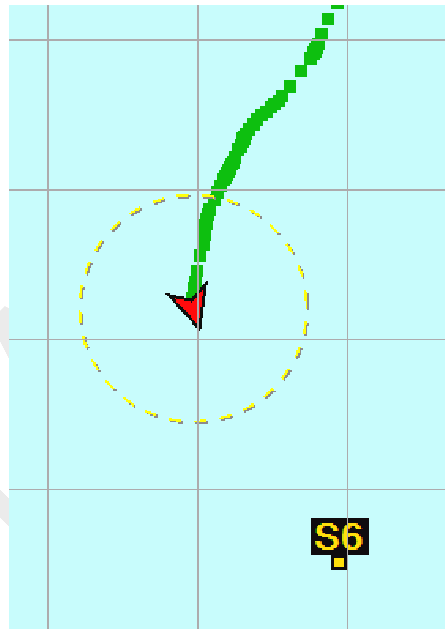
A current drift test may be performed in the water to determine the current using a GPS to track your position as the current causes you to drift.



To perform the current drift test, make sure you have a valid GPS fix, then click “Perform Current Drift Test”. Allow yourself to drift in the current, and DiveLog will track the GPS movement to determine the water current. Once the display for the direction and speed of the water current has stabilized (after about 30 seconds to get enough GPS readings), click “End Current Drift Test”.

20.9. Circle of Confidence

20.9.1. Circle of Confidence Overview



With any position source, there will be an inherent uncertainty between the actual position and the position given by that source. For each source, there will be a different uncertainty. Standard GPS sources will be accurate to a 2.5m radius, whereas a DNS's accuracy decays over time. In missions where positioning is critical, is it useful to know confidently that you are or are not within a certain region.

DiveLog will track these uncertainties automatically, and generate a Circle of Confidence, which is displayed on the Track Screen. The Circle of Confidence will always center on your current calculated position, and show the region which you are confidently inside of. This circle may grow or shrink depending on which position source you are using, and if that source is a "hard" or "soft" position source.

"Hard" or absolute position sources will give a static Circle of Confidence, whereas a "soft" or additive position source will always add uncertainty to the existing uncertainty over time and/or distance.

For example, if you are travelling using a standard, 2.5m accurate GPS position source, your Circle of Confidence will constantly have a 2.5m radius. If you then begin to use DNS as your main position source, that radius will begin to grow based on several sources of inaccuracy called "metrics". Each position source has its own set of metrics that it uses to determine how fast or slow the confidence radius will grow.

It is important to note that while the Circle of Confidence will display the range of possible actual positions, is it always more likely the actual position will be closer to the center of this range, than the edges.

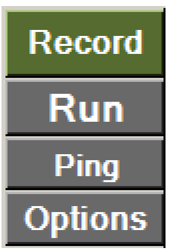
21. Forward-Looking Sonar (FLS) Screen

Note: The FLS Screen is an optional feature to DiveLog. If the system does not have an FLS equipped then the screen can be turned OFF on the System Setup window, under Active Screens.

With the Forward-Looking Sonar (FLS) Screen as the primary screen, the user can view the sonar image and details of the sonar data from a live head or recorded file. With the sonar as the primary screen, display parameters can be easily adjusted. Additional parameters and details can be viewed or adjusted in the Options window.

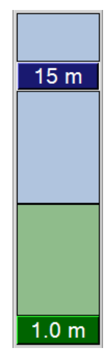
21.1. Main Sonar Controls

21.1.1. Run, Record, Options



When the sonar is connected and powered up, the connection to DiveLog is automatic. To start and stop continuous pinging, click the "Run" / "Hold" button, or click the "Ping" button for a single ping from the sonar head if continuous acoustic transmission is not desired. The "Options" button opens the Forward-Looking Sonar Options window. For further details on recording a file and the Options window see the sections *21.5 Recording* and *21.2 Forward-Looking Options* respectively.

21.1.1. Range Slider



The range slider is found on the left side or bottom of the sonar screen, depending on the sonar field of view angle. The range slider is made of up two sliders, which adjust the minimum and maximum ranges of the sonar image. They can be adjusted by dragging the slider itself or by clicking in the region above or below the slider. By changing the minimum and maximum ranges, the user can focus on an area of interest.

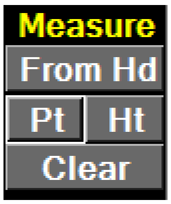
21.1.2. Display

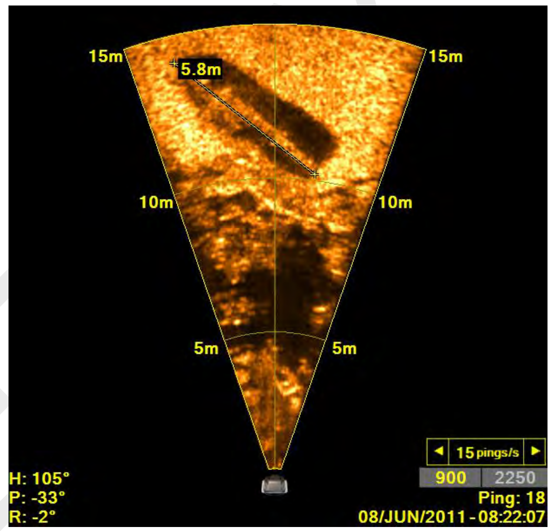
The control panel at the left side or bottom of the sonar screen contains three checkboxes, control the visibility of sonar image elements. The Grid checkbox shows and hides the range arcs, the info checkbox shows and hides geodetic cursor info, and the Targets checkbox shows and hides target markers (if configured to be displayed (on the Manage Targets window).

21.1.3. Ping Rate

The ping rate controls (at the bottom right of the sonar image) allow the user to limit the number of pings per second to the value selected. This is useful for limiting file size or reducing processor load.

21.1.4. Measuring Tools

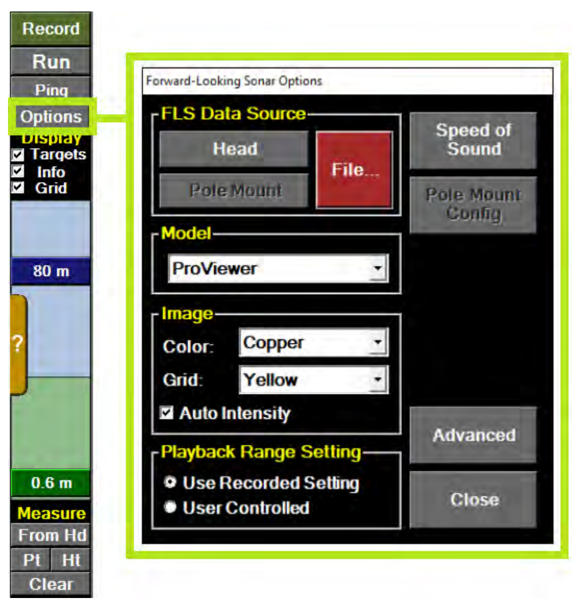




In the control panel, there are three buttons for making measurements on the screen. A measurement can be taken from the head to any point on the screen by first clicking on the "From Hd" button and then clicking on the sonar image. A line from the sonar head to that point will be drawn showing the slant range and true bearing to the point from the head. A point-to-point measurement can be taken between any two arbitrary points on the sonar image by first clicking the "Pt" button then clicking two points on the sonar image. An estimate of an objects height can be measured by first clicking the "Ht" then clicking the top of the object on the sonar image followed by the end of its shadow. To clear measurements from the screen click the clear button. The image to the right illustrates a point-to-point measurement of 5.3 meters.

21.2. Forward-Looking Options Window

A button on the primary screen brings up the Options window. From this window, the data source for the sonar can be toggled between two different real-time sources, or to playback by clicking on the respective buttons. Clicking "File" allows selection of a file for playback.



21.2.1. *Model*

To connect to a sonar, the correct model must be selected on the Options window. Three models of forward looking sonars are currently available.

- **ProViewer** (BlueView)
- **Gemini** (Tritech)
- **ARIS** (Sound Metrics)

The various types of each model will be automatically detected when a sonar is connected. The selected model only applies to realtime operation; the correct model will be automatically chosen when a file is opened for playback.

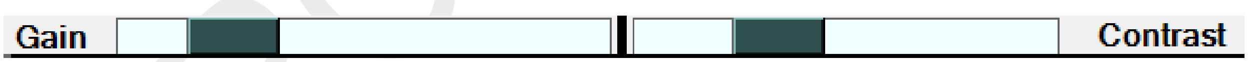
21.2.2. *Image*

The sonar image can be displayed using one of six different color maps, and the grid colour can be selected from six different options as well.

Auto Intensity or Auto Contrast, depending on the sonar model, can also be enabled or disabled using the checkbox.

When Auto Intensity (BlueView ProViewer only) is disabled, the manual gain and threshold sliders will appear at the top of the sonar screen. These allow the user to adjust the upper threshold (left slider) and lower threshold (right slider) as shown below.

When Auto Contrast (Gemini and ARIS) is disabled, the manual contrast slider will appear to the right of the gain slider. This allows the user to raise or lower the level of contrast enhancement being applied to the image.



21.2.3. *Playback Range Setting*

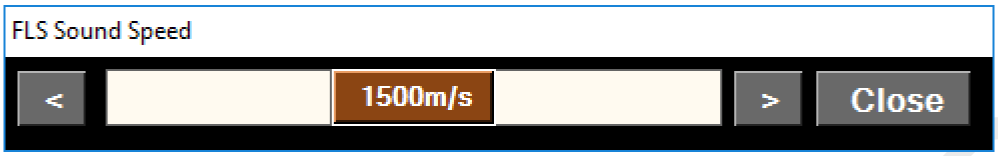
When playing back a file the user has the option to view the range as set by the operator during real time data acquisition or to select the range window manually.

21.2.4. *Pole Mount Configuration*

The “Pole Mount Config” button opens the Pole Mount Setup window. See section *15.9.1 Pole Mount Setup* for further details on the pole mounted sonar setup.

21.2.5. *Speed of Sound*

If the speed of sound in water is known, then it can be entered into the software by clicking the “Speed of Sound” button on the Options window. This will open the Sound Speed window. The effect of a change here can immediately be seen on the sonar image in real time or playback.



21.3. Forward-Looking Advanced Options Window

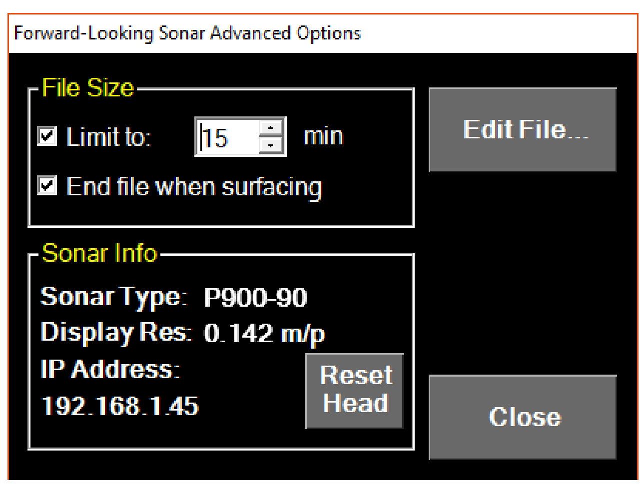
The advanced options window is reached through the Advanced button on the Options window. This window provides sonar information and allows configuring of additional options that are not normally adjusted by the operator.

21.3.1. *File Size*

The File Size box allow the user to limit each recorded file to a certain duration. At the end of this duration, a recording file will end and a new recording will automatically begin. You may also choose to automatically end recording when the unit surfaces. If this option is selected, a prompt will be displayed a short time after surfacing to indicate that recording will end. The operator can choose to continue recording, and if the prompt is not answered then recording will automatically stop.

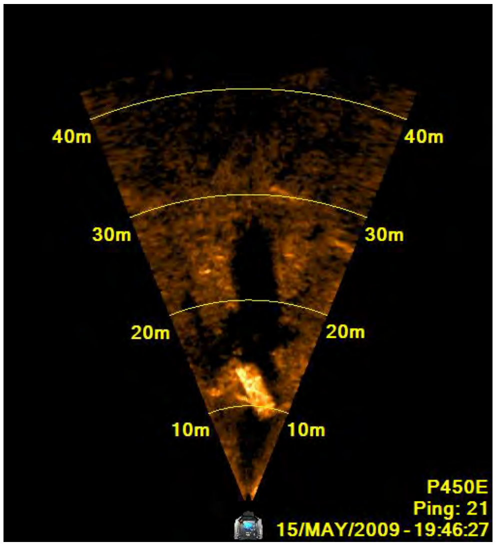
21.3.2. *Sonar Info*

The Sonar Info box on the provides information regarding the current sonar (either real-time or playback): The sonar model, the current resolution of the sonar image in distance per pixel, and the IP address of a real-time head. Additionally, this box allows the user to re-initialize the sonar by pressing the “Reset Head” button, in case a head error has occurred (normally DiveLog attempts error recovery automatically).



Note: There may be additional options on this window depending on the sonar model selected.

21.4. The Sonar Image



The main sonar image presents a visual representation of the echo data being collected. The position of the sonar head is at the bottom of the screen. The sonar image is displayed as if viewed from above looking down, i.e. the top of the image is ahead of the sonar head location when the sonar is pointing forward (horizontal).

In the lower right corner of the sonar image is the current sonar model being used, the ping count and the date and time.

21.4.1. Geodetic Referencing

When DiveLog has a valid GPS source and has an attitude reference to the sonar, the sonar image is completely geodetically referenced accounting for both the pitch and roll of the sonar. On the Navigator or a vehicle, the HPR sensor(s) would supply the attitude reference; while on a pole mount, the attitude reference would need to come from an external HPR on the pole mount setup. A geodetic position is available for any cursor position over the image when these conditions are satisfied. This is useful for marking targets and navigation.

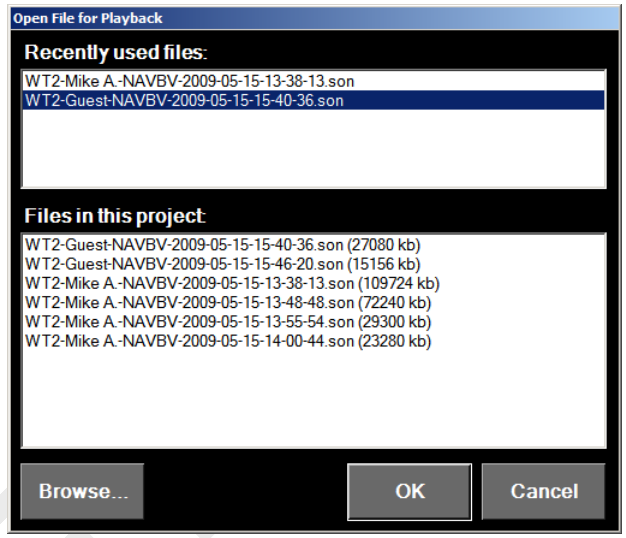
21.4.2. Targets

When the Targets checkbox is checked, all targets from the current project will be shown on the sonar image if they are within the field of view of the sonar. The targets will be marked using a circle and a corresponding number or name, this is done so that the target marker does not cover the target image on the sonar screen.

21.5. Recording

To record a file, click the record button during real-time operation. For wide angle sonar models, the record button is found near the lower left corner of the screen, otherwise it is near the top left. A file name will automatically be created and recording of the echo data will start immediately. During recording full functionality of the sonar will remain; the operator can continue to adjust the range through the entire range. The recorded data can be accessed at a later time for playback and review. Every time the record button is clicked off and then on again, a new file is started.

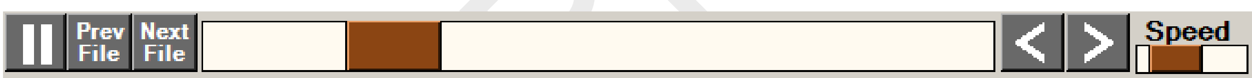
21.6. Playback



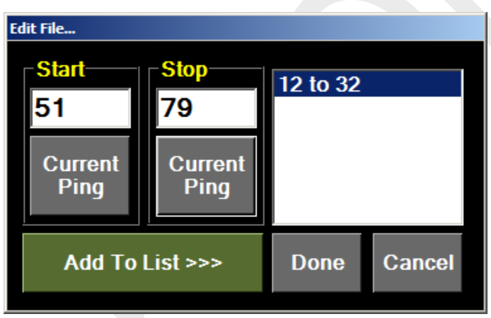
To play back a previously recorded sonar file, click the Options button on the sonar screen, then click “File”. A window will open (shown to the right) allowing you to select the desired file from the current project. Once opened, playback will begin immediately.

When playing back a sonar file, a file position slider and a playback speed slider will appear at the bottom of the display. Playback position and speed can be adjusted. The two arrow buttons are used for stepping through a file one ping at a time.

At the left of this bar is the “Play “/ “Pause” button, this button toggles the screen between “Play” and “Pause”. Next to this is a button labelled “Next File”, when you are already playing a file this button allows the user to load and play the next file in the project in a chronological order.



21.6.1. Editing a File



When playing back a file, segments of the file can be extracted and compiled into a sub file containing only segments of the file of interest to the user, or to summarize a file. From the Options window, the “Edit File” button opens the file editing window. Segments of pings can be added to the sub file by entering the start and stop pings for a particular segment and then clicking the “Add To List >>>” button. The “Current Ping” buttons populate the field for start or stop with the current playback position. Once all the desired segments have been added, clicking the “Done” button will create a new file with only the sections specified. A track file will also be created for the new file with the corresponding segments of track data.

21.7. FLS on the Track Screen

When an FLS file is recorded, a corresponding track file is also recorded. The path of the file will be displayed as a blue track on the Track Screen (See image of an FLS track during playback with coverage and sonar area shown, right). Past recorded FLS track files in the project will be displayed on the Track Screen. See section *20 Track* Screen for more information.

21.7.1. Sonar Area

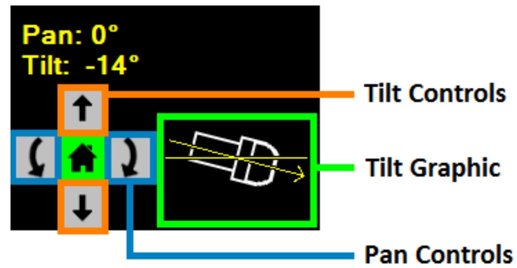
When the sonar is running or a file played, the current sonar image area will be shown on the Track Screen as a cross-hatched shape. As the position and heading changes, the sonar area will move to reflect the current area of the sonar image. This will only be displayed if the position of the sonar image is valid.

21.7.2. Coverage Mapping

For all past recorded sonar files and the currently recording sonar file, the total cumulative area of coverage is shown as a shaded region on the Track Screen. The coverage for a currently recording file or a file open for playback will be highlighted. The coverage will only be shown for parts of the files(s) where the position is valid. The coverage map will not be shown when the Track Screen is toggled to Secondary Mode. The display options for the coverage map can be set on the Track Screen Options window (see section *20.4.7 Coverage Map*).

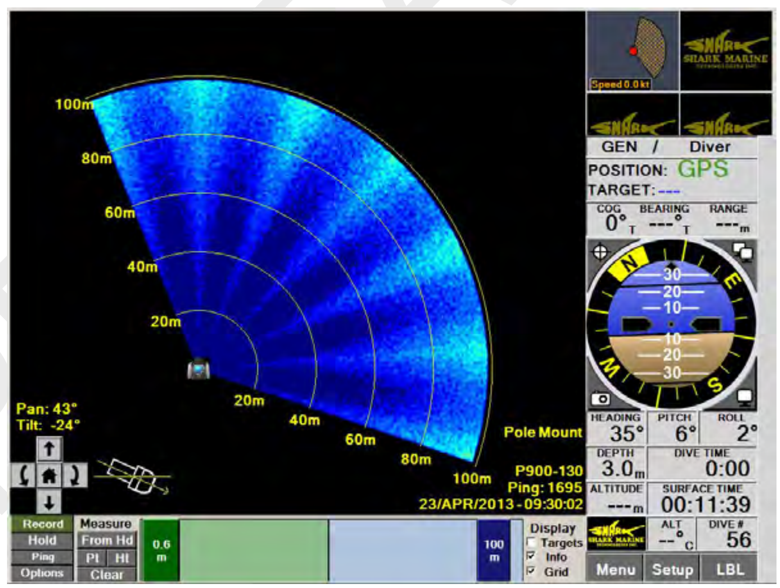
21.8. Pan/Tilt Controls

The FLS Active Screen supports interfacing to a pan and tilt pole mount such as the BV3100. When activated, an additional set of controls for adjusting the pan and tilt angle of the sonar head will be available in the lower left corner of the sonar image.



The up and down buttons are used to change the tilt angle of the sonar head, while the buttons with the rounded arrows are used to adjust the pan angle of the sonar head. The middle button with the house icon is used to move the pan and tilt motors to a predefined ‘home’ position. For further information about setting the ‘home’ position see section *15.9.3 BV3100 Pole Mount Setup*.

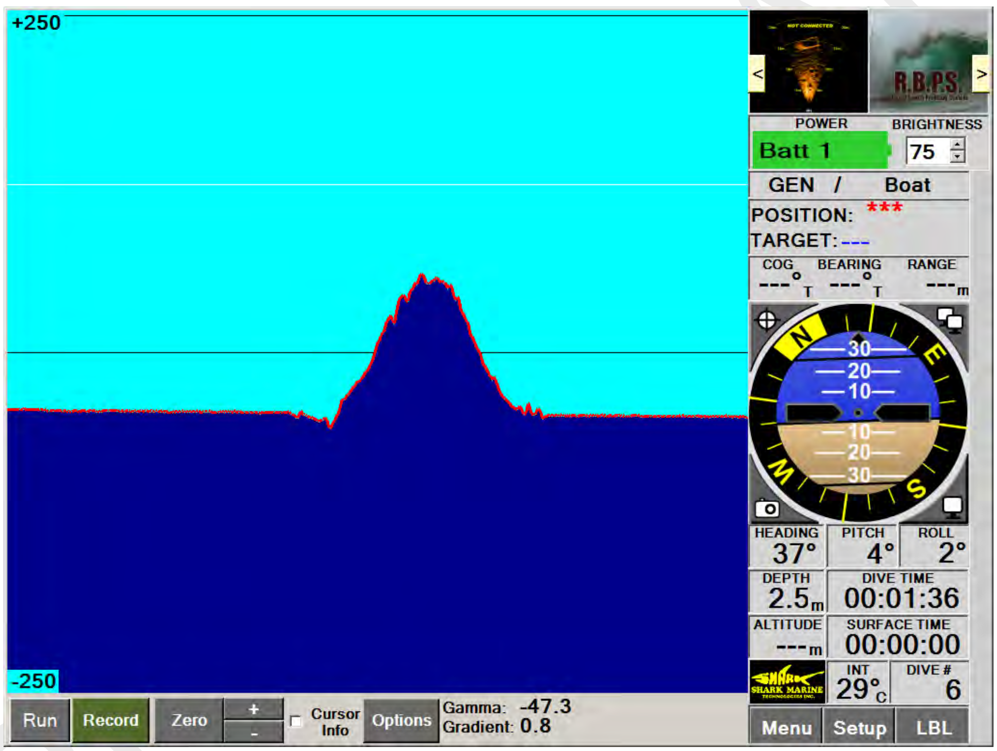
When the pan/tilt functionality is active, a small graphic next to the pan/tilt controls will be visible to indicate the current tilt orientation of the sonar head with respect to the pole. The sonar image will now rotate to the corresponding pan angle to give an indication of the sonar direction with respect to the heading. That is, even though the image rotates, up on the image still reflect the current compass heading.



22. Magnetometer Screen

Note: The Magnetometer is an optional feature to DiveLog. If the system does not have a Magnetometer Probe equipped then the Magnetometer Screen can be turned OFF on the System Setup window, under Active Screens. Details on the hardware for the Magnetometer Probe can be found in a separate manual; the *Magnetometer Probe Manual*.

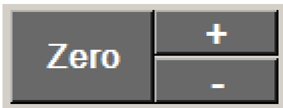
With the Magnetometer Screen as the primary screen, the user can easily view the details of the magnetometer data currently being received or played back. The most commonly adjusted parameters can be set directly from the primary screen controls. Additional parameters and details can be seen and/or adjusted in the "Options" window for the Magnetometer.



22.1. Main Magnetometer Controls

If the magnetometer probe is connected and not currently running, it can be started by pressing the "Run" button in the lower left corner of the display. This button toggles between "Run" and "Hold".

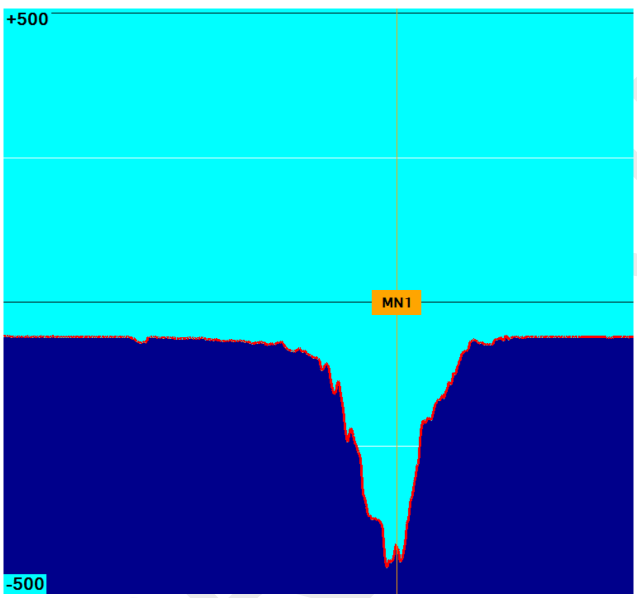
22.2. Graph Scaling and Zeroing



To the right of the “Run” and “Record” buttons are buttons for scaling and zeroing the graph. The “+” button increases the scale on the graph, while the “-“ button decreases the scale on the graph. The current maximum and minimum of the graph are shown in the top left and bottom left of the graph image respectively. The user may want to adjust the scale of the graph if the magnitude of the data climbs beyond the limits of the graph, or alternatively to focus in on a smaller area and see fine changes in the data.

The “Zero” button zeros the display and places the current reading in the center of the screen. Zeroing is required at the start of each line or if the readings creep slowly of the screen.

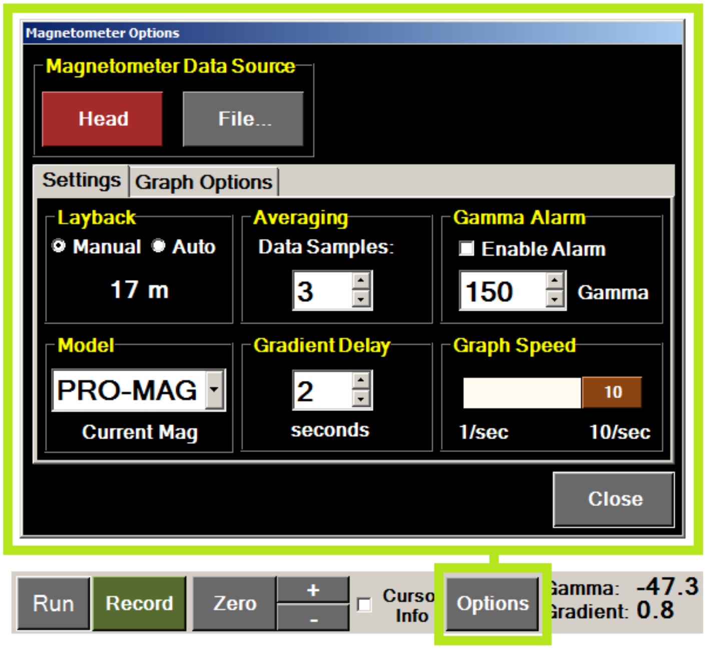
22.3. Targets



A target can be marked on the Magnetometer Screen by clicking the DiveLog target button (on the Navigation View), then clicking the main image on the Magnetometer Screen. The target created will be added to the list of targets for the current project in DiveLog (and will be visible in other Active Screens). Note: you must have a valid position to mark a target.

Right clicking the target will provide various target options. See section *12 Marking and Managing Targets* for more information.

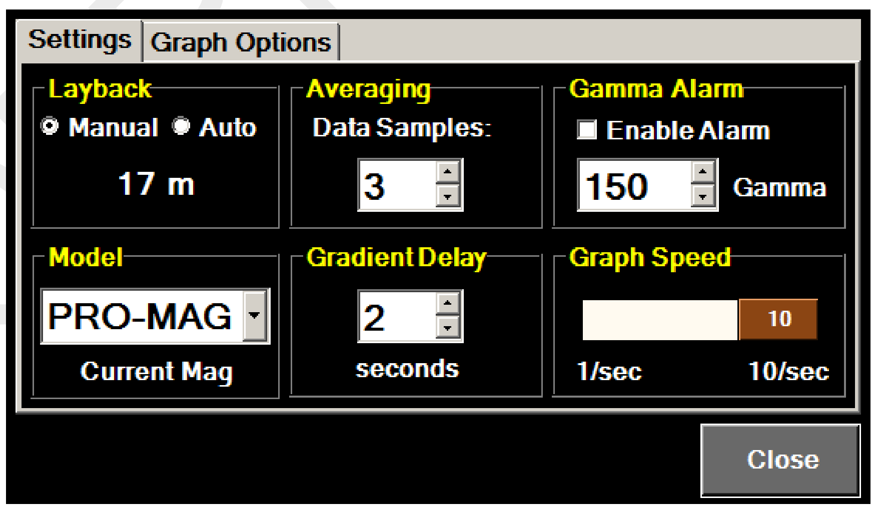
22.4. Magnetometer Options



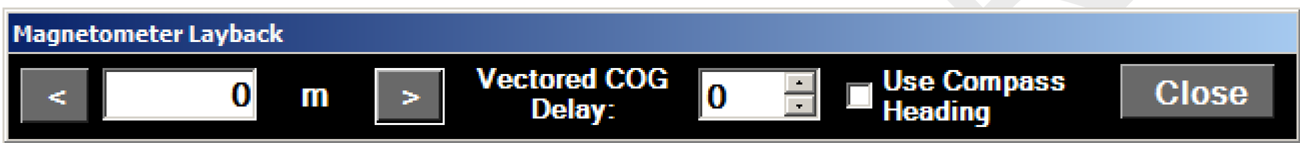
Clicking on the “Options” button on the magnetometer screen brings up the “Magnetometer Options” window. From this window, the data source for the graph can be toggled from “Head” (real-time) to previously recorded data “File...” by clicking on the respective buttons. Clicking the “File…” button automatically opens the window to select a file.

22.4.1. Settings

The Settings tab on the Options window allows the user to change settings that affect the main Magnetometer operation.



Layback: When operating a Magnetometer mounted on the Navigator or ROV, the position of the Magnetometer is the same as the current position in DiveLog, and no layback is needed. For surveys that use towed the Magnetometer in a towed configuration, a layback can be applied for more accurately positioning the magnetic readings. The layback can be entered automatically via a cable payout encoder (see section *15.11 Cable Payout Encoder)* or entered manually by clicking on the layback and entering the value in the window show below. The Magnetometer Layback window also allows the user to choose to use the current compass value for calculating the towfish position or use a vectored COG (course over ground) delay. The vectored COG uses a heading derived from two different GPS positions in time; the current position and a position that is a variable amount of time in the past. A vectored COG delay of zero simply uses the current course over ground value from the GPS source in the calculation for the towfish position (this is the default).



Averaging: The number of magnetometer data samples used to generate a point can be varied between 1 and 20. Averaging can reduce the small variances in the readings and have the effect making the data appear smoother.

Gamma Alarm: An alarm can be set that will alert the operator when the detected gamma readings exceed a given preset value. Checking the checkbox labelled “Enable Alarm” will activate the alarm.

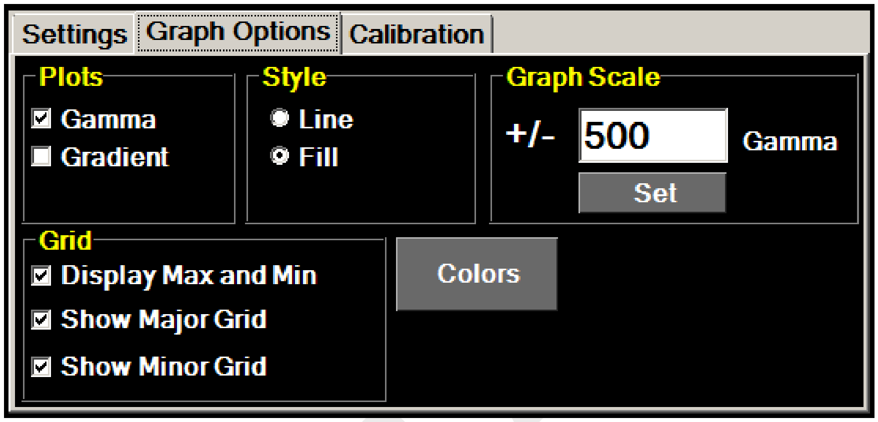
Model: Two magnetometer models exist; the SMD-N300 and the SDM-4000. The correct model needs to be selected to ensure proper operation.

Gradient Delay: The gradient can be calculated based on a variable time delay in seconds.

Graph Speed: The graph speed can be adjusted to as fast as 10 points per second or as slow as 1 point per second. Note that this does not reflect the rate at which the sensor acquires data.

22.4.2. *Graph Options*

The data collected from the Magnetometer can be plotted in a number of different visual styles. The Graph Options tab on the Options window allows the user to adjust how the graph displays.

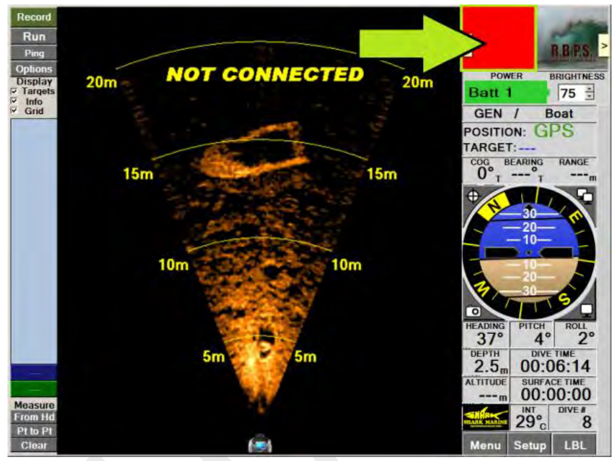


Plots:	The scrolling graph on the main image can plot the gamma value, the gradient or both simultaneously.
Style:	The data on the graph can be shown as a thick line with a contrasting underlay or a fill style graph. Note that only one plot type can be shown if fill style is chosen.
Graph Scale:	Although the scale of the graph can be readily adjusted in increments on the main display, a precise value can be entered here.
Grid:	Checking "Display Max and Min" will show the numerical extremes of the graph scale on the graph image. Checking "Show Major Grid" will show the reference line for the maximum, minimum and centre value for the graph. Checking "Show Minor Grid" will show reference lines on the graph that are halfway between the centre line and the maximum and the centre line and the minimum.
Colors:	The Colors button will bring up a dialog box that allows the user to change the colors of the various elements on the graph image.

22.5. Alarm

As described in the Settings section of the Options window, an alarm can be set that will alert the operator when the detected gamma readings exceed a given pre-set value.

When the magnetometer screen is in secondary mode, the entire graph will flash red to indicate that the current magnetic field has reached or exceeded the alarm value. When the magnetometer is on the primary screen, the word “ALARM” will flash in red at the top center of the graph. When the current gamma readings drop below the alarm threshold, the alert will subside.



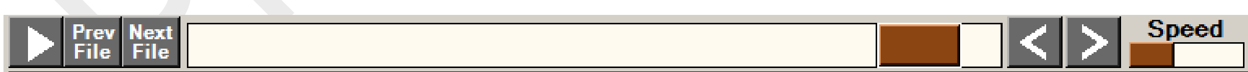
22.6. Recording

To record a file, simply click the record button during real-time operation. A file name with the current date and time, project code and operator ID will automatically be created and recording of the magnetometer data will start immediately. The recorded data can be accessed at a later time for playback and review. Every time the record button is clicked off and then on again, a new file is started.

22.7. Playback

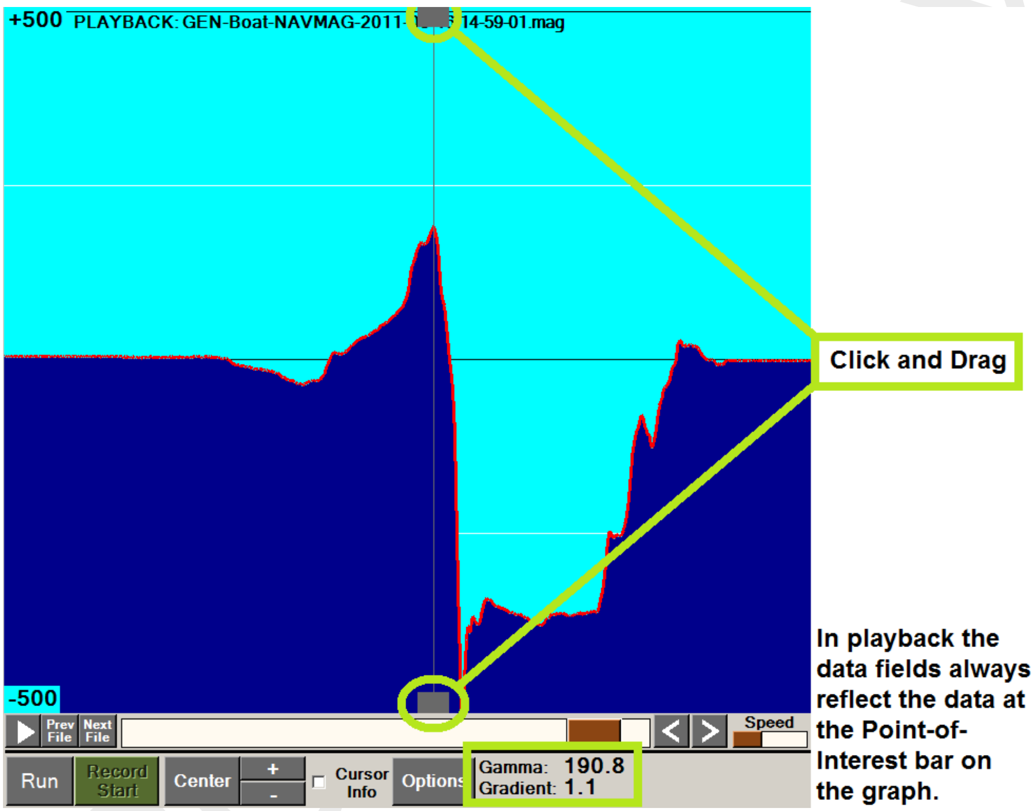
A file recorded can be opened for playback by clicking the File button on the Magnetometer Options window and selecting a file from the open file window.

In playback, additional controls will be added to the bottom of the main image to control play position, speed, and for quickly advancing to the next file in a project.

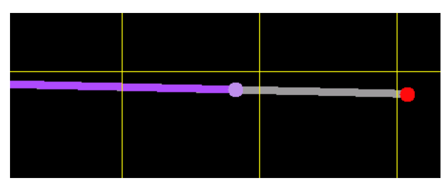


22.7.1. *Point-of-Interest Bar*

For playback, a vertical bar is displayed, which can be dragged horizontally along the width of the graph. The position of this bar defines the Point-of-Interest or POI. In playback the data fields for the magnetometer will reflect the data on the graph at the POI. This differs from real time operation in that the data fields always reflect the most recent data when collecting data.



22.8. Magnetometer Track



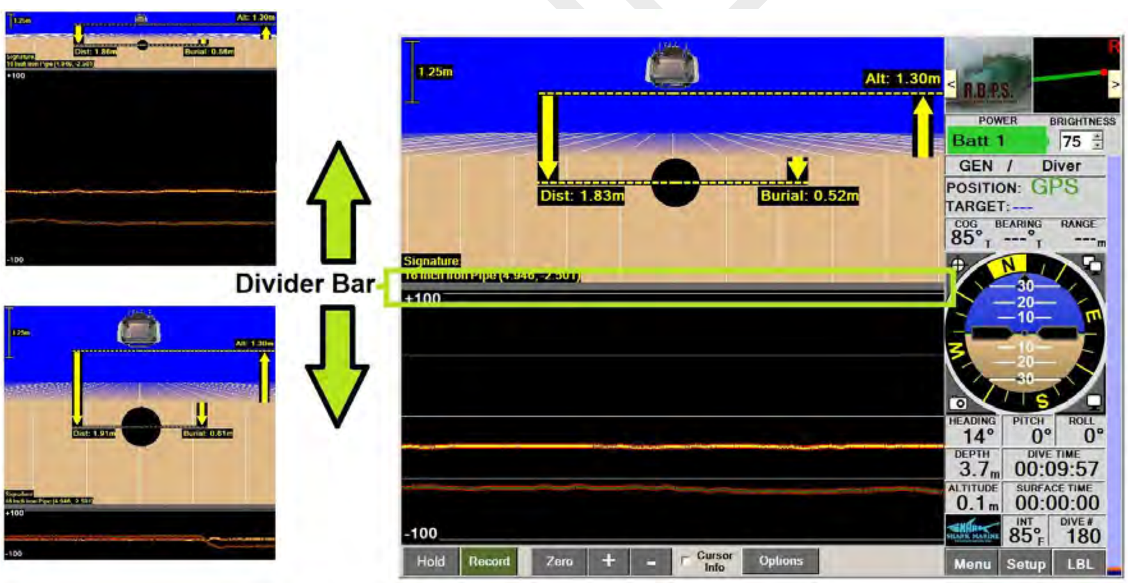
When a Magnetometer file is recorded, a corresponding track file is also recorded. The path of the Magnetometer will be displayed as a purple track on the Track Screen (See image of a Magnetometer track with layback, right). Past recorded Magnetometer track files in the project will be displayed on the Track Screen. See section *20 Track Screen* for more information.

23. Gradiometer Screen

Note: The Gradiometer is an optional feature to DiveLog. If the system is not equipped with a Gradiometer, then the Gradiometer Screen can be turned OFF on the System Setup window, under Active Screens. Details of the hardware for the Gradiometer can be found in the "*Gradiometer Hardware Manual*".

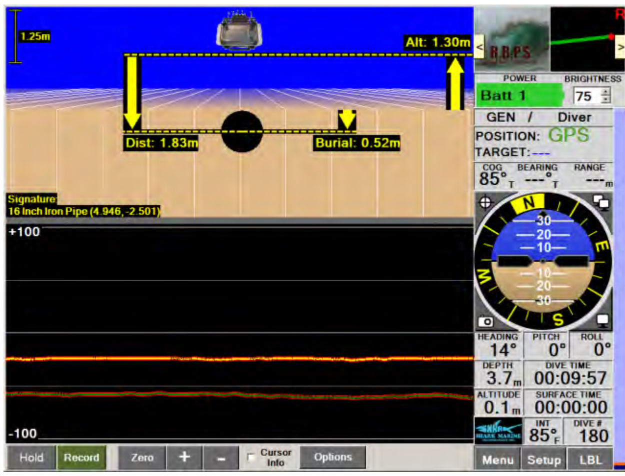
With the Gradiometer Screen as the primary screen, the user can easily view the Gradiometer data currently being received or played back. The most commonly adjusted parameters can be set directly from the primary screen controls. Additional parameters and details can be seen and/or adjusted in the "Options" window for the Gradiometer.

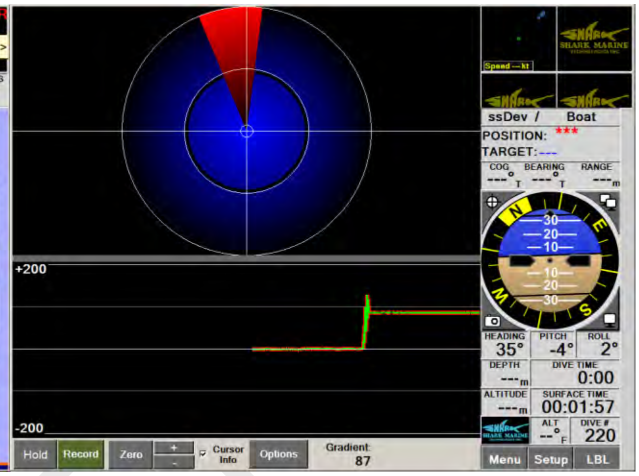
The Gradiometer Screen presents the data in two ways. The upper portion of the main image either shows an illustration representing the relative position of the Gradiometer, the pipe/cable and the seabed or, if in searching mode, a circular graphic indicating the direction of the strongest gradient readings. The lower portion of the image displays a scrolling graph showing of the actual data from both the vertical gradient and the crosstrack data. The percentage of the screen that each portion occupies can be adjusted by dragging the divider bar up and down as shown in the image below.



23.1. Operation Modes

The Gradiometer Screen has two types of operation modes. The Pipe/Cable tracking mode facilitates the tracking of a buried pipe or cable on the seabed, while the Searching mode presents the data in a more general fashion that indicates the direction of current magnetic gradient. This mode can be used for searching for ferrous targets. The images below illustrate the different graphical representations of the data. In both cases the scrolling graph is still displayed. This image on the left is typical of the Pipe/Cable Tracking Mode while the image on the left is typical of the Searching Mode. The operation mode can be toggled on the Options window for the Gradiometer.





23.2. Main Gradiometer Controls

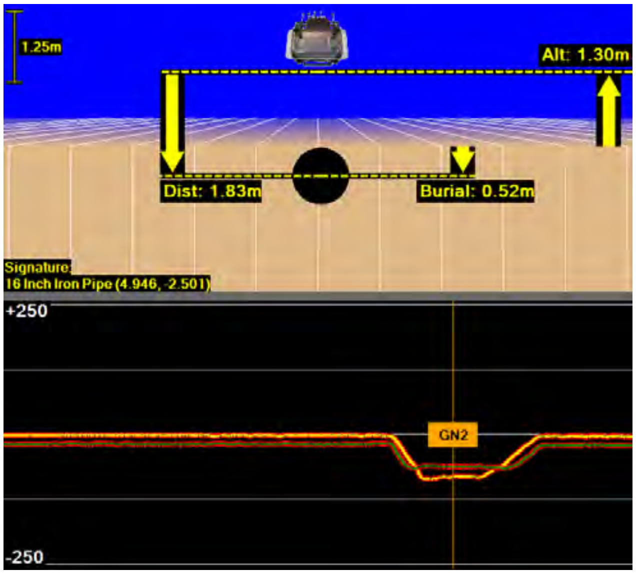
If the Gradiometer is connected and not currently running, it can be started by pressing the “Run” button in the lower left corner of the display. This button toggles between “Run” and “Hold”.

23.3. Graph Scaling and Zeroing

To the right of the “Run” and “Record” buttons are buttons for scaling and zeroing the graph. The “+” button increases the scale on the graph, while the “-“ button decreases the scale on the graph. The current maximum and minimum values of the graph are shown in the top left and bottom left of the graph image respectively. The user may want to adjust the scale of the graph if the magnitude of the data climbs beyond the limits of the graph, or alternatively to focus in on a smaller area and see fine changes in the data.

The “Zero” button zeros the display and places the current reading in the center of the screen. Zeroing is required for cancelling out the ambient magnetic fields and focusing solely on the anomaly created by the pipe/cable. Zeroing of the readings should be done in the area of the pipe or cable to be tracked, yet far enough from the pipe/cable that it has no effect on the surrounding field.

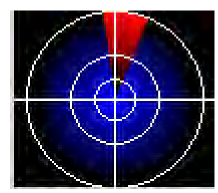
23.4. Targets



A target can be marked on the on the Gradiometer Screen by clicking the DiveLog target button, then clicking the main image on the Gradiometer Screen. The target created will be added to the list of targets for the current project in DiveLog (and will be displayed in other Active Screens). If Gradiometer data is being recorded, the target data will also be embedded in the Gradiometer data file.

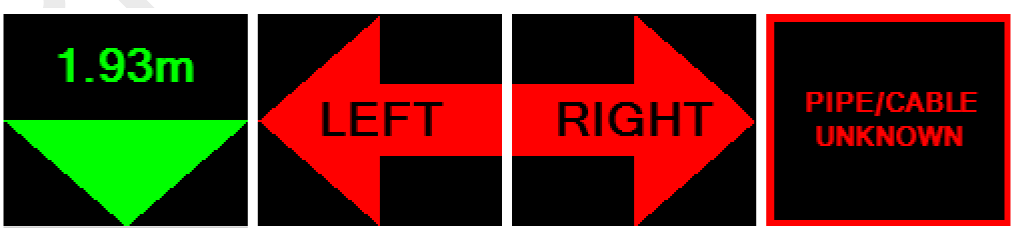
If the upper portion of the image is clicked, the position of the target will be at the data corresponding to that image. In real-time this will be the current position in DiveLog, while in playback, the position will correspond to that of the Point of Interest bar (more on the Point of Interest bar below). If the graph is clicked for a target, the position of the target will be the position that corresponds to that point on the graph.

23.5. Secondary Screen

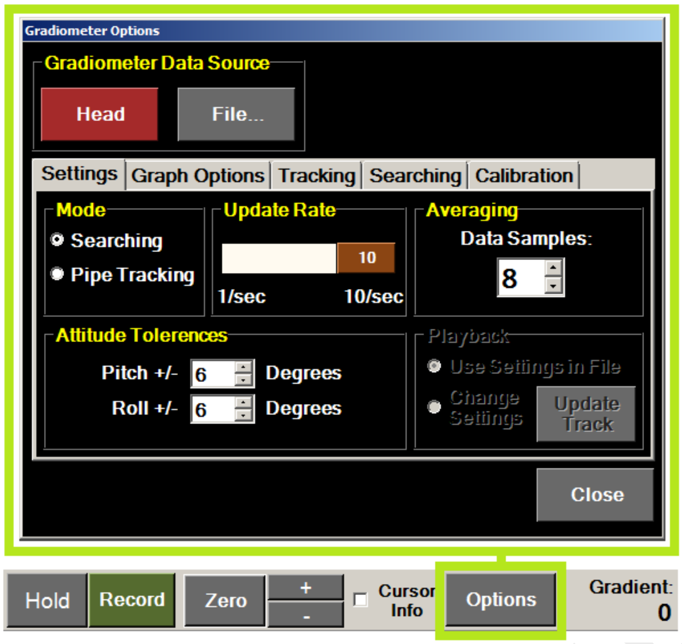


When toggled to a secondary screen the gradiometer displays a simplified display. For the Searching mode the secondary screen will show only the searching graphic for quick reference.

During pipe or cable tracking operations, the secondary screen will simply show the vertical distance to the pipe/cable if the gradiometer is above it, otherwise it will indicate that the operator must move left or right to get back above the pipe/cable. If the operator has gone too far to detect the pipe/cable, then “PIPE/CABLE UNKNOWN” will be shown in the secondary screen. Alternatively, if a valid signature is not loaded, the graph will be displayed in the secondary screen.



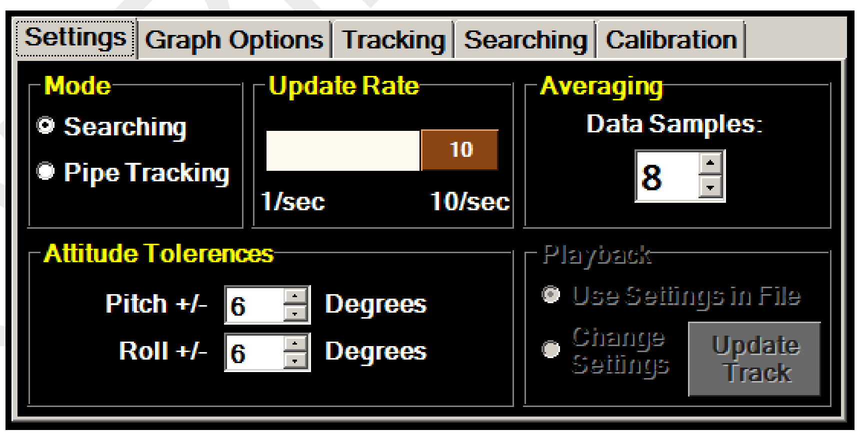
23.6. Gradiometer Options



To bring up the “Options” menu click on the button labelled “Options” at the bottom of the Gradiometer screen. From this window, the data can be toggled from real-time (Head) to previously recorded data (File…) by clicking on the respective buttons. Clicking the “File…” button automatically opens the window to select a file.

23.6.1. Settings

The Settings tab on the Options window allows the user to change settings that affect the main Gradiometer operation.



Mode: “Searching” and “Pipe Tracking” are the two modes of operation for the Gradiometer.

Update Rate: The update rated can be adjusted to as fast as 10 points per second or as slow as 1 point per second.

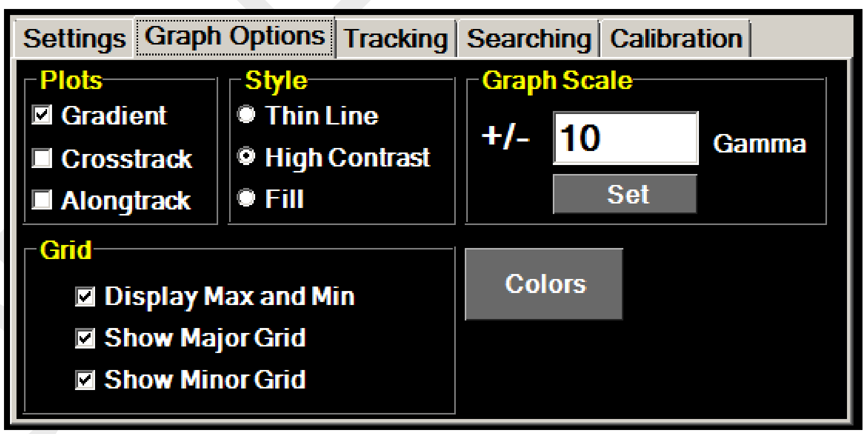
Averaging: The number of magnetometer data samples used to generate a point can be varied between 1 and 20. Averaging can reduce the small variances in the readings and have the effect making the data appear smoother.

Attitude Tolerances: While operating the Gradiometer, it is important that it remain as level as possible in order to achieve greater reliability of the data. Data collected outside these pitch and roll tolerances will be considered invalid.

Playback: The choices in the playback box will activate when playing back a file. The default choice, “Use Settings in File”, will play back the file as it was recorded. If “Change Settings” is selected, then the user will be able to adjust different parameters and see their effect on the data. When “Change Settings” is selected, the user can change the attitude tolerances, signature, crosstrack parameters and range factor for previously recorded data. The update track button will update the displayed track to reflect the current changes.

23.6.2. Graph Options

The data collected from the Gradiometer can be plotted with a number of different visual styles. The Graph Options tab on the Options window allows the user to adjust how the graph displays.



Plots: The scrolling graph on the main image can plot the crosstrack, the alongtrack , the gradient or all three simultaneously.

Style: The data on the graph can be shown as a precise thin line, a thicker line with a contrasting underlay or a fill style graph. Note that only one plot type can be shown if fill style is chosen.

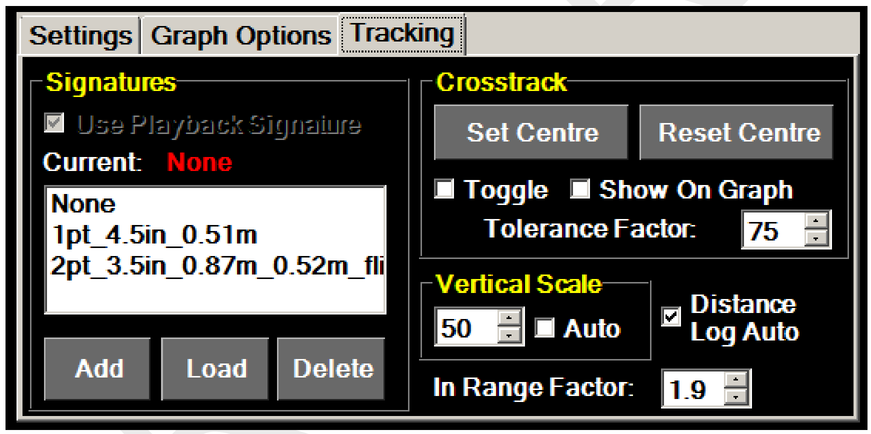
Graph Scale: Although the scale of the graph can be readily adjusted in increments on the main display, a precise value can be entered here.

Grid: Checking “Display Max and Min” will show the range values of the graph.
Checking “Show Major Grid” will show lines for the maximum, minimum and centre of the graph.
Checking “Show Minor Grid” will show additional lines on the graph halfway between the major lines.

Colors: The Colors button will bring up a dialog box that allows the user to change the colors of the various elements on the graph image.

23.6.3. Tracking

Parameters specific to tracking a pipe/cable, such as the signature used and various sensitivities and tolerances, can be set from the Tracking tab of the Gradiometer Options window.



Signatures: The Signatures box manages the magnetic signatures for each specific target. The currently loaded signature will be displayed here (as well as on the main screen). Here, the currently loaded signature will be red if the signature is incomplete or invalid; otherwise it will be green indicating that the currently loaded signature is complete and valid. Adding, loading and deleting signatures are detailed in a subsequent section.

Crosstrack: Within the Crosstrack box are controls for setting/resetting the centre. Setting the centre should be done as the survey is about to begin and the operator is certain that the gradiometer is centred over the pipe/cable.

Depending on the environment and orientation of the pipe it may be necessary to toggle the left and right directions. The directions can quickly be verified by positioning the gradiometer over the centre of the pipe/cable and slowly moving left or right to confirm the directions are correct. If they are opposite, then check the toggle box in the Crosstrack box. If “Show On Graph” is checked a dashed horizontal line will indicate where left and right is currently defined for the crosstrack.

The crosstrack tolerance factor relates to how sensitive the gradiometer is with respect to considering itself to be over top of the pipe/cable. The lower the tolerance factor the more precisely the gradiometer must be positioned over the pipe/cable for valid readings. The readings will typically be more reliable and accurate with a lower tolerance factor. A higher tolerance factor will effectively widen the horizontal range over top of the pipe/cable that will be considered acceptable for valid readings; however the reliability and accuracy may decrease in some of the readings with a higher crosstrack tolerance factor. That is, you may not be exactly centred over the pipe/cable record a distance reading that will be considered valid.

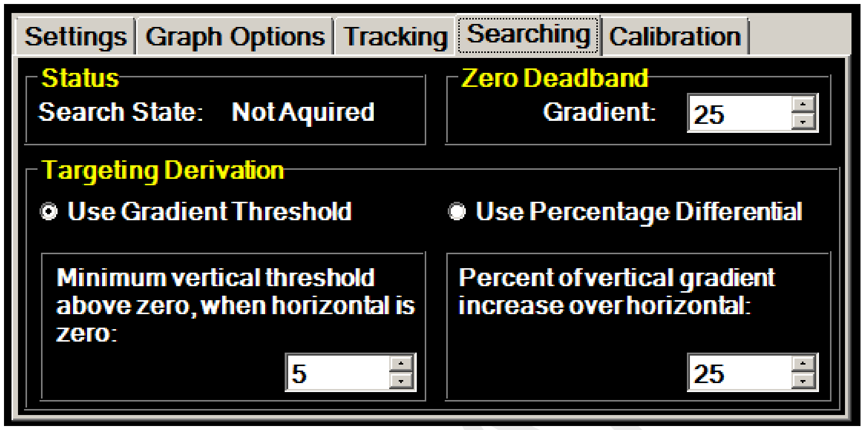
Vertical Scale: This numerical up/down box allows the user to change the vertical scale on the upper image. Checking "Auto" lets the software adjust the vertical to keep the pipe visible on the main image.

Distance Log Auto: When "Distance Log Auto" is checked the software will continuously perform calculations and logs the distance to the present. If this box is not check, the software will rely on the user to indicate when a distance calculation should be performed. Clicking the main image will manually perform a distance calculation, but only if the parameters are correct. A message on the image will inform the user that the image must be clicked to perform this action.

In Range Factor: The "In Range Factor" relates to the minimum gradient required for the gradiometer to consider the pipe/cable in range. The lower this value the farther out the pipe/cable can be detected, the reliability at the range extremes is less certain. The higher this value, the shorter the effective range of the gradiometer, however the reliability at the range extremes is greater.

23.6.4. Searching

Parameters specific to searching, such as the zero deadband and algorithm thresholds, can be set from the Search tab of the Gradiometer Options window.



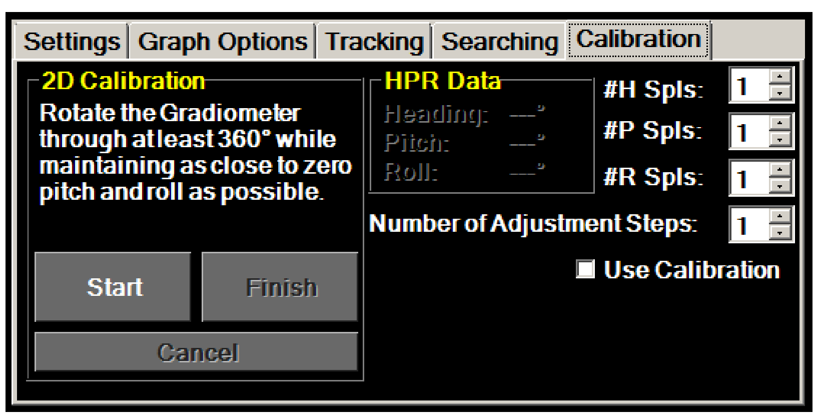
Status: When searching for a ferrous target the status of the search is dictated by the current gradient and its direction. The search state can either be “Not Acquired”, “Acquired” or “Over Ferrous”.

Zero Deadband: This value defines the minimum gradient value for a direction to the strongest magnetic field to be “Acquired”

Targeting Derivation: The method used to determine if the Gradiometer is over a ferrous object or target can be changed by choosing one of two options:

- The Gradient Threshold defines a minimum absolute vertical gradient that must be exceeded over the horizontal gradient to be considered over the target.
- The Percentage Differential defines a minimum percentage that the vertical gradient must be greater than the horizontal to be considered over the target.

23.6.5. Calibration



In some situations and applications it may be advantageous to perform a calibration on the Gradiometer (which is effectively a simultaneous calibration of the two magnetometers comprising the Gradiometer). A calibration is performed by rotating the Gradiometer a full 360 degrees in the horizontal plane. Offsets will be accumulated for each degree increment and applied to the readings thereafter when oriented in the corresponding direction. A calibration is best done in the area of interest, but away from any ferrous material.

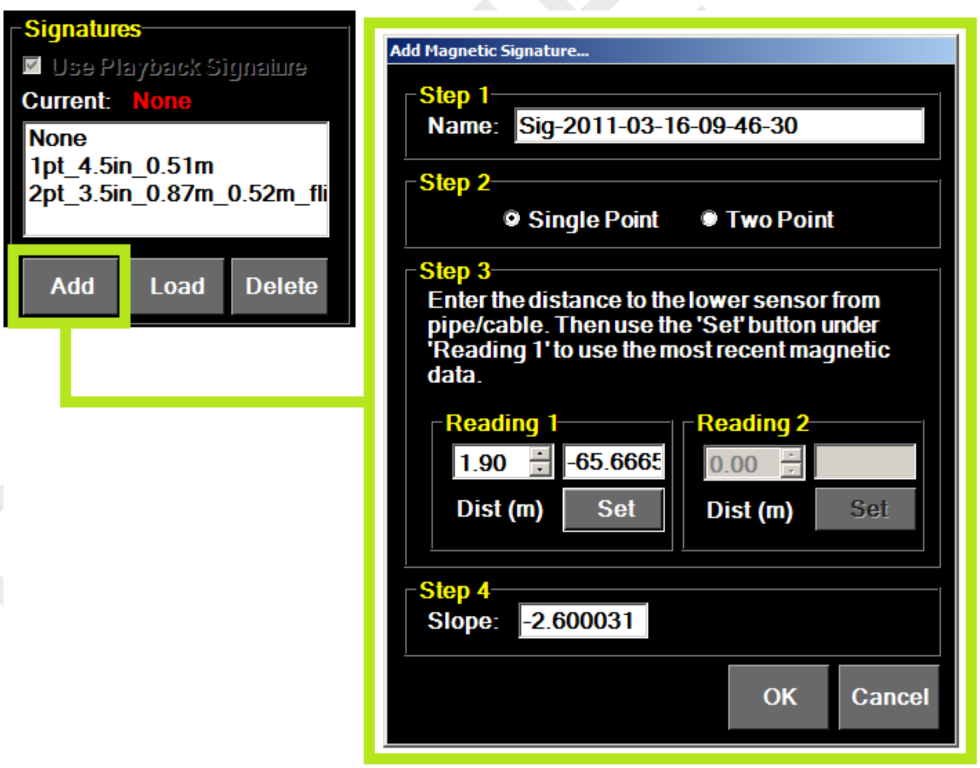
When performing a calibration it is critically important to keep the Gradiometer from varying in pitch or roll. Moreover, when using a calibration it will also be important to keep the Gradiometer as level as possible and to use steady, smooth motions.

23.7. Signatures

The magnetic signatures used by the Gradiometer in Pipe/Cable Tracking mode are mathematical parameters based on magnetic field readings from the pipe/cable. The signatures are also specific to one type of pipe or cable. Single and two point signatures can be made. An accurate signature is required for proper pipe/cable tracking.

23.7.1. Adding

With the gradiometer running and zeroed, open the Gradiometer Options window and select the Tracking tab. In the signatures group box click the Add button to bring up the Add Magnetic Signature window.



Step One: Choose a name for the signature you are about to create. The name field will be auto populated with a name that contains the current data and time. This can be changed to something more descriptive if desired.

Step Two: A single or two point signature needs to be selected. A single point signature requires only on reading at a **known vertical distance** directly above the pipe/cable. A two point signature requires two readings each at **different known vertical distances** directly above the pipe/cable to be tracked.

A single point signature is easier to set and can work well when large variations in burial distance are not expected. Two point signatures require additional setup but will provide greater accuracy over larger burial depth ranges.

Step Three: The data to create the signature needs to be input. If creating a single point signature, move the Gradiometer into position, enter the distance and click set in the “Reading 1” box. If creating a two point signature the Reading 2 box will be activated after the first reading. The gradiometer then must be repositioned to the second point, the distance entered and the set button clicked.

Step Four: If step three was completed successfully, the slope field will automatically be populated and no user input is required in this step. Click the OK button to complete and create the signature.

23.7.2. Loading

Once the signature is created it will automatically be loaded and added to list of selectable signatures on the “Tracking tab” of the Gradiometer “Options window”. Should a different signature need to be loaded, double clicking the desired signature or selecting it from the list and clicking Load will set the current signature to the one selected. If playing back a file, checking the “Use Playback Signature” checkbox will use the signature that was used to create the file.

23.7.3. Deleting

To delete a signature, select it from the list of signature and click the delete button.

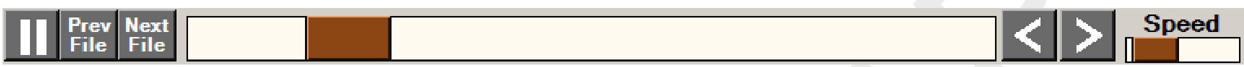
23.8. Recording

To record a file, simply click the record button on the main control panel during real-time operation. A file name with the current date and time, project code and operator ID will automatically be created and recording of the Gradiometer data will start immediately. The recorded data can be accessed at a later time for playback and review. Every time the record button is clicked off and then on again, a new file is started.

23.9. Playback

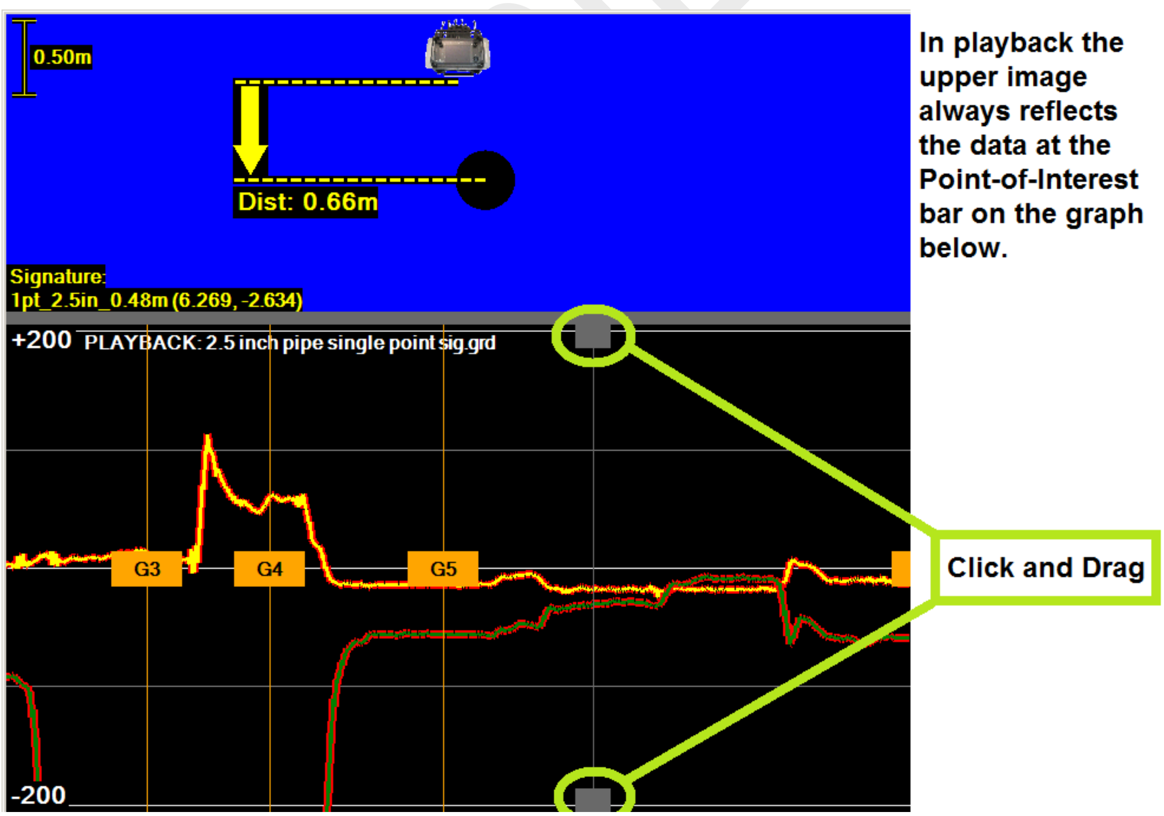
A recorded file can be opened for playback by clicking the “File” button on the Gradiometer “Options” window and selecting a file from the “open file” window.

In playback, additional controls will be added to the bottom of the main image to control play position, speed, and for quickly advancing to the next file in a project.



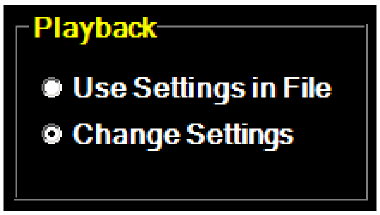
23.9.1. Point-of-Interest Bar

In playback, a bar is displayed that can be dragged horizontally along the width of the graph. The position of this bar defines the Point-of-Interest or POI. In playback, the upper image depicting the relative positions will reflect the data on the graph at the POI. This differs from real time operation in that the upper image always reflects the most recent data when collecting data.



23.9.2. *Post Processing*

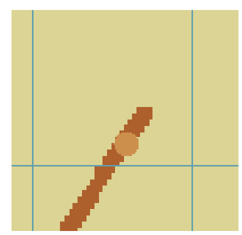
When a file is opened for playback, DiveLog will automatically load the signature that was used to create the file as well as the setting that were used to create the file. If the signature that is in the file does not exist in the current list the user will be prompted to add it.



In some cases it may be useful to view the data with parameters that are different than those saved in the file. With a file currently open, selecting “Change Settings” in the Playback group box on the Options window will allow the user to change the settings and even the signature used. Any changes will have an immediate effect on the data set. If any parameters are changed, the user will be prompted to resave the file with a new name when the file is closed.

When “Change Settings” is selected, the user can change the attitude tolerances, signature, crosstrack parameters and range factor for previously recorded data. For instance, the user may want to decrease the attitude tolerance and crosstrack tolerance factor to increase the reliability of the dataset.

23.1. Gradiometer Track



When a Gradiometer file is recorded, a corresponding track file is also recorded. The path of the Gradiometer will be displayed as a brown track on the Track Screen (See image of a Gradiometer track during playback, right). Past recorded Gradiometer track files in the project will be displayed on the Track Screen. See section *20 Track* Screen for more information.

24. NavCam Screen

Note: The NavCam is an optional feature to DiveLog, which displays and records video. If the system does not have a camera equipped then the NavCam Screen can be turned OFF on the System Setup window, under Active Screens.

With the NavCam Screen as the primary screen, the operator can readily view the video captured by the camera. The most commonly used video controls can be accessed from the primary screen. Additional parameters and details can be seen and/or adjusted on the "Video Options" window. The NavCam Screen supports different camera models and the controls and interface may be slightly different between each camera model depending on the camera capabilities.

On the Navigator, operation of the real-time video is halted when toggled to a secondary screen. The video will resume its last state when toggled back to the Primary Screen.

24.1. Main NavCam Controls

Most video inputs to DiveLog support the capture of both video and snapshots simultaneously. Some camera models also support auto and manual focus, which can be toggled using the "Auto" checkbox. When in manual focus mode, the user can focus the camera by clicking and holding down "F" (Far) or "N" (Near) button until the desired focus level is achieved.

24.1.1. Run

If a camera is connected and selected on the Video Options window as the current video source and is not currently running, it can be started by pressing the “Run” button in the lower left corner of the display. This button toggles between “Run” and “Hold”.

24.1.2. Record

Video files can be recorded by clicking the “Record” button. When recording the button will turn red and the text will change to “Stop Recording”, which now will stop the recording if clicked. Each time recording is started, a new file is created. Depending on the camera model and system configuration, recorded video files may be recorded as “.wmv” files or “.avi” files. These files are stored in the “NavCam” folder in the current project directory.

After a video is recorded, a dialog will come up with options for saving the video and linking it to a target. See *24.2.1 Linking Video or Snapshot with a Target* below for more information.

24.1.3. Snapshot

Still images are captured from the current camera by clicking the Snapshot button. When an image is captured, the preview video will pause for a moment while the still image is captured. The snapshot will be saved in “NavCam” folder in the current project directory.

After the snapshot is taken, the operator will be prompted with options for saving and linking to a target. See *24.2.1 Linking Video or Snapshot with a Target* below for more information.

For snapshots taken during the recording of a video, a prompt for saving and linking the snapshots will appear when the video recording stops. At this time, the user will be prompted to save the video and all the snapshots or discard them all.

24.2. Targets

24.2.1. Linking Video or Snapshot with a Target

When a snapshot or video recording is complete the user will be prompted with three options:

- Save the video/snapshot with no target association.
- Associate the video/snapshot file with a target.
- Cancel the saving of the recorded file (video/snapshot will be discarded).

See images right.

For the middle option “Link with Target”, any target in DiveLog can be selected via the dropdown list, as well as “New Target”. If “New Target” is selected, a new target will be set at the current position and the snapshot/video will be linked to it. As when normally setting a target, a quick pick list will be displayed if a quick pick list is set to be used.

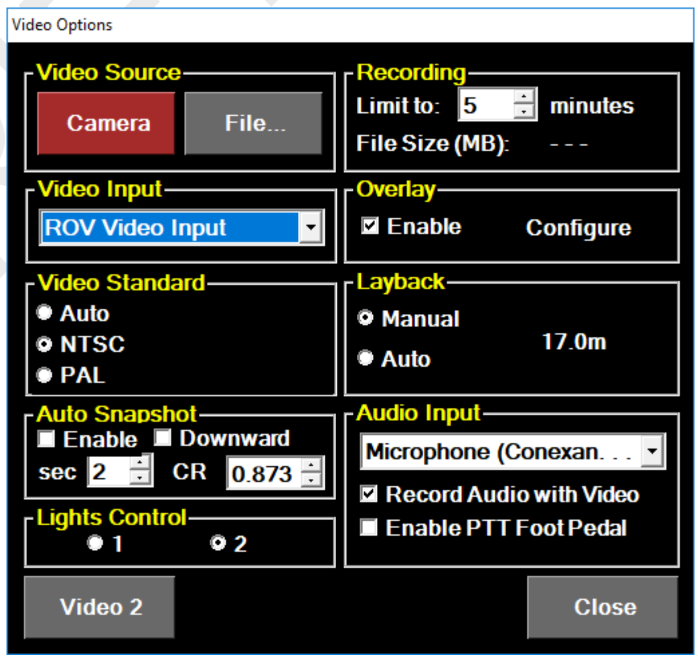
If a target is nearby, the default selection for linking will be the closest target. If no target is close by, the default selection for linking will be “New Target”. For more information on target associated files, see section *12.6.3 Target Associated Files*.

24.2.2. Setting a Target

To set a target using the NavCam screen, turn on Target Marking Mode (by clicking the target icon on the Navigation View, in the top left of the graphical heading pitch roll display), then click anywhere on the video image. This will create a target at the current GPS position. Additional videos or snapshots can then be linked to the target using the method described above in section *24.2.1 Linking Video or Snapshot with a Target*.

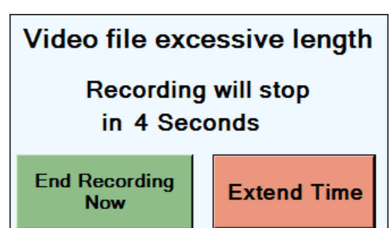
24.3. Video Options

The Options button on the NavCam Screen will bring up the “Video Options” window. From this window, the data source for the video can be toggled from a camera (real-time video input) to a file by clicking on the respective buttons. Clicking the “File” button automatically opens the Select File window. The options window also allows the user to adjust the video resolution, configure the camera for automatic snapshot capture, configure the video overlay, adjust the layback parameters and setup the audio input. Note that the options window may be slightly different depending on the camera model used and the features available on that camera.



24.3.1. File Size

Since video files can grow in size quickly, the current file size the operator is currently recording will be displayed with the current video details. Moreover, an adjustable limit to the length of time a file can be recorded is also adjustable. When the record time limit expires the user will be prompted to extend



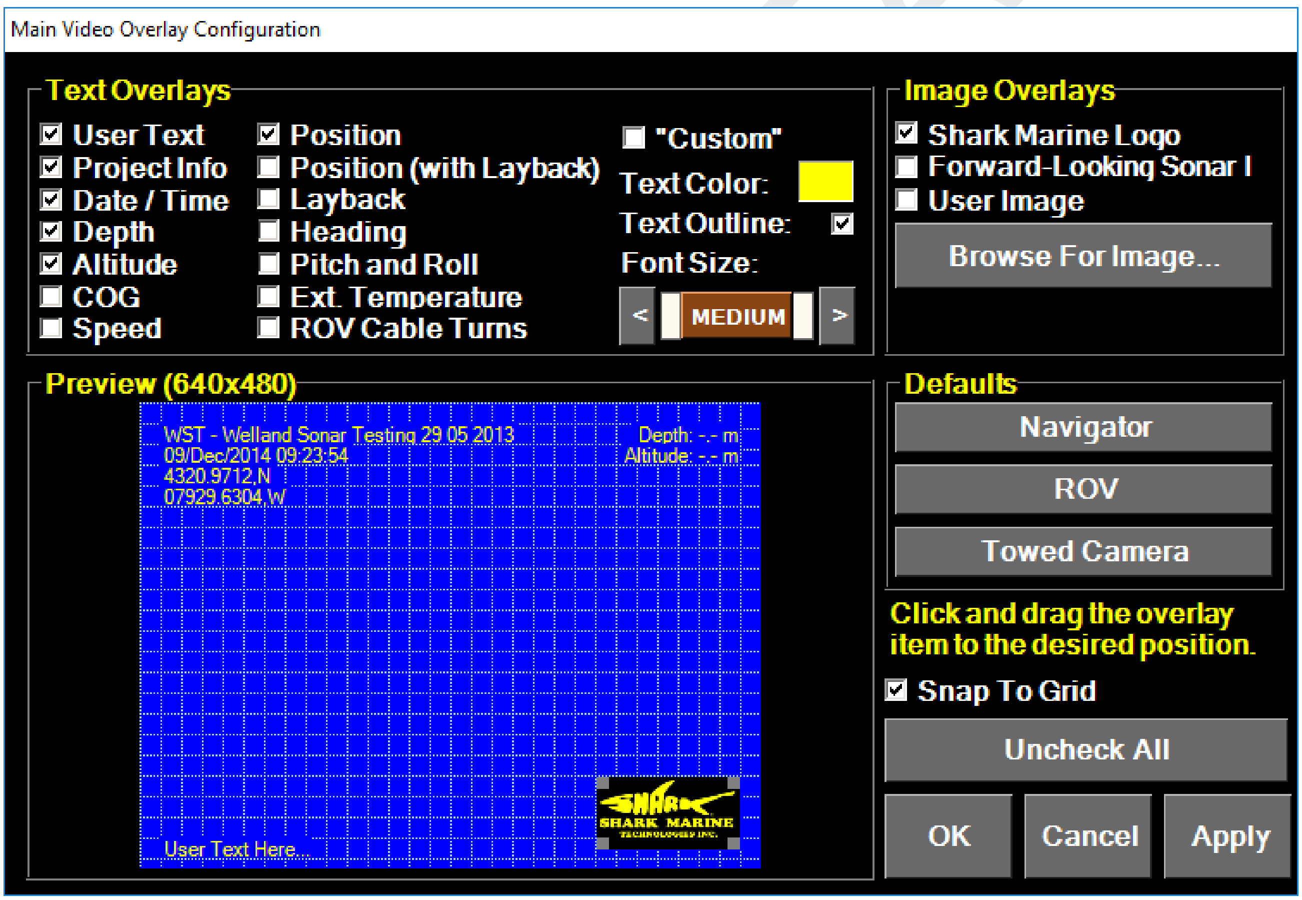
the time, if the user takes no action within 20 seconds the recording will be stopped automatically.

24.3.2. Video Resolution

The video resolution choices vary by camera model and allow the user the change the resolution for video capture and recording. In the case of analog video sources (i.e. NTSC or PAL) inputs, the resolution choices will be replaced with the option to select the video standard for the input.

24.3.3. Overlay

Video overlay can be enabled or disabled entirely by using the Enable checkbox in the Overlay group box on the Video Options window. To configure the video overlay, click the “Configure” text next to the checkbox to open the Video Overlay Configuration window.



Text Overlays: Various text fields to be overlaid onto the video can be selected using the checkboxes. The color, option for a contrasting outline and the size of the text can also be configured. These options apply to all the text overlays at once. A customizable static text can be applied to the video by checking the “Custom” box. This can be useful in labeling video streams if more than one video device is being used.

Image Overlays: Different overlay options exist to put images onto the video. The real-time Forward-Looking Sonar data can be embedded into the video and placed and sized to the user’s preference. If no sonar data is available, no overlay image will appear. Additionally, the user can select an image to be put into the video. Image overlay is only supported when DiveLog is running in PC Mode. See section *1.4 DiveLog Run Mode* for further information on the different run modes.

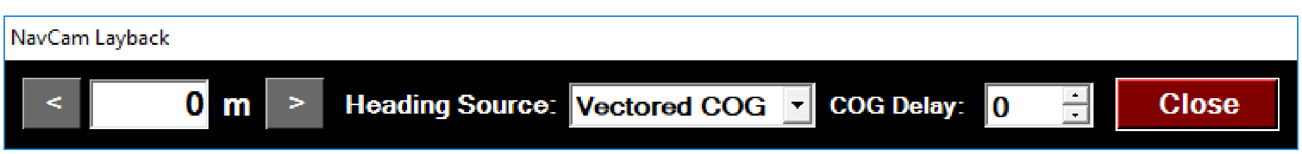
Preview: The preview window allows the user to position the overlay items simply by clicking and dragging them to their desired position within the preview frame. Images can also be resized by clicking one of the four anchor points in the corners and dragging the image larger or smaller. A snap to grid option also exist to make aligning the overlay items easier.

Defaults: Default overlay configurations for common setups can be quickly configured by clicking one of the default buttons.

Once the overlay setup is complete and the OK or Apply button is clicked, the overlay configuration is saved so the next time DiveLog is run, the overlay will automatically be loaded in the same way.

24.3.4. Layback

When operating a camera mounted on the Navigator or ROV, the position of the camera is the same as the current position in DiveLog, and no layback is needed. For surveys that use towed camera systems, a layback can be applied for more accurate geodetic positioning. The layback can be entered automatically via a cable payout encoder (see section *15.11 Cable Payout Encoder*) or entered manually by clicking on the layback and entering the value in the window show below. The NavCam Layback window also allows gives the user the choice to use the current boat heading value for calculating the towfish position or use a vectored COG (course over ground) delay. The vectored COG uses a heading derived from two different GPS positions in time; the current position and a position that is a variable amount of time in the past. A vectored COG delay of zero simply uses the current course over ground value from the GPS source in the calculation for the towfish position (this is the default).



24.3.5. *Video Inputs*

In most cases there will be only one source for video input. In the case where multiple cameras or real-time video sources are available, the current inputs can be configured. Video Input 1 corresponds to the video that is displayed in the main NavCam display while Video Input 2 can be opened in a separate window by clicking the “Video 2” button on the Video Options window. The display window for Video 2 can be adjusted in size and position on the screen. When using two video inputs, the input 1 and input 2 can be swapped from the main screen by clicking the Swap Video button that will be available on the main screen. When this is done, the video that was in the “Video 2” (or aux video) window will now be shown in the main NavCam display. Conversely what was shown in the main NavCam display will now be displayed in the “Video 2” (or aux video).

24.3.6. *Audio Input*

An audio input can be configured to be recorded with the video. For topside operations such as ROV piloting or towed camera surveys the audio input source can be selected using the pull-down menu. The option for recording audio with the video can be enabled/disabled using the checkbox. When recording audio with the video, the “Push to Talk” button on the main NavCam screen can be pressed to record sound. Additionally, a USB “Push to Talk” foot pedal can be configured for the same purpose.

24.3.7. *Auto Snapshots*

Depending on the camera model and system configuration, the option for automatic snapshot capturing at a specific interval may be available. To enable the automatic snapshot functionality, check the “Enable” box in the “Auto Snapshot” group box on the Video Options window. When the auto snapshot functionality is enabled, the record and snapshot buttons will be replaced with a single button for starting and stopping the automatic snapshots. From the “Auto Snapshot” group box on the Video Options window additional parameters such as the interval at which pictures are taken, whether the camera is downward facing, and the coverage ratio (CR) for coverage mapping if downward facing can be adjusted.

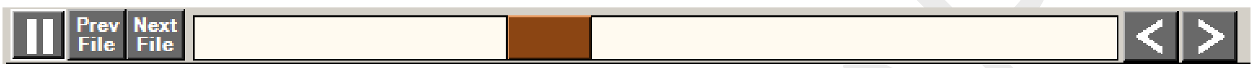
24.3.8. *Lights Control*

In some systems, there maybe a second video/lights control, particularly with 2 independent video sources with 2 independent light controls. In this case, the “Lights Control” group box on the video options form can assign a specific light control to a specific video source. When the light controls are available, a control slider bar will appear with the main video controls.

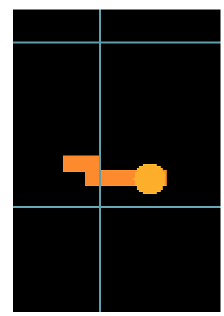
24.4. Playback

A file recorded, video or snapshot can be opened for viewing by clicking the File button on the Video Options window and selecting a file from the open file window.

In playback, additional controls will be added to the bottom of the NavCam Screen to control play position and for quickly advancing to the next file in a project. The arrows on the right also allow for single frame step forward and backward.



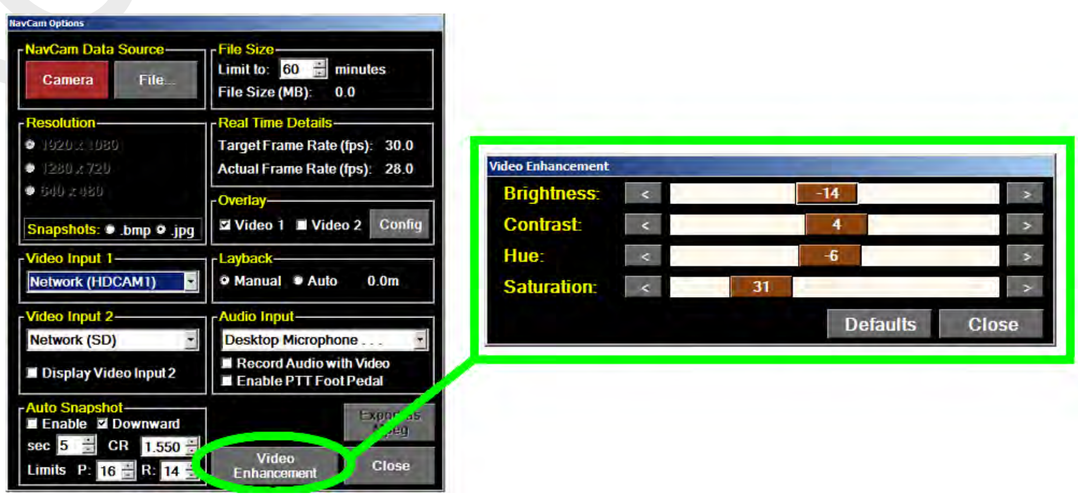
24.5. NavCam Track



When a NavCam snapshot is taken or video is recorded, a corresponding track file is also saved. The path of the NavCam file will be displayed as an orange track on the Track Screen (See image of a NavCam track during playback, right). Past recorded NavCam track files in the project will be displayed on the Track Screen. See section *20 Track* Screen for more information.

24.6. Video Enhancement

The video enhancement is a feature option for specific camera configurations. When enabled, the button "Video Enhancement" will become visible on the NavCam Options window. When clicked, this button will open a window that will allow modification to the video brightness, contrast, hue and saturation. Changing these parameters will affect the displayed video and will also be applied to any recorded video files and snapshots.



25. Sidescan Sonar Screen

Note: The Sidescan Sonar Screen is an optional feature to DiveLog. If the system does not have a sidescan sonar equipped then the Sidescan Sonar Screen can be turned OFF on the System Setup window, under Active Screens.

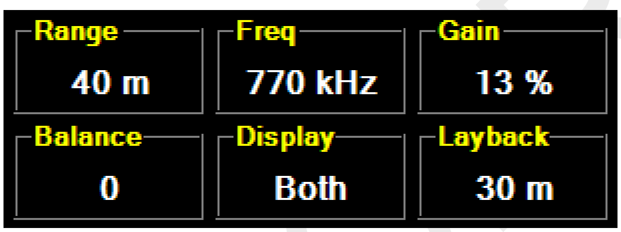
With the Sidescan Sonar Screen as the primary screen, the user can easily view the details of the sonar data currently being captured or played back. With the sonar as the Primary Screen, the most commonly adjusted parameters can be easily adjusted. Additional parameters and details can be seen and/or adjusted in the Options window for the sonar.

25.1. Main Sidescan Controls

25.1.1. Run and Record

If the Sidescan is connected, and not currently running, it can be started by pressing the “Run” button in the lower left corner of the display. This button toggles between “Run” and “Hold”.

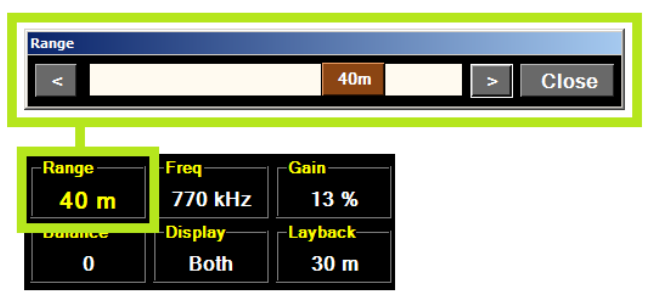
25.1.2. Settings



The main settings for the Sidescan Sonar allow the user to adjust the range, frequency, gain, balance, display side of the sonar head and layback. These options may change slightly depending on the model of sidescan connected. Clicking on these indicators will allow the user to adjust the particular parameter. As the mouse cursor moves over any of these indicators, they will change to yellow signifying they can be adjusted.

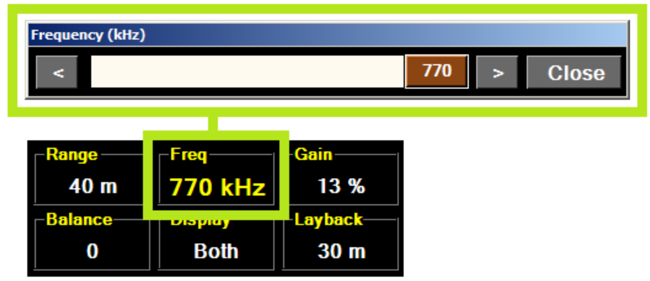
Range

To adjust the sidescan range during real-time data acquisition, cursor over the current range value and click to open up the range slider window.



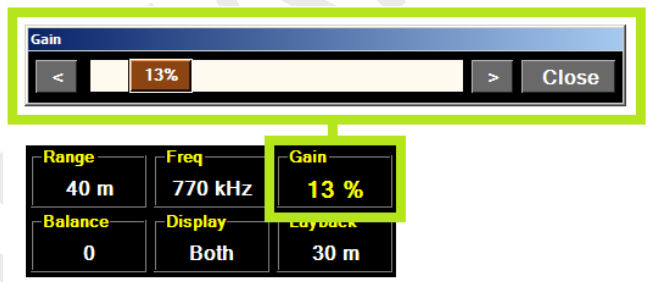
Frequency

To adjust the sidescan frequency during real-time data acquisition, cursor over the current frequency value and click to open up the frequency slider window. When operating at low or medium frequency, the full set of ranges is available. When operating at high frequency, the maximum range setting is 50m.



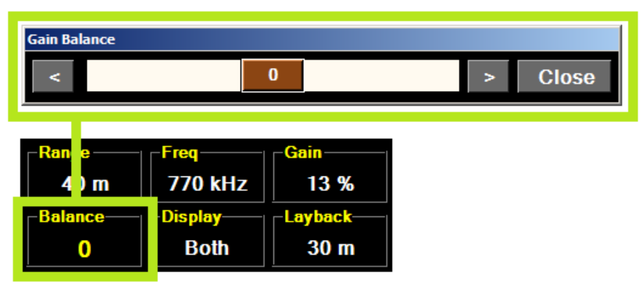
Gain

To adjust the sidescan gain during real-time data acquisition, cursor over the current gain value and click to open up the gain slider window. The gain is used to adjust the intensity levels of the returned echo data from the sonar head. The gain can be set as a percentage from 0-100%. A greater gain percentage results in higher colour intensity in the image that is produced.

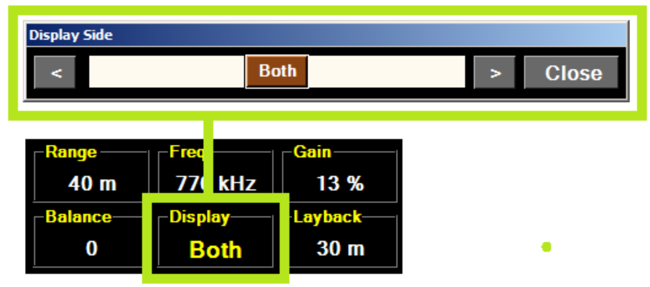


Balance

To adjust the sidescan gain balance during real-time data acquisition, cursor over the current balance value and click to open up the gain balance slider window. When the gain balance slider is centred on zero both the port and starboard gain will be proportioned evenly. Shifting the slider to the left or right weights the gain towards the port or starboard respectively. The displayed gain balance value is a multiplier of 0.1-decibel increments from the gain level matched on both sides. A positive value increases the gain on the starboard side, and a negative value increases the gain on the port side. For example, a value of –15 would mean an increase of 1.5 dB on the port side and a decrease of 1.5 dB on the starboard side. It is normal to have the slider slightly off centre to match the transducers.

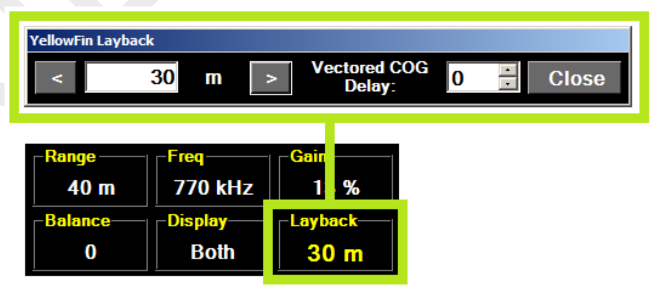


Display



To adjust the sidescan display side during real-time data acquisition or playback or recorded data, cursor over the current display side indicator and click to open up the display side slider window. This control changes the sidescan image as it is displayed. This is set to both as default; the entire sonar image will be displayed. The display can be changed to view only one side of the image, either the port or starboard. When viewing either the port or starboard scan by itself, it will be at a higher resolution than when both sides are displayed, as the full image is normally compressed to fit in the window. Note, that changing this control only affects the current view, and has no effect on how the sonar pings, or what data is recorded. The sidescan sonar always pings both port and starboard, and both sides are always recorded to the file with full resolution.

Layback



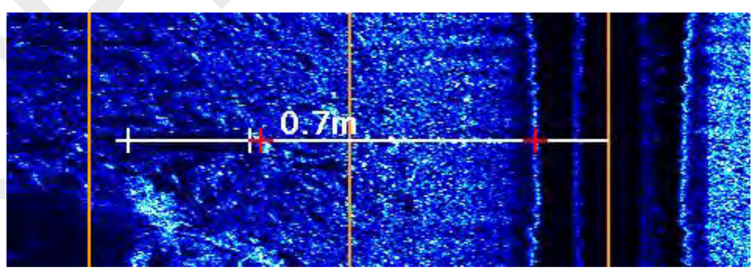
To adjust the sidescan layback during real-time data acquisition, cursor over the current layback value and click to open up the layback control window. Since the sidescan is a towed sonar head, it may have a significant displacement behind the boat, which will affect the positioning of the sonar image data. Enter the layback as the amount of sidescan cable that is paid out (i.e. the distance between the boat's GPS device and the sidescan sonar head). This distance will have a direct impact on the geodetic co-ordinates of the entire sidescan image. To get the most accurate results for displaying or marking targets with the sidescan image, be sure that the Layback value is accurate and changed as the cable length is altered. If the system is equipped with a Cable Payout Encoder, the layback can be automatically input by selecting Auto on the sidescan options window and configuring the COM port for the Cable Payout Encoder on the System Setup from. See section *13 System Setup* for further details on how to configure optional COM ports.

Also on the sidescan layback window is an option to adjust the "Vectored COG Delay" where COG is the *course over ground*. When set to zero, the sidescan heading, which is used to geo-reference the sonar image, is taken directly from the GPS data. For typical surveys, this is acceptable. The vectored COG delay used the current position from the GPS and the position at some delay interval in the past to derive the current heading of the sidescan. Such an approach may be advantageous for surveys done at slower speeds or to correct for a GPS units experiencing temporary heading inaccuracies.

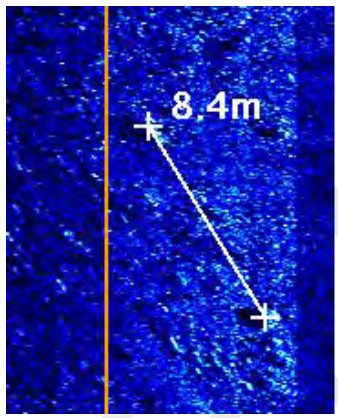
25.1.3. Measurements

The Measuring Tools allow measuring of different features found in the sonar image. The Measuring Tools can be used in either real-time mode, or playback mode. Click the appropriate button to activate the measuring tool. For each of the tools, when active the button will turn yellow. Once a measurement is complete, the button will deactivate. In all cases, when making a measurement on the sonar image, the tool tip will give instruction on how to perform the measurement.

Measure Height: This tool is used to measure an approximate height of an object in the sonar image. The calculation for the height of the object is based on a trigonometric formula, relating the altitude of the sonar above the bottom, the horizontal distance between the sonar and the object, and the length of the object's shadow. Once the "Height" Button is pressed, there are four steps to performing a height measurement. To start, click anywhere on the object that you are interested in. Second, click the "first return" of the image from the head. This will be where the image starts beyond the black region, close to the centre of the image. Third, click the start of the objects shadow. Finally, click the end of the object's shadow. The measured height of the object will appear next to the object on the image.



Measure Distance: This tool is used for measurements that are from one point to another on the image. After clicking the "Dist." button, click the first point on the sonar image followed by the second point on the sonar image. The distance between the two points is then displayed beside the first selected point. The distance calculation is based on the selected range of the sonar and the difference in geodetic position of the sonar between the two points.



Measure Offset: This tool is used for measuring the horizontal distance from the sonar to an object in the image. After clicking the "Measure Offset" button, click the object on the sonar image. The distance between the object and the sonar will be displayed beside the object. The distance calculation is based on the horizontal point within the selected range of the sonar.

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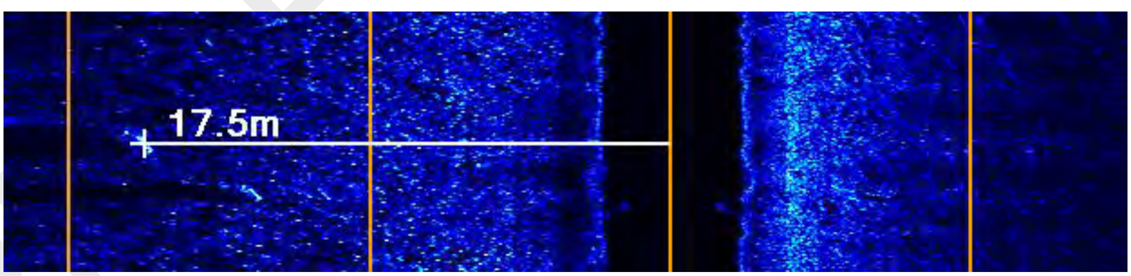
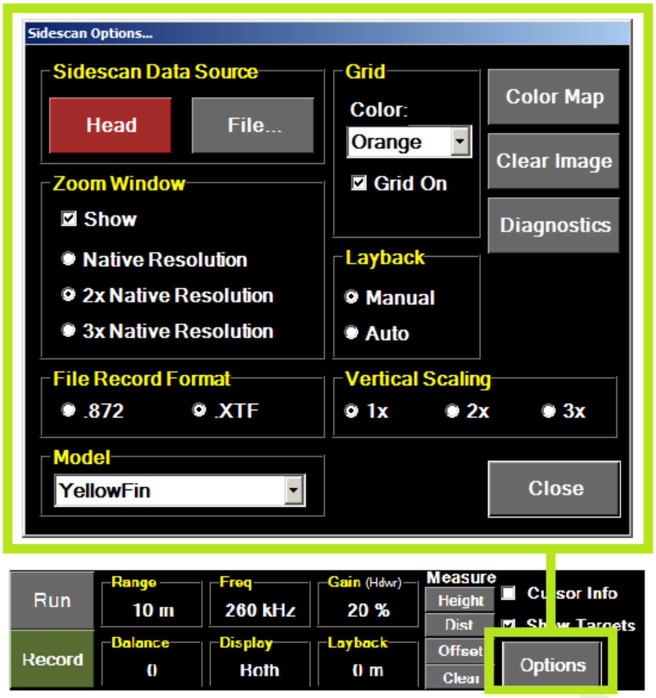


Clear Measure: This button will clear all measurements from the screen without changing any other aspect of the image.

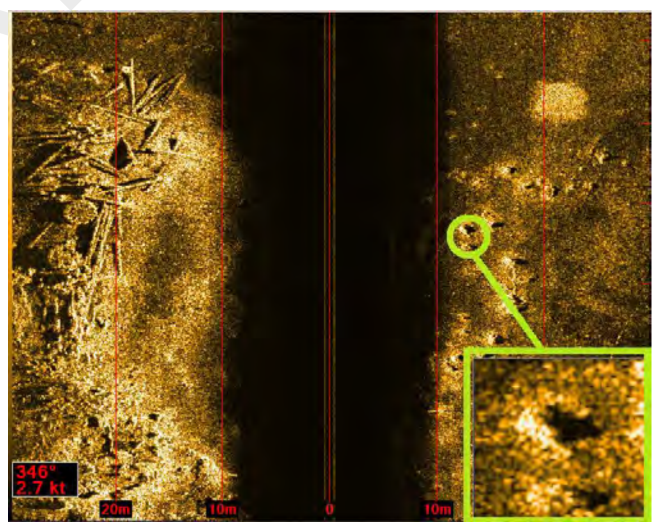
25.2. Sidescan Options Window



The “Options” button on the Sidescan screen brings up the “Sidescan Options” window. From this window, the data source for the sonar can be toggled from “Head” (real-time) to “File” by clicking on the respective buttons. Clicking the “File” button automatically opens the Select File window.

25.2.1. Zoom Window

The zoom window appears in the lower right corner of the sonar image when the “Show” checkbox is checked. The zoom window will magnify the portion of the sonar image that the mouse cursor is positioned over.



There are three zoom levels available; native resolution as well as 2 and 3 times native resolution. Often, the native resolution of the sidescan data is larger than the display window for the sonar image; therefore the native resolution was included as a zoom level.

25.2.1. Grid

The grid on the sidescan sonar image can be toggled on or off by checking or un-checking the checkbox next to “Grid On”. The grid colour can also be changed to a number of different choices as to maximize the contrast of the grid to the data image drawn with a particular colour map. Any changes to the grid options will have no effect on any measurements marked, or targets shown on the data image.

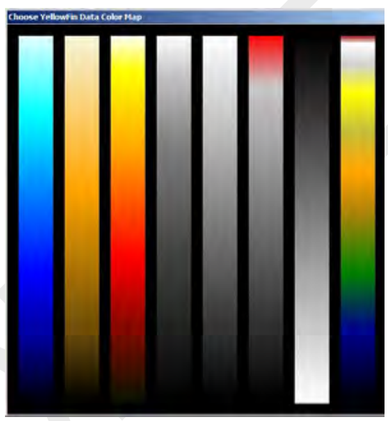
25.2.2. Layback

The Sidescan Options window presents the user with the option to choose whether the layback in input manually by the operator or automatically via a Cable Payout Encoder.

25.2.3. Additional Sidescan Options

The Options window also has several buttons for additional options such as adjusting the color map, clearing the image or opening a diagnostics window.

Color Map: This will open the color map selection window where a simple click on the desired color scheme is all that is required. The currently selected color map for the sidescan data will be displayed as a vertical bar to the immediate left of the sidescan image when it is the primary screen.



Clear Image: Clears all data and measurements from the sidescan image.

Sonar Diagnostics: The "Diagnostics" button opens a window that will display the current values of a wide range of parameters used by DiveLog when operating the sidescan. These values represent various setup and communication parameters with the sidescan sonar head. This is not normally used except for troubleshooting purposes.

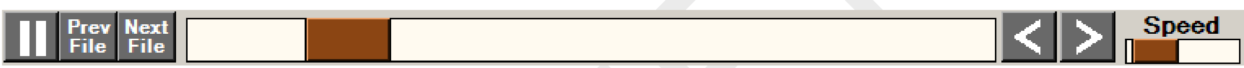
25.3. Recording

To record a file, click the record button during real-time operation. A file name with the current date and time, project code and operator user ID will automatically be created and recording of the echo data will start immediately. During recording full functionality of the sonar will remain; the user can continue to adjust the range through the entire range. The recorded data can be accessed at a later time for playback and review. Every time the record button is clicked off and then on again, a new file is started. The data is normally recorded in the XTF format with specific models allowing for head specific formats in some cases.

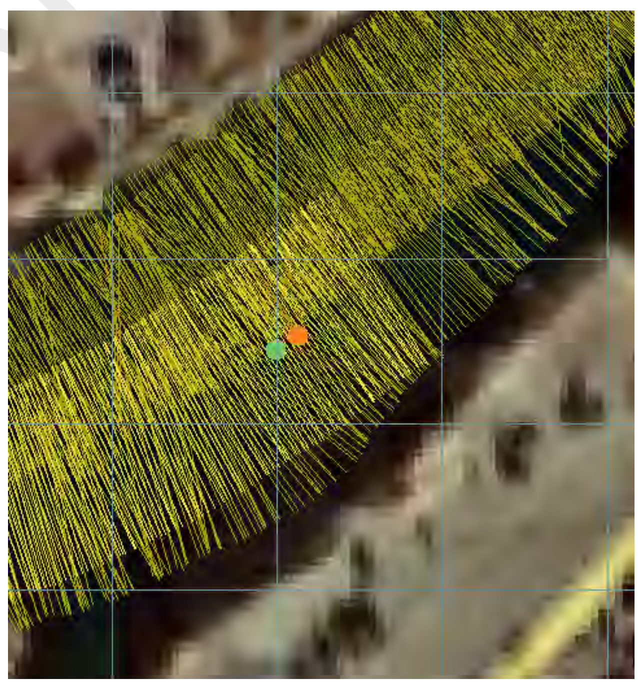
25.4. Playback

When playing back a sonar file, a file position slider and a playback speed slider will appear at the bottom of the display. The file position slider in the middle can be dragged to quickly scan through a file or the white space can be clicked for incremental jumps. The playback speed slider increases or decreases the playback speed. The two arrow buttons are used for stepping through a file in increments of the display height.

At the left of this bar is the “Play “/ “Pause” button, this button toggles the screen between “Play” and “Pause”. Next to this is a button labelled “Next File”, when you are already playing a file this button allows the user to load and play the next file in the project in a chronological order.



25.5. Sidescan Track



While the sidescan is running, the track of the towfish is displayed on the Track Screen. The swath is shown by yellow lines representing the range and location of the sonar pings (See image of a sidescan track during playback, right).
When a sidescan file is recorded, a corresponding track file is also recorded. See section *20 Track* Screen for more information.

Past recorded sidescan track files in the project will be displayed on the Track Screen. During playback, the track for the current file will be highlighted. While the sidescan file plays, the boat position will be shown as a green dot, the towfish position will be shown as an orange dot, and the current ping will be highlighted orange. The coverage display can be turned off, so that only the position of the pings are shown as dots. See section *20.4.7 Coverage Map* for more information.

26. 881A Scanning Sonar Screen

Note: The 881A Scanning Sonar Screen is an optional feature to DiveLog. If the system does not have an 881A scanning sonar equipped then the 881A screen can be turned OFF on the System Setup window, under Active Screens.

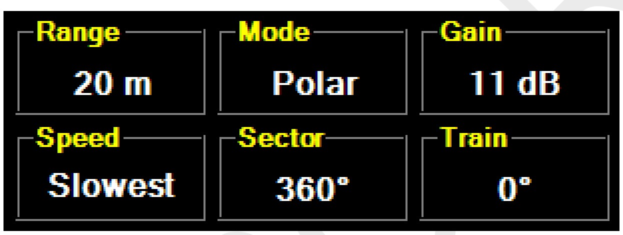
With the 881A Scanning Sonar Screen as the primary screen, the user can easily view the details of the sonar data currently being captured or played back. With the sonar as the Primary Screen, the most commonly adjusted parameters can be easily adjusted. Additional parameters and details can be seen and/or adjusted in the Options window for the sonar.

26.1. Main Scanning Sonar Controls

26.1.1. Run and Record

If the 881A is connected, and not currently running, it can be started by pressing the ‘Run’ button in the lower left corner of the display. This button toggles between “Run” and “Hold”.

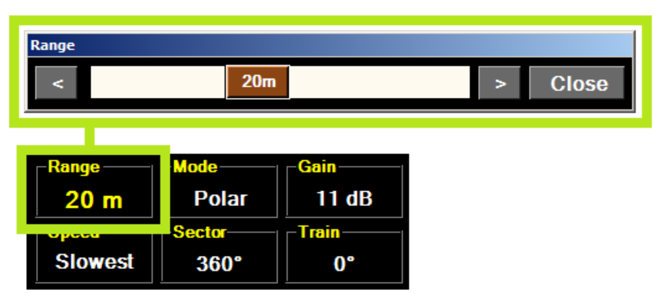
26.1.1. Settings



The main settings for the 881A Scanning Sonar allow the user to adjust the range, operation mode, gain, scan speed, sector of scan and the train angle of the scan. Clicking on these indicators will allow the user to adjust the particular parameter. As the mouse cursor moves over any of these indicators, they will change to yellow signifying they can be adjusted. None of these parameters can be changed in playback. The image generated during playback will be based on the recorded values of these settings while the file was being recorded.

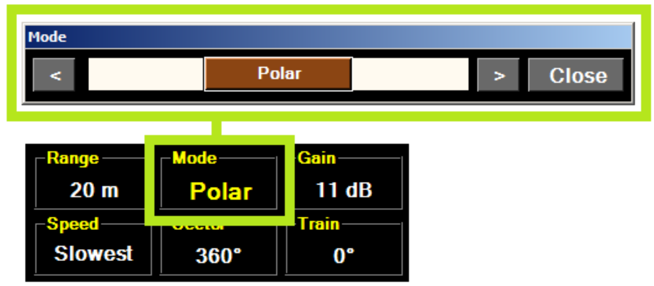
Range

To adjust the 881A range during real-time data acquisition, cursor over the current range value and click to open up the range slider window.



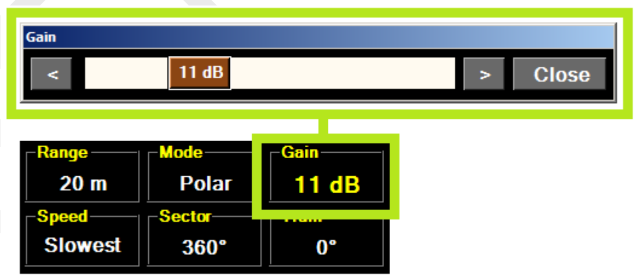
Mode

To adjust the 881A operation mode during real-time data acquisition, cursor over the current operation mode indicator and click to open up the operation mode slider window. There are three modes of operation available for the scanning sonar; Sector, Polar and Polar HR. Polar mode allows for a full 360° scan but still allows the sector and train angles to be adjusted as to focus on a particular area. Sector mode delivers an image that is twice the resolution of Polar mode; however its scan is limited to a sector size of 180°. Finally, Polar HR (High Resolution) allows for a full 360° scan at the resolution of a sector scan.



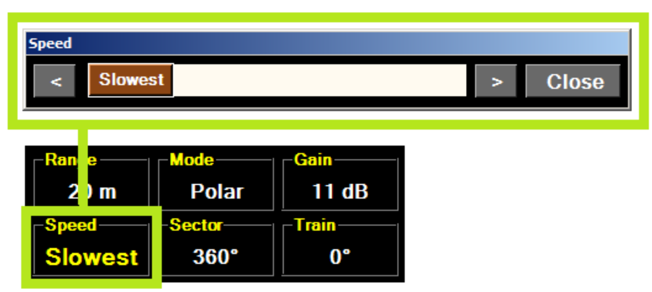
Gain

To adjust the 881A gain during real-time data acquisition, cursor over the current gain value and click to open up the gain slider window. The gain is used to adjust the intensity levels of the returned echo data from the sonar head. The gain can be set to a value from 0 to 40 in units of dB. To increase the return levels, select a higher gain. Conversely to decrease the intensity levels of the return data, select a lower gain.



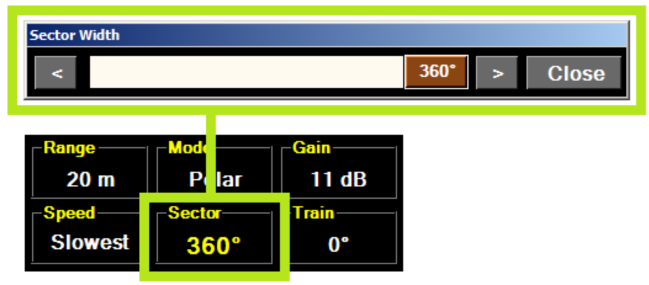
Speed

To adjust the 881A speed during real-time data acquisition, cursor over the current speed indicator and click to open up the speed slider window. Speed of the sonar corresponds to the step size of the head as it moves through its scan. Slower speeds will provide more detail; however faster scans will allow the user to scan an area quicker but in less detail.



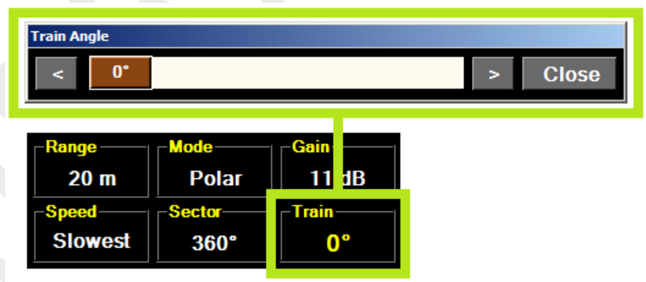
Sector

To adjust the 881A sector size during real-time data acquisition, cursor over the current sector size value and click to open up the sector size slider window. The sector of the scan refers to the sweep angle of the 881A sonar. The sweep angle can be adjusted in 30° increments from 30° to up to a full 360° in polar and polar HR modes and a maximum of 180° in sector mode.

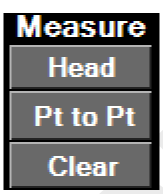


Train

To adjust the 881A train angle during real-time data acquisition, cursor over the current train angle value and click to open up the sector size slider window. The train angle represents the direction of the scan with respect to the centre angle of the sonar head. When the tripod position is set, the train angle represent the true geodetic direction of the scan.

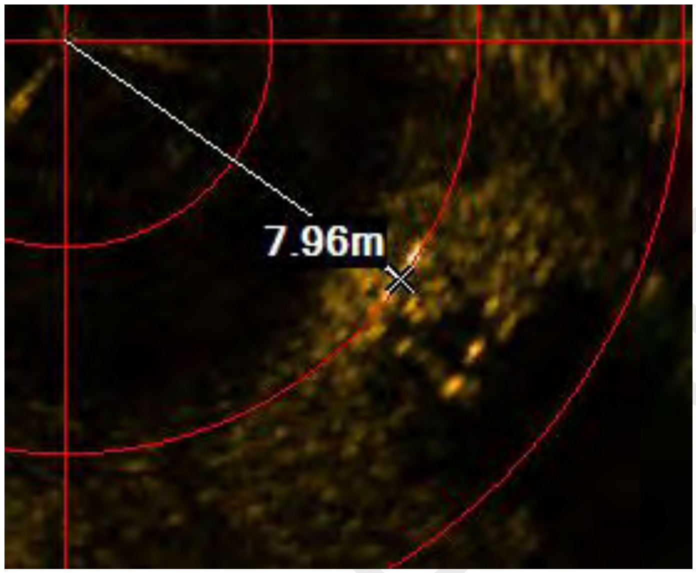


26.1.1. Measurements

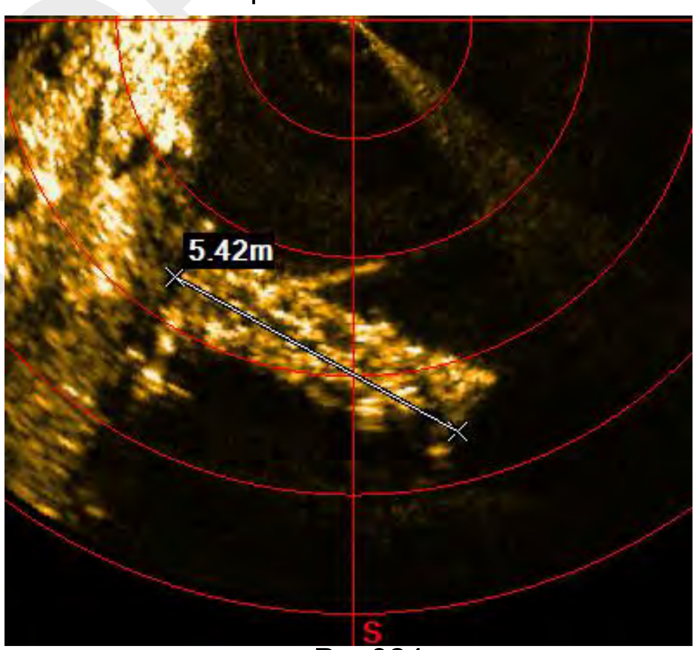


The Measuring Tools allow measuring of different features found in the sonar image. The Measuring Tools can be used in either real-time mode, or playback mode. Click the appropriate button to activate the measuring tool. For each of the tools, when active the button will turn yellow. Once a measurement is complete, the button will deactivate. In all cases, when making a measurement on the sonar image, the tool tip will give instruction on how to perform the measurement.

Head: This tool is used to measure the distance from the sonar head. To make a measurement from the head, first click the head button under measure, then click the desired point on the sonar image.

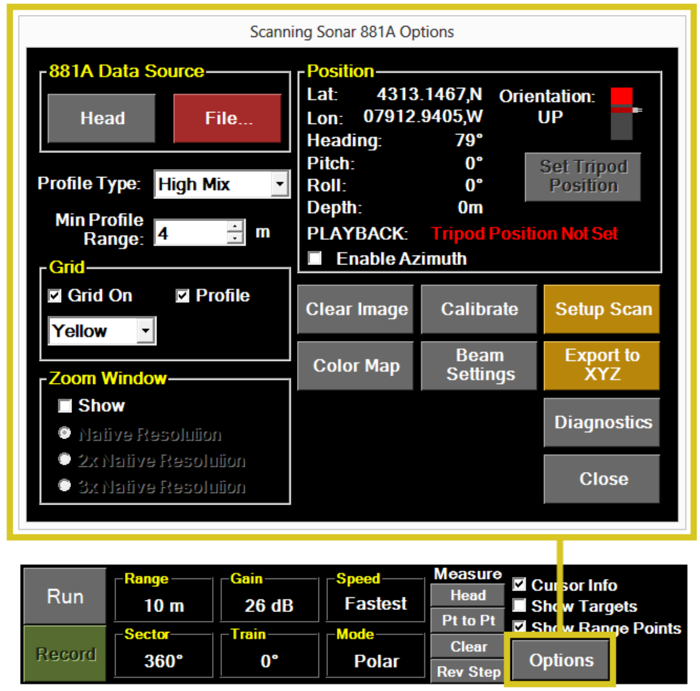


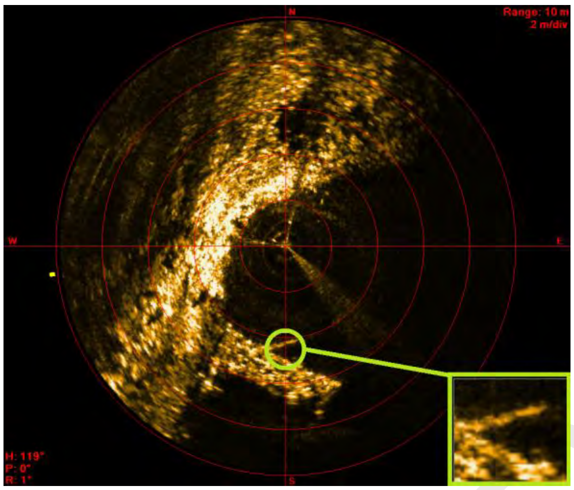
Pt to Pt: This tool is used for measurements that are from one point to another on the image. After clicking the “Pt to Pt” button, click the first point on the sonar image followed by the second point on the sonar image. The distance between the two points is then displayed beside the first selected point. The distance calculation is based on the selected range of the sonar and the difference in geodetic position of the sonar between the two points.



26.2. 881A Scanning Sonar Options Window

The “Options” button on the 881A screen brings up the “Scanning Sonar 881A Options” window. With this window, the data source for the sonar can be toggled from “Head” (real-time) to “File” by clicking on the respective buttons. Clicking the “File” button automatically opens the Select File window.





26.2.1. Zoom Window

The zoom window appears in the lower right corner of the sonar image when the “Show” checkbox is checked. The zoom window will magnify the portion of the sonar image that the mouse cursor is positioned over.

There are three zoom levels available; native resolution as well as 2 and 3 times native resolution.

26.2.1. Grid

The grid on the 881A sonar image can be toggled on or off by checking or un-checking the checkbox next to “Grid On”. The grid colour can also be changed to a number of different choices as to maximize the contrast of the grid to the data image drawn with a particular colour map. Any changes to the grid options will have no effect on any measurements marked, or targets shown on the data image. The Profile grid option, when checked, changes the gird from a circular grid to a rectangular grid style.

26.2.2. Profile Type

The Profile Type refers to the graphical representation of the echo data and profile data returned from the sonar. Points Only will show only the profile data as points on the image. Low, Medium, and High Mix will show the profile data as points, with the echo data at varying brightness levels in the background. No Points shows only echo data at full brightness.

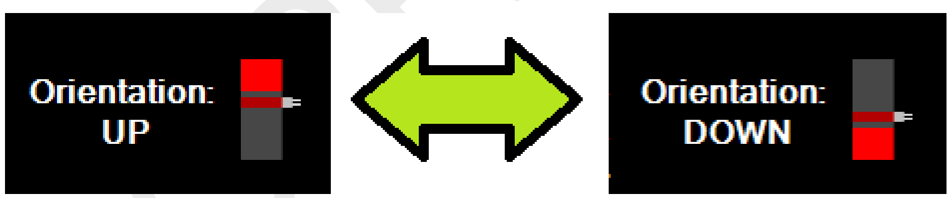
26.2.3. Min Profile Range

The Min Profile Range determines the minimum profile range point that will be returned by the sonar. If the profile range is set to 3m, the sonar will keep searching for a valid profile point, even if a valid point exists below 3m.

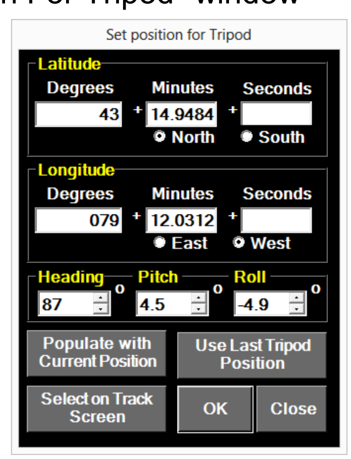
26.2.4. Position

When the 881A sonar is fixed at a location with its heading known, such as on a stationary tripod with an attitude sensor, the entire sonar image can be geodetically referenced, otherwise the only position on the image that is accurately known is that of the head (i.e. the origin on the image).

Regardless of operation from a tripod or on a moving platform such as an ROV, the orientation of the sonar must be correct. To adjust the head orientation, simply click the image of the sonar head in the position box. This is only a function of real time operation since this data is embedded in the sonar file.

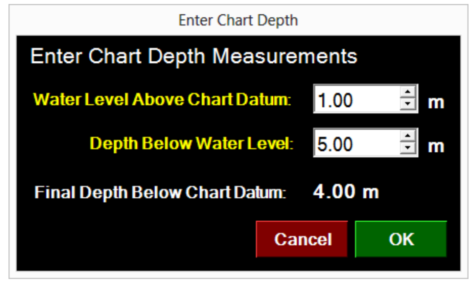


With the head orientation setup correctly, the position of the tripod (i.e. the sonar head) can be set by clicking the button “Set Tripod Position”. The “Set Position For Tripod” window will open, which automatically fills with the current position, heading, pitch, and roll. From here, 3 options are available.

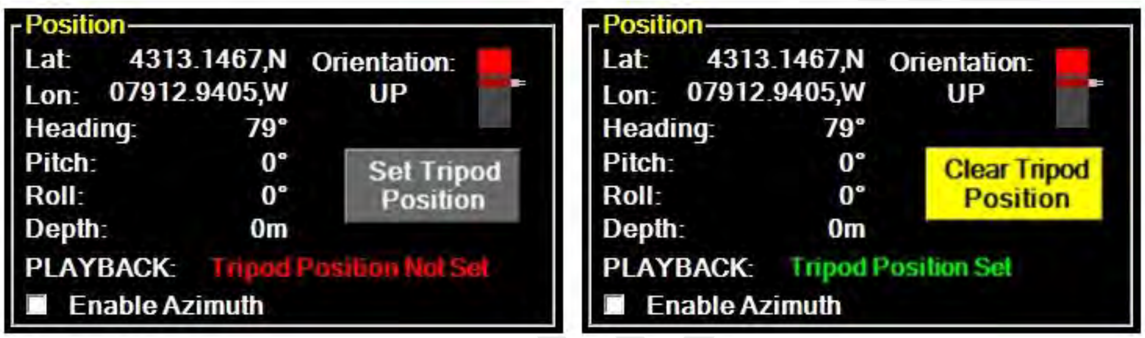


1. The tripod position can be set using the current valid position and orientation information.
2. The tripod position can be set using the last used tripod position and orientation.
3. The tripod position can be entered manually either by typing in the geodetic coordinates or selecting the position of the tripod on the Track Screen. Heading, pitch, and roll must be manually entered (see image, right).

Click the OK button to finish the positon selection. The “Enter Chart Depth” window will open, allowing you to set both the water level above Chart Datum, and the tripod depth below the water level.

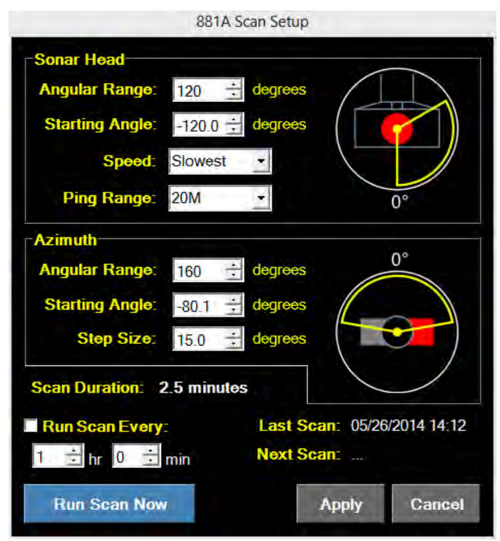


Once the tripod position is set, the button “Set Tripod Position” will turn yellow and change to “Clear Tripod Position”. Therefore when clicked a second time, the tripod position will un-set and the geodetic referencing over the sonar image will no longer be available. All tripod position states are saved in any 881A scanning sonar file being recorded. When a recorded file is played back, tripod position state change will reflect what was done at the time the file was recorded. The following diagram illustrates the above procedure.



26.2.5. Azimuth Drive

The 881A scanning sonar may also be mounted on an azimuth drive, allowing the sonar to rotate through 360 degrees perpendicular to its beam. This allows the sonar to record pings in a full sphere. This is especially useful when using the pencil-beam 881A profiling sonar to do a full 3D scan. These scans will be done by moving the azimuth drive incrementally between a start and end angle, and at each increment, running a cross-sectional profile with the sonar head.



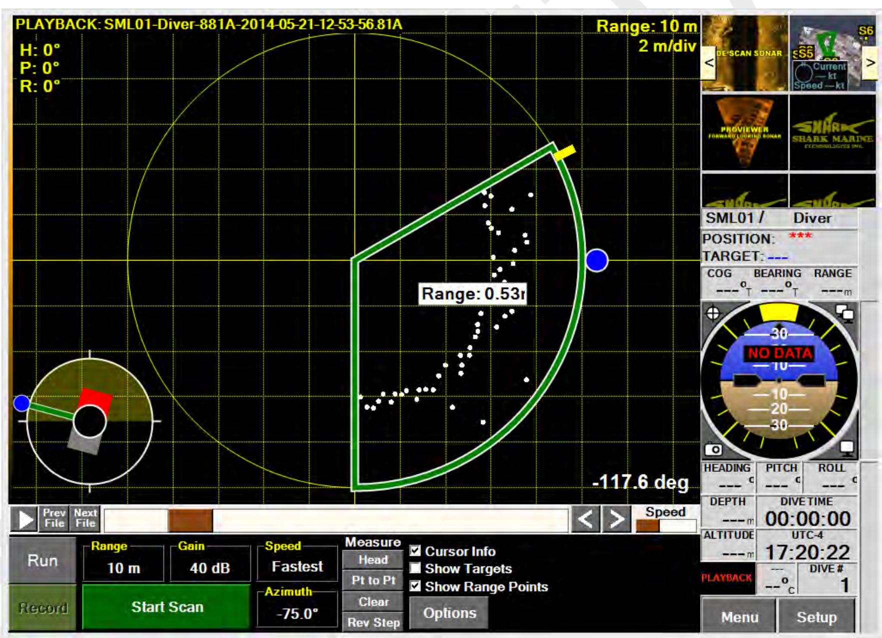
To set up an azimuth drive powered scan, click the Setup Scan button on the 881A Options window. The window has three sections:

- The first section contains settings for the sonar head, including the start angle and angular range of the each cross-sectional scan, as well as the speed of the sonar head rotation.
- The second section contains settings for the azimuth drive, including the start angle and angular range of the drive, as well as the angular size of each incremental azimuth rotation. The minimum rotation value of the azimuth drive is 0.3 deg.

- The third section allows the user setup a scheduled scan. If no previous scans have been run, after pressing the Apply button, you will be prompted to choose a date and time for the first scan. If you wish to run the first scan immediately, click the “Run Scan Now” button, instead of Apply. The scan duration estimate will be updated each time to scan interval is changed.

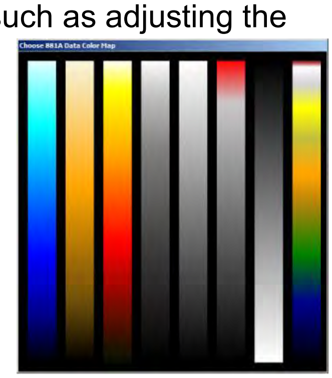
When the azimuth drive is enabled and running, or an azimuth-enabled file is played back, the main display updates to show 2 additional overlays.

- **Sonar Scan Range Overlay:** Shows the angular region of the sonar display that will be covered when a scan is run, as a green pie.
- **Azimuth Overlay:** Shows top-down view of the sonar with an azimuth range preview shown as a yellow pie shape. The green line and blue circle indicate the “forward” direction of the sonar, which assists in determining the alignment of the sonar unit before a scan. When performing a scan, the display will show an outline of the azimuth scan range, which will fill in as the scan progresses, as well as text showing the percentage of the scan completed.



26.2.6. Additional 881A Options

The Options window also has several buttons for additional options such as adjusting the color map, clearing the image, opening a diagnostics window or viewing the beam settings.



Color Map: This will open the color map selection window. Click on the desired color scheme to choose the color map. The currently selected color map for the scanning sonar will be displayed as a vertical bar to the immediate left of the sonar image when it is the primary screen.

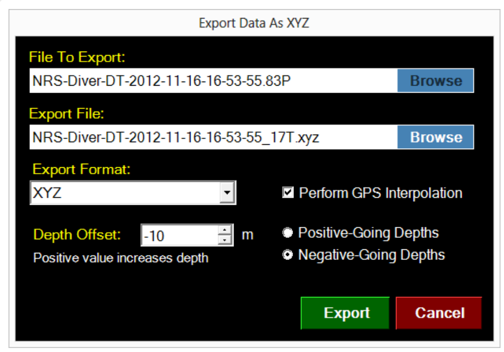
Diagnostics: The “Diagnostics” button opens a window that will display the current values of a wide range of parameters used by DiveLog when operating the scanning sonar. These values represent various setup and communication parameters with the sonar head. This is not normally used, except for troubleshooting purposes.

Beam Settings: Clicking “Beam Settings” will open up a window that displays information on the current scanning sonar beam settings. This window is for informative purposes only and does not change any parameters affecting operation of the actual sonar head.

Calibrate: This button moves sonar head position to 0˚with respect to the heads centre position.

Clear Image: Clears all data and measurements from the scanning sonar image.

Export to XYZ: Shows the “Export Data As XYZ” window, which allows you to process and export any number of selected files to a number of point cloud formats, including ".xyz" and ".kml". The data can be vertically offset by altering the depth offset, or flipped by choosing either Positive or Negative-Going Depths. The Track search boundary can also be used to limit the range of data considered for export. See section *10.3 Exporting Point Cloud Data* for more information.



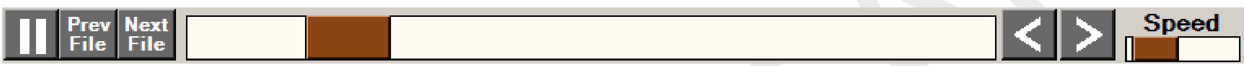
26.3. Recording

To record a file, click the record button during real-time operation. A file name with the current date and time, project code and operator ID will automatically be created and recording of the echo data will start immediately. During recording full functionality of the sonar will remain; the user can continue to adjust all the operational parameters of the sonar. The recorded data can be accessed at a later time for playback and review. Every time the record button is clicked off and then on again, a new file is started.

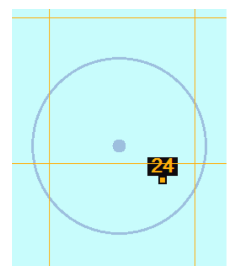
26.4. Playback

When playing back a sonar file, a file position slider and a playback speed slider will appear at the bottom of the display. The file position slider in the middle can be dragged to quickly scan through a file or the white space can be clicked for incremental jumps. The playback speed slider increases or decreases the playback speed. The two arrow buttons are used for stepping through a file in increments of the display height.

At the left of this bar is the “Play “/ “Pause” button, this button toggles the screen between “Play” and “Pause”. Next to this is a button labelled “Next File”, when you are already playing a file this button allows the user to load and play the next file in the project in a chronological order.



26.5. 881A Track

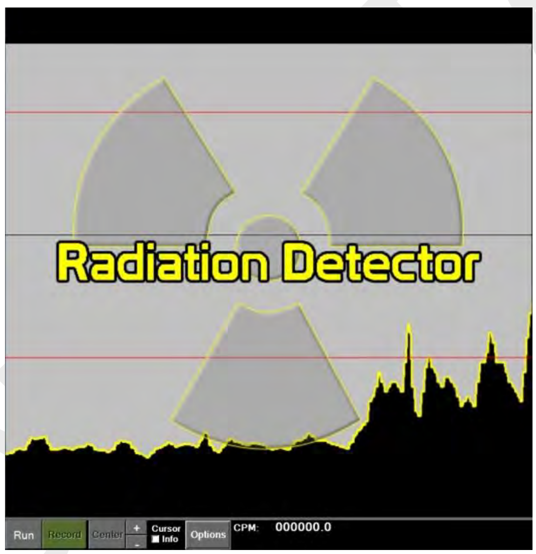


When an 881A file is recorded, a corresponding track file is also recorded. The position (or path) of the 881A file will be displayed as a blue track and range circle on the Track Screen (See image of an 881A track during playback, right). Past recorded 881A track files in the project will be displayed on the Track Screen. See section *20 Track* Screen for more information.

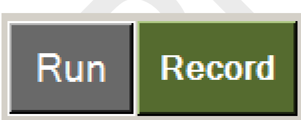
27. Radiation Detector Screen

Note: The Radiation Detector Screen is an optional feature to DiveLog. If the system does not have a Radiation Detector Probe equipped then this active screen can be turned OFF on the System Setup window under Active Screens. Details on the hardware can be found in the Radiation Detector Hardware Manual.

With the Radiation Detector Screen as the primary screen, the user can view the Radiation Detector data currently being received or played back. The most commonly adjusted parameters can be set directly from the primary screen controls. Additional parameters and details can be seen and/or adjusted in the "Options" window for the Radiation Detector.



27.1. Main Radiation Detector Controls

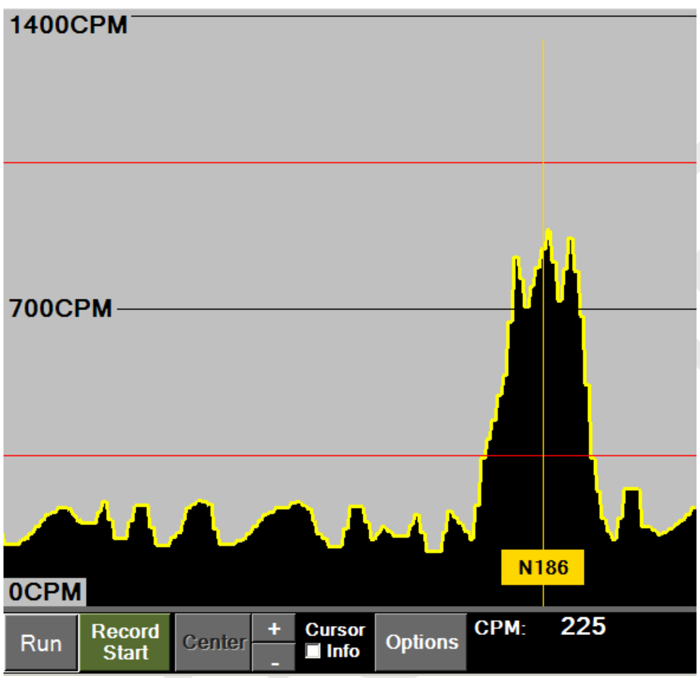


If the Radiation Detector is connected and not currently running, it can be started by pressing the "Run" button in the lower left corner of the display. Click the button again to hold operation. When running the Radiation Detector, DiveLog will connect the COM port if not already connected. If the COM port settings are not correct, the Radiation Detector will fail to run. The COM port can be set on the System Setup window; see section *13.1 COM Setup Table* for more information.

27.2. Graph Scaling and Zeroing

To the right of the “Run” and “Record” buttons are buttons for scaling the graph. The “+” button increases the scale on the graph, while the “-“ button decreases the scale on the graph. The scale of the graph is in the units of CPM (Counts per Minute), and the zero point will always be at the bottom of the graph. The operator may want to adjust the scale of the graph if the magnitude of the data climbs beyond the limits of the screen, or to focus in on a smaller area and see fine changes in the data.

27.3. Targets

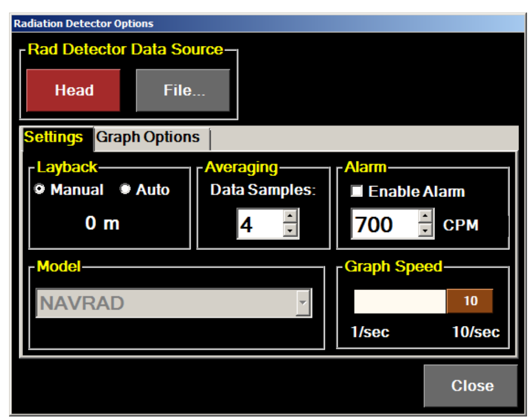


A target can be marked on the Radiation Detector Screen by clicking the DiveLog target button (on the Navigation View), then clicking the main image on the Radiation Detector Screen. The target created will be added to the list of targets for the current project in DiveLog and will be visible in other Active Screens. Note: you must have a valid position to mark a target.

Right clicking the target will provide various target options. See section *12 Marking and Managing Targets* for more information.

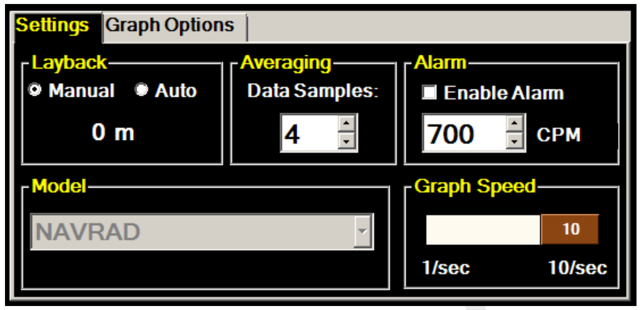
27.4. Radiation Detector Options

Clicking on the “Options” button on the Radiation Detector screen brings up the options window. From this window, the data source for the graph can be toggled from “Head” (real-time) to “File...” (previously recorded data). Clicking the “File…” button opens a window to select a file in the current project, with an option to browse for a file in another location.



27.4.1. Settings

The Settings tab on the Options window allows the user to change settings that affect the Radiation Detector operation.



Layback: When operating a Radiation Detector mounted on the Navigator or ROV, the position of the Radiation Detector is the same as the current position in DiveLog, and no layback is needed. For surveys that use the Radiation Detector in a towed configuration, a layback can be applied for more accurately positioning the readings. The layback can be entered automatically via a cable payout encoder (see section *15.11 Cable Payout Encoder*) or entered manually by clicking on the layback and entering the value in the window show below. The Radiation Detector Layback window also allows the user to choose to use the current compass value for calculating the towfish position or use a vectored COG (course over ground) delay. The vectored COG uses a heading derived from two different GPS positions in time; the current position and a position that is a variable amount of time in the past. A vectored COG delay of zero simply uses the current course over ground value from the GPS source in the calculation for the towfish position (this is the default).

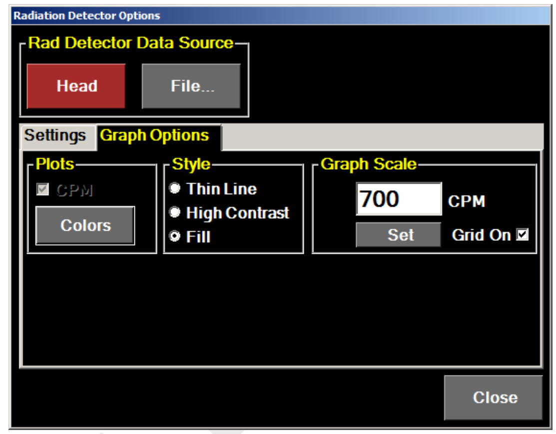
Averaging: The number of Radiation Detector data samples used to generate a point can be varied between 1 and 20. Averaging can reduce the small variances in the readings and have the effect making the data appear smoother.

Alarm: An alarm can be set that will alert the operator when the detected CPM readings exceed a given preset value. Checking the checkbox labelled “Enable Alarm” will activate the alarm.

Model: Currently only the NAVRAD model is available.

Graph Speed: The graph speed can be adjusted to as fast as 10 points per second or as slow as 1 point per second. Note that this does not reflect the rate at which the sensor acquires data.

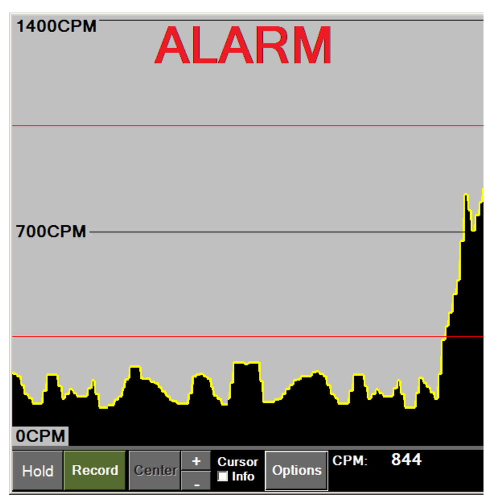
27.4.2. Graph Options



The data collected from the Radiation Detector can be plotted in several different visual styles. The Graph Options tab on the Options window allows the user to adjust the graph display style.

Plots:	The scrolling graph on the main image will plot the CPM (radiation level in Counts per Minute).
Colors:	The Colors button will bring up a dialog box that allows the user to change the colors of the various elements on the graph image.
Style:	The data on the graph can be shown as a thin line, a high contrast line or a fill style graph.
Graph Scale:	Although the scale of the graph can be readily adjusted in increments on the main display, a precise value can be entered here.
Grid:	Turns the grid on or off. The grid breaks the graph into horizontal segments for easier measurement/reference.

27.5. Alarm



As described in the Settings section of the Options window, an alarm can be set that will alert the operator when the detected radiation readings exceed a given pre-set value.

When the Radiation Detector is set as the primary screen, the word “ALARM” will flash in red at the top center of the graph to indicate that the current radiation level has reached or exceeded the alarm value. When

the current radiation readings drop below the alarm threshold, the alert will subside.

When the Radiation Detector screen is in secondary mode, the entire graph will flash red to indicate the alarm (see image, right).

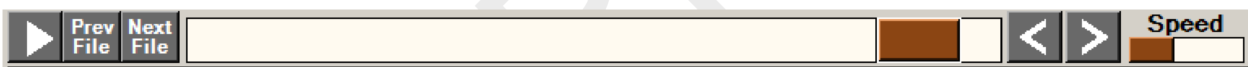
27.6. Recording

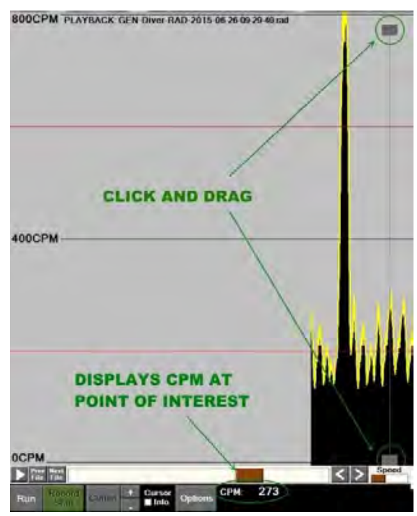
To record a file, click the record button during real-time operation. A file name with the current date and time, project code and operator ID will automatically be created and recording of the Radiation Detector data will start. All navigation data such as heading, pitch, roll, depth, position, et cetera is recorded along with each reading.

27.7. Playback

A recorded file can be opened for playback by clicking the File button on the Radiation Detector Options window and selecting a file.

The playback controls will be added to the bottom of the main image to control the play position, play speed, and for quickly advancing to the next recorded file in the project.

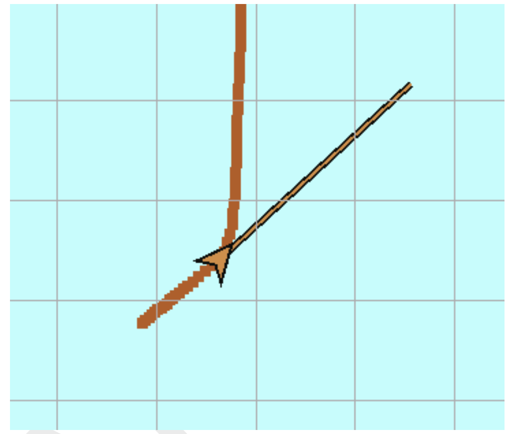




27.7.1. Point-of-Interest Bar

For playback, a vertical bar is displayed, which can be dragged horizontally along the width of the graph. The position of this bar defines the Point-of-Interest or POI. In playback the data fields for the Radiation Detector will reflect the data on the graph at the POI. This differs from real time operation in that the data fields always reflect the most recent data when collecting data. The navigation data displayed in the Navigation View, and the position played on the Track Screen will all reflect the data at the position of the POI bar.

27.8. Radiation Detector Track

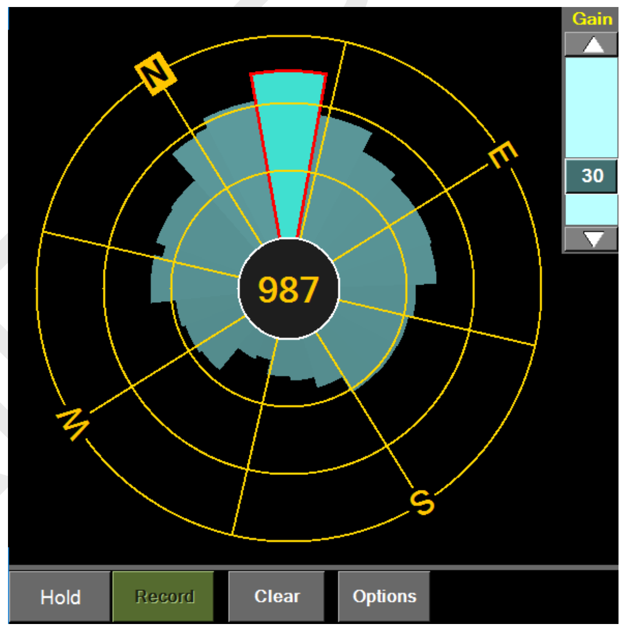


When a Radiation Detector file is recorded, a corresponding track file is also recorded. While the file is being recorded or played back, the path of the Radiation Detector will be displayed as a brown track on the Track Screen (See image, right). Past recorded Radiation Detector files in the project will also be displayed on the Track Screen. See section *20 Track Screen* for more information.

28. Pinger Locator Screen

Note: The Pinger Locator is an optional feature to DiveLog. If the system does not have a Pinger Locator equipped then this active screen can be turned OFF on the System Setup window, under Active Screens. Details on the hardware can be found in the Pinger Locator Hardware Manual.

With the Pinger Locator Screen set as the primary screen, the operator user can view a visual representation of the strength of the received pinger signal. The receiver gain can be adjusted on the main screen, while other setup parameters are contained on the "Options" window.

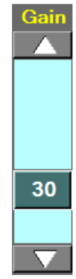


The numeric value in the center of the image represents the current detected relative signal strength, with a maximum of 1200. Each detected pinger signal is added to the image as a wedge shape, with the length of the wedge representing the relative signal strength. The center of the circular grid represents the receiver's location. The image is presented in a "heads up" orientation. The current received data will be added above the center of the image, representing forward. Past received pings are shown at the heading that the detection was made. As the heading of the receiver changes, the grid and the past readings will rotate to show the direction of those readings compared to the current heading.

With this method of display, a 360 degree map of readings can be accumulated by taking a reading, then turning about 15 to 20 degrees, then taking another reading and so on. After doing this through 360 degrees, a full image will be created representing the received pinger strength in each direction. The direction to the signal source will likely be in the direction that the strongest signal was received.

Note that before any readings are taken, the parameters for the specific signal source (pinger) must be entered into DiveLog. See below, section *28.4 Pinger Locator Options*.

28.1. Gain Control



Adjusting the gain (at the top right of the image) adjusts the sensitivity of the receiver and will have a corresponding effect on the magnitude of the received readings. Adjusting the readings will cause the past displayed readings on the image to fade darker, to represent their reduced relevance to the new readings at the current gain level.

When starting operation, increase the gain until the pinger signal is reliably received. At this point you may receive readings from more than one direction due to acoustic reflections. To increase directionality, reduce the gain to a point where readings are only received in a particular direction.

28.2. Run / Record

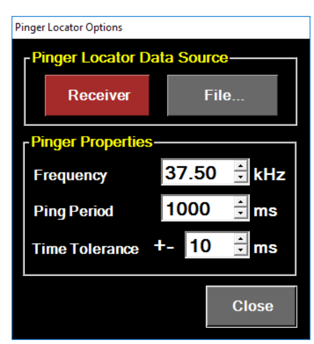
Running will normally automatically start, but if the Pinger Locator is connected and not currently running then it can be started by pressing the "Run" button in the lower left corner of the display. Press this button again to hold operation. When running the Pinger Locator, DiveLog will connect the COM port if not already connected. If the COM port settings are not correct, the Pinger Locator will fail to run. The COM port can be set on the System Setup window; see section *13.1 COM Setup Table* for more information.

The clear button is used to hide the past readings and start with a blank image. This doesn't not affect recorded data; all readings will be recorded while recording.

28.3. Recording

To record a file, click the record button during real-time operation. A file name with the current date and time, project code and operator name will automatically be created and recording of the Pinger Locator data will start. All navigation data such as heading, pitch, roll, depth, position, et cetera is recorded along with each reading.

28.4. Pinger Locator Options

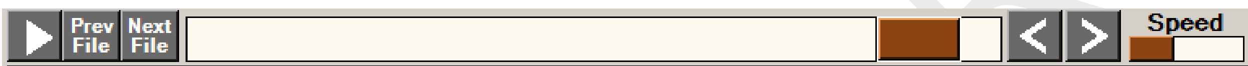


Click on the "Options" button on the Pinger Locator screen to bring up this window. From this window, the data source for the graph can be toggled from "Receiver" (real-time) to "File..." (previously recorded data). Clicking the "File…" button opens a window to select a file in the current project, with an option to browse for a file in another location.

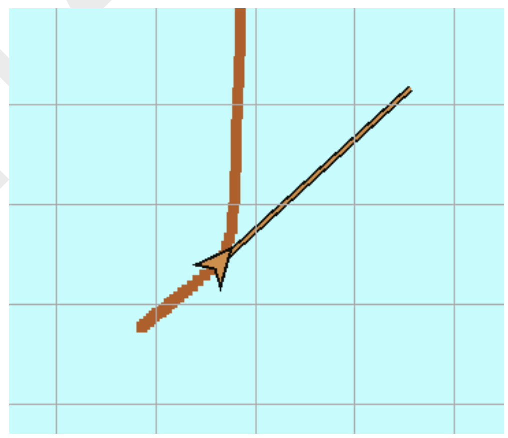
The Pinger Properties settings are important for specifying the type of pinger that is being searched for, since other frequencies are filtered out to eliminate noise. Enter the frequency in kilohertz and the ping period in milliseconds that corresponds to the pinger being searched for. The Time Tolerance setting is used to filter out readings that fall outside of the expected ping period.

28.5. Playback

A recorded file can be opened for playback by clicking the File button on the options window and selecting a file. The playback controls will be added to the bottom of the main image to control the play position, play speed, and for quickly advancing to the next recorded file in the project.

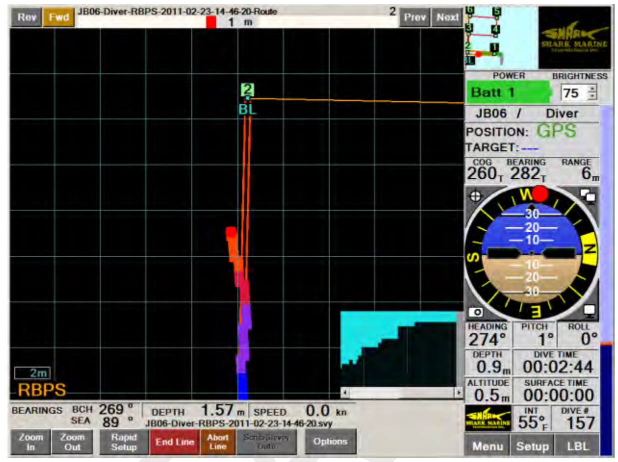


28.6. Pinger Locator Track



When a Pinger Locator file is recorded, a corresponding track file is also recorded. While the file is being recorded or played back, the path of the Pinger Locator will be displayed as a brown track on the Track Screen (See image, right). Past recorded Pinger Locator files in the project will also be displayed on the Track Screen. See section *20 Track Screen* for more information.

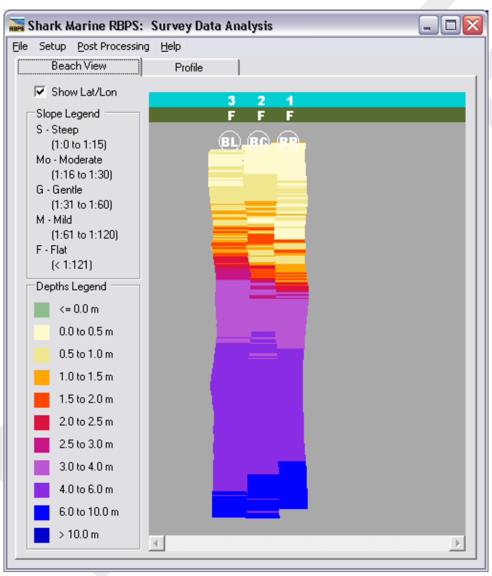
29. Rapid Beach Profiling System Screen

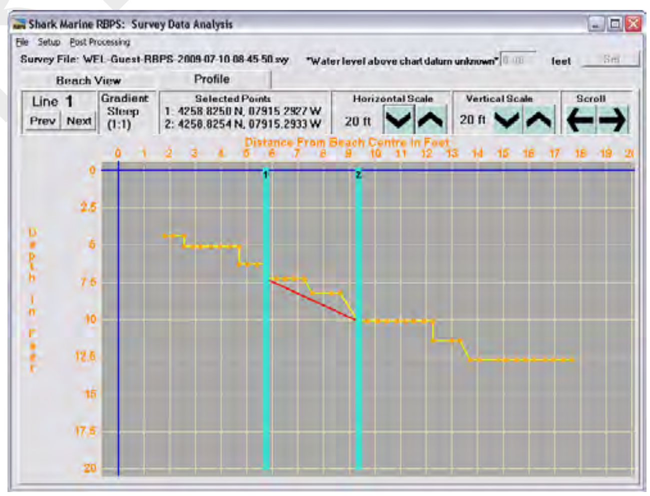


The Rapid Beach Profiling System (RBPS) is an Active Screen in DiveLog that makes use of the built in sensors as well as an Altimeter or Doppler unit to perform a survey of a beach or other area. RBPS consists of data acquisition mode with a route follower view. After data is recorded, a data analysis window presents a top-down view of the recorded depths, as well as analysis of each recorded profile line.

The RBPS Screen may be used in any copy of DiveLog for viewing survey setup parameters and analysis of collected data. To setup or modify an RBPS survey file, or record data, RBPS must be purchased as an add-on and activated on the system (activated with a Security Dongle or by other means).

All RBPS Hardware and Software operation is covered in the document *Rapid Beach Profiling System (RBPS) Manual*.





30. Troubleshooting

Refer to specific sections of this manual for details on particular aspects of software operation. The section headings have been broken down to easily find information on a particular element of the software (see the Table of Contents). Hardware troubleshooting steps are detailed in the hardware manual and/or accessory manuals provided with the system.

For technical support contact Shark Marine Technologies Inc. at:

Phone:	905-687-6672
Email:	sales@sharkmarine.com
Office Hours:	Monday to Friday 8:30am to 5:00pm Eastern Standard Time

31. Appendix A: System Requirements

The following table outlines the recommended minimum system requirements for the DiveLog software.

Specification	Minimum Requirement
CPU	900 MHz
Disk Space	325 MB (75 MB installation, min 250 MB data) Recommended: >1GB
Memory (RAM)	248 MB
Operating System	Windows 7, Windows Vista, Windows XP
Graphics	800 x 600 pixels

32. Appendix B: End User License Agreement

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1- Failure of Shark Marine Technologies Inc. to enforce its rights with respect to any violation of this Agreement shall not constitute, or be interpreted as, a waiver from Shark Marine Technologies Inc. to exercise such right at any later stage, as it shall deem appropriate.

2- Should any provision of this Agreement be in conflict with any law governing this Agreement, it will be deemed stricken from the Agreement and the remaining provisions will remain in effect.

3- This Agreement shall be binding upon the parties hereto and their respective successors and permitted assigns.

Dive SOP 2 - Underwater Intrusive Investigation Operations

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct underwater intrusive investigation operations in support of munitions response project work plans. Any changes or deviations from this SOP will be included in the project plans and approved by the Marine Operations Program Manager. This SOP will be reviewed annually.

TMR Senior Diving Supervisor, Don Schwalback		Date:	04/26/2022
TMR Director of Quality, Eugene Mikell III, CQA		Date:	04/26/2022
TMR Marine Operations Program Manager, Scot Wilson, PMP		Date:	04/26/2022
TMR Diving Safety Officer, Patrick Oberley		Date:	04/26/2022

Review Date	Reviewer	Next Review
02/04/2022	TMR Senior Diving Supervisor, Don Schwalback	01/2023
02/08/2022	TMR Diving Safety Officer, Patrick Oberley	01/2023

SUPERVISOR'S STATEMENT

I have read and understood this SOP. To the best of my knowledge, the procedures described in this SOP can be performed in a safe and environmentally sound manner. I have confirmed that all persons assigned to this process are qualified, have read and understood the requirements of this SOP, and have signed the worker's statement for this purpose. I will ensure the SOP contains current procedures. If a major change to the SOP is necessary, I will ensure active processes are suspended until the SOP is revised and approved. If unexpected safety, health, or environmental hazards are identified, I will make sure the process is stopped until the hazards have been eliminated.

SUXOS/ Diving Supervisor Date

WORKER'S STATEMENT

I have read Dive SOP – Underwater Intrusive Investigation Operations and have received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

AHA	activity hazard analysis
AOI	areas of interest
BEM	buried explosion module
BIP	blown-in-place
DDESB	Department of Defense Explosives Safety Board
DGM	digital geophysical mapping
DMM	discarded military munitions
DS	diving supervisor
ESP	explosives site plan
ESS	explosive safety submission
EZ	exclusion zone
FCA	function check area
GPS	global positioning system
IVS	instrument verification strip
JSA	job safety analysis
MC	munitions constituents
MD	munitions debris
MDAS	material documented as safe
MEC	munitions and explosives of concern
MPPEH	material potentially presenting an explosive hazard
MQO	measurement quality objective
MSD	minimum separation distance
NMRD	non-munition related debris
OESS	ordnance and explosives safety specialist
PDA	personal digital assistant
PM	project manager
QC	quality control
ROV	remote operated vehicle
RRD	radiological dispersal device
SADS	surface air delivery system
SSA	surface supplied air
SM	shark marine underwater navigation system

SSHO	site safety and health officer
SOP	standard operating procedure
SUXOS	senior UXO supervisor
WP	work plan
TL	team leader
TP	technical paper
U.S.	United States
UUV	unmanned underwater vehicle
UXO	unexploded ordnance
UXOQCS	UXO quality control specialist
UXOSO	UXO safety officer

1.0 PURPOSE AND SCOPE

The purpose of this Standard Operating Procedure (SOP) is to provide procedures and technical guidance for the underwater intrusive investigation operations at designated munitions response sites. These operations include:

- Mag and Dig Operations (clearance)
- Target Investigation of Targets and Areas of Interest (AOI) based on geophysical data collection
- Unexploded ordnance (UXO) surveys and characterization tasks

All training on equipment or software will be either formal or on-the-job training prior to the commencement of field operations. This training will be documented by site personnel and subject to review for accuracy and completeness. The UXO quality control specialist (UXOQCS) and UXO safety officer (UXOSO) will verify training is complete, documented, and reported.

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials that may be required to implement this activity.

2.1 PERSONNEL

The following individuals or vendors may be involved in field underwater investigation activities:

- UXO divers qualified in accordance with the United States Department of Defense Explosives Safety Board (DDESB) technical paper (TP) 18, Minimum Qualifications for Personnel Conducting Munitions and Explosives of Concern-Related Activities (DDESB 2016).
    - Project Manager (PM). Responsible for all aspects of the project.
    - Senior UXO supervisor (SUXOS)/diving supervisor (DS). Responsible for planning, directing, and executing all field operations.
    - UXOQCS. Responsible for all aspects of project quality at the project site.
    - UXOSO and site safety and health officer (SSHO). Responsible for all aspects of health and safety on the project site.
    - UXO divers. Responsible for performing the intrusive investigation operations under the guidance and direction of the SUXOS/DS.
    - Geophysical personnel as required by the project work plan.
- Subcontractors (Marine services, scientists, geophysist, security, technical support, etc.)
- Visitors or other site personnel

2.2 EQUIPMENT

- Personal protective equipment outlined in the Activity Hazard Analysis (AHA)/Job Safety Analysis (JSA)
- Hand-held geophysical instruments -
    - Global Positioning System (GPS)

  - Shark Marine underwater navigation system (SM).
- Underwater all metals detectors.
- Underwater capable cameras.
- Operations support vehicles.
- Markers, floats, or buoys with appropriate anchoring as authorized in the project work plan.
- Support vessels, small boats as required.
- Health and safety equipment per pre-operation checklists.
- Diving equipment as outlined in the project work plan and the Tetra Tech Munitions Response Diving Safe Practices Manual.

3.0 PROCEDURES AND GUIDELINES

The SUXOS, UXOSO, and UXO Team Leader (TL) will review the site conditions and determine the best approach available in the project work plan to complete the underwater intrusive investigation operations. Any inaccessible locations will be documented in the field logbook. Any changes to the procedures will be made by a field change request as outlined in the project work plan.

3.1 EQUIPMENT SET-UP

Materials or equipment received at the site will be inspected for serviceability and against purchase order requirements or operations manuals. Photos will be taken and filed with the daily quality control reports, the quality receipt inspection report, or equivalent record.

Analog metal detector sensors will be assembled with fully charged batteries and tested for functionality at an Function Check Area (FCA) or Instrument Verification Strip (IVS) prepared under the direction of the project quality manager and/or UXOQCS. The test strips will include a collection of Industry Standard Objects buried at depths and orientations defined in the Quality Assurance Project Plan or equivalent planning document. This will simulate the size and depth of the targets expected at the project site. Sensors will be tested before beginning operations each day, and the results recorded in the team logbook or on forms. All tests will be reported to the UXOQCS for inclusion in the daily report.

GPS, remote operated vehicle (ROV), unmanned underwater vehicle (UUV), and underwater navigation systems will be assembled and operated following manufacturer's guidelines and the appropriate SOP. This includes daily equipment checks and data recordings to their use in support of underwater intrusive investigations.

Cameras and video systems, when used, will be tested, and have video cards and batteries checked as applicable.

All tests will be reported to the field management team. All tests will be documented for inclusion in the daily reporting.

3.2 EXCLUSION ZONES, ENGINEERING CONTROLS, AND ROAD CLOSURES

Engineering controls should be employed whenever possible to minimize the damage from munition response operations. These controls may consist of sandbags, ecology blocks, trenching, buttressing, taping of glass, mounding, flooding and/or venting to reduce the effects of intentional or unintentional detonations.

During underwater intrusive activities at a munitions response site, the open-air exclusion zone for vessels and non-essential personnel will be the hazardous fragment distance for the munitions with the greatest fragmentation distance of the approved project Explosive Safety Submission (ESS) or Explosives Site Plan (ESP). Underwater minimum separation distances (MSDs) will be provided by the United States (U.S.) Army using the U.S. Army Munitions Response Actions – Minimum Separation Distances (Relative to Impulse Water Pressure) from Underwater Detonations (Safe Separation Distance for Swimmers and Divers) SAIE-ESOH Memorandum, dated 16 Sep 2013 and the most recent buried explosion module (BEM) model. All vessels and personnel at the water surface will be outside of the Blast Withdrawal Distance or the Maximum Fragment Distance, whichever is greater, as calculated using the BEM. If an underwater intentional detonation is permitted, then the depth of water will be factored into the BEM and used as an engineering control.

The SUXOS will ensure exclusion zone (EZ) barricades are set up with signs at all access roads and marked appropriately: Danger, UXO Remediation Project in Progress, DO NOT ENTER, and list contact information on the barricade sign. If roads/water areas cannot be blocked, guards will be posted, and work halted if non-essential personnel enter the MSD. The explosives of concern (MEC) intrusive operations will not resume until non-essential personnel have exited the MSD.

4.0 OPERATIONS

4.1 GENERAL SAFETY

The most pertinent rules for handling munitions are summarized below:

- Underwater investigation activities will not be conducted until the required training and proper equipment checks have been completed, documented, and the appropriate EZ is established, marked, and secured.
- A designated DS with a dive team consisting of a minimum of four personnel will perform MEC investigation, reacquisition, and recovery operations.
- The UXOSO will be stationed on-site and will maintain visual contact to the best extent possible with the dive and any other field teams downrange during field operations. The UXOSO will maintain communications with the team and the Tetra Tech site office.
- The appropriate authorities will identify all utilities prior to intrusive operation.
- Appropriate supervisors will be notified immediately of all MEC or suspected MEC finds as outlined in the project work plan.
- Non-UXO personnel must always be escorted by UXO-trained personnel after receiving a site safety briefing and 3R training in areas potentially containing MEC.
- If MEC is encountered that presents an immediate threat to life or property, it will be marked and secured until a plan for the item's safe disposition has been made and approved.
- UXO personnel must always remain on site when non-UXO personnel are conducting intrusive operations.
- Personnel will not collect souvenirs under any circumstances.
- If non-essential personnel are encroaching the site, all intrusive operations will be suspended immediately until resolved.

- Suspend all operations immediately upon the approach of an electrical storm (lightning observed or measured within 10 miles). All personnel will shelter as identified in the project work plan or as directed by the UXOSO.
- Assume munitions contain an explosive filler, are armed, and are ready to fire until determined otherwise.
- Make every effort to identify the munitions. Carefully examine the munition for markings and other identifying features such as shape, size, and external fittings. Take careful measurements and document. Ensure photos and/or videos have size reference features included.
- Do not move the suspected munition until it is identified and confirmed acceptable to move by the SUXOS and UXOSO.
- Plan for, provide, and know the measures to be taken in the event of an accident.
- Provide a designated emergency vehicle (if applicable) in the area in case of an accident or an emergency.
- Always base operations on minimum exposure consistent with efficient operations.
- Do not rely on the color-coding of MEC for positive identification of contents. Munitions having non-existent, incomplete, or improper color codes may be present.
- Avoid the area forward of the munition's nose until it can be determined that the item does not contain a shape-charge or is a high-explosive anti-tank round. The explosive jet can be fatal to great distances forward of the item's longitudinal axis. Assume any shape-charge munitions contain a piezoelectric fuzing system until the fuzing is otherwise identified.

Fuzed and fired munitions, when intact, are designated as MEC-UXO, which is the most hazardous classification of MEC. Specific munitions that may be encountered are researched and reviewed by the project team. Any additional safety measures are implemented where required in the project specific work plan. General specific fuzing systems of concern include:

- Piezoelectric fuzing systems can fire at the slightest physical change and may remain hazardous for an indefinite period.
- All way acting fuzing systems are extremely sensitive to movement and orientation changes and can fire when any movement is imparted on any munitions fuzed with them.
- Base detonating fuzing systems can contain a cocked striker or impinged primer. They are extremely sensitive to vibration, movement, and orientation change for any munitions fuzed with this feature.

4.2 DAILY BRIEFING

After arriving at the worksite, the SUXOS/DS or designee will conduct a field operation brief at the work location. The UXOSO or designee will conduct a safety brief to all team members on potential hazards in the area and the operations conducted during the shift and review the AHA/JSA for the task. The following briefings will be given:

- Operation overview
- Team assignments
- Type and condition of expected MEC
- Dive - system, conditions, and profile for task
- Emergency procedures

The TL will ensure hand-held instruments, GPS, communications equipment, safety gear, or other equipment are function checked and serviceable before beginning field operations. All daily meetings, briefs, and equipment checks will be documented in team logs and project forms outlined in the work plan.

4.3 INTRUSIVE OPERATIONS

4.3.1 Underwater Intrusive Investigation of Targets and AOI

Reacquisition of specific targets will be made using the SM or GPS to navigate the known anomaly location. The vertices of grid locations will be provided to the field teams. In general, individual targets and grids will be systematically investigated, starting in the deeper, lower density areas, and moving toward the shallower depths and high-density areas. The following are general descriptions of the options available to investigate underwater grids and anomaly targets using the SM or manual search methods, based on depth, bottom type, and the local environment:

4.3.2 Rectangular Grids

For rectangular grids in water 3 to 4 feet or deeper, the investigation team will conduct a grid lane search using a UXO diver(s) tethered to the SM. The diver(s) will utilize the SM, including self-contained navigation and underwater imaging system, providing the diver(s) with location, navigation, and situational awareness. The diver(s) will use the SM to descend to the entrance point (grid corner). Guided by the SM, the diver(s) will then swim and search each lane within the grid, performing an analog instrument-assisted visual search.

As the diver(s) encounter anomalies, they will note the item's location, status, and condition and take a photograph using the SM underwater camera. At the completion of the search, the population of MEC and munitions debris (MD) within the grid will be recorded. For areas with coral, rock, or another hard substrate, the diver(s) will conduct an analog instrument-assisted visual search. In areas with soft substrate or seagrass, the diver(s) will use the SM for navigation and a hand-held metal detector to help locate anomalies.

If an anomaly is buried in a soft substrate, the diver(s) will use their hands or small hand tools to excavate down to the anomaly until an identification can be made. If the diver(s) have not reached the anomaly after excavating to a predetermined depth or the depth of refusal, the anomaly will be labeled accordingly in the access database Intrusive results table.

If the SM cannot be used, a manual jackstay or similar search pattern (e.g., Two marker buoys with sandbag anchors placed by GPS location and a highway line between them on the bottom) may be used.

4.3.3 Circular Grids

For circular grids in water 3 to 4 feet or deeper, the investigation team will conduct diving operations using a UXO diver(s) tethered to the SM. The diver(s) will use the SM to descend to the center of the grid. Guided by the SM, the diver(s) will perform a search pattern expanding around the center point until the entire circular grid is investigated. As the diver(s) encounter anomalies, they will note the item's location, status, and condition and take a photograph using the SM underwater camera. At the completion of the search, the population of MEC and MD within the grid will be recorded. If an anomaly is buried in a soft substrate, the diver(s) will use their hands or small hand tools to excavate down to the anomaly until an identification can be made. If the diver(s) have not reached the anomaly after excavating to a predetermined depth or the depth of refusal, the anomaly will be labeled accordingly in the Access database Intrusive Results table.

If the SM cannot be used, a manual circle line or similar search pattern (e.g., One marker buoy with sandbag anchor placed by GPS location and a manual circle line search pattern attached) may be used.

4.3.4 Shallow Water

For anomalies that are located in water shallower than 3 feet, the investigation team will use UXO technician(s) snorkeling or using paddleboard(s) (lying down or seated in a position to ensure legs are not dangling in the water) who can investigate the anomaly from the surface, or UXO diver(s) wading in shallow areas where contact with the bottom is allowed and feasible using a surface air delivery system (SADS) or surface supplied air (SSA) diving systems. A preliminary identification will be made, the item's location, status, and condition will be recorded, and a photograph will be taken using the SM camera. The UXO diver(s) will be equipped with a GPS, manual marker, or both, which can record the target's location.

For AOIs in water shallower than 3 feet, the investigation team will conduct grid searches over areas delineated with GPS boundaries. The geometric shapes (polygons) of these areas will be selected to correspond to the shapes of the AOIs. To investigate these areas, UXO diver(s) snorkeling or using paddleboard(s) to investigate the target from the surface, or diver(s) wading in shallow areas where contact with the bottom is allowed and feasible using the SADS or the surface supplied air (SSA) diving systems. A preliminary identification will be made, the item's location, status, and condition will be recorded, and a photograph will be taken. The UXO diver(s) will be equipped with a GPS capable of recording the target's location. At the completion of the search, the population of MEC and MD within the grid and its status and condition will be recorded.

If MEC is found, it will be left in place, documented as outlined in the project work plan, and clearly marked. The UXO diver will notify via a post-dive debrief of their findings to the field management team.

4.3.5 Underwater Mag and Dig Operations

The general intrusive investigation procedures for mag and dig operations are:

- For mag and dig operations, establish a search area within the grid or transect as outlined above.
- If SM navigated pattern is used; diver/s will guide the SM operator while swimming forward slowly down the search lane sweeping the head of the analog sensor smoothly from side to side.
- If the manual search pattern is used; diver/s will guide on the lines while swimming forward slowly down the search lane sweeping the head of the analog sensor smoothly from side to side.
- Ensure the sensor head exceeds the width of the search lane to slightly overlap the adjacent lane.
- A wide-head electromagnetic analog sensor requires an overlap of one-half the head's width to perform an effective search. The sensor head must be parallel to the ground surface. Keep the head close to the ground.
- The sensor head must be kept at a constant height throughout the sweep.
- Each pass across a search lane should take 2-3 seconds.
- Investigate every anomaly detected that is consistent with the smallest munition anticipated at the site.
- Do not be deceived by a dull or low volume signal from a sensor. Deep targets do not necessarily produce a loud or sharp signal.
- Define the extent of the anomaly using the analog sensor.
- Technicians may use hand tools if sediment conditions permit.
- Using a shovel, trowel, or other suitable tools, remove sediment in small amounts from the side of the anomaly and work inward toward the anomaly.
- Once the anomaly is uncovered, characterize it as described in this SOP.

- Recheck the excavation with the analog sensor and continue clearing the anomaly if necessary.
- When restarting the sweeping activity, back up a foot and begin sweeping. This should ensure that no residual target is present in the excavation.
- Backfill any excavation after completing documentation unless otherwise instructed; and
- Continue the process until the assigned area/lane is complete.
- TLs will verify dig sheets/personal digital assistant (PDA) are filled out correctly, are complete, correct, standardized nomenclature is used, and no-finds are listed. MEC requires positive identification on the dig sheet. The gross weight of material documented as safe (MDAS) per grid is documented separately. Location and depth of item are recorded.
- All quality control activities must be documented in accordance with the project quality control plan and associated definable features of work.

4.3.6 Underwater DGM Anomaly Target Investigation

The specific intrusive investigation procedures for digital geophysical mapping (DGM) anomaly target investigations are:

- The selected anomaly targets from the DGM data are marked with target markers or buoys using the appropriate positioning system/s.
- Each target will be investigated to the radius and depth defined in the work plan bypassing the analog sensor over the ground's surface and then investigating all contacts identified within the search radius. The search radius may be extended by the geophysical data processor and noted in the dig sheet.
- After prosecution of the target to the extent required, the analog metal detector will verify any remaining signature is less than the threshold criteria selected for the project. Once complete, the target marker or buoy may be recovered and documented to indicate a completed target.
- If the target investigation results in a “no find-no contact”, the target marker or buoy will be removed and the target reacquired. A second UXO diver will investigate the target and record the results. The TL will follow all procedures for documentation, as outlined in the project work plan.
- The QC diver will verify no find-no contact targets as outlined in the project quality control plan and document the findings accordingly.

Upon completion of the target clearance, all MD, range related debris (RRD), and non-munition related debris (NMRD) will be 100% inspected by a UXO technician II and a UXO technician III, before it is removed from the grid to ensure it is free of explosive hazards. If MEC or material potentially presenting an explosive hazard (MPPEH) is found, it will be left in place, clearly marked, and the UXO Technician III will notify the SUXOS and UXOSO.

The TL will photograph all MEC/MPPEH and record as much information as possible in the TL’s logbook or the PDA. Recorded data includes nomenclature (if known), type (projectile, mortar, rocket, etc.), size, physical condition, fuzed or unfuzed and fuze type by function (point detonating, mechanical time, etc.), condition (fired or unfired, armed or unarmed), filler if known, and GPS coordinates.

All MD, RRD, and NMRD will be brought to the central collection point for SUXOS and UXOQCS or government representative inspection as outlined in the project work plan. See SOP for MPPEH and MDAS Management.

All project records will be returned to the SUXOS or project data manager at the end of the day.

4.4 COLLECTION POINTS

Collection points allow for temporary accumulation of recovered and classified MEC and MPPEH that are acceptable to move to another area for storage or destruction. Collection points must be authorized by the project work plan and the associated ESP/ESS. A bottom survey will identify an underwater disposal area free of obstacles or sensitive environmental situations (e.g., endangered species habitat). This area should have a hard bottom, be at the greatest depth possible, and protected from prevailing weather, underwater conditions (e.g., high currents), or high-sea states. The area should contain a pallet, net, or basket to place the MEC/MPPEH and prevent scouring. Once identified, this area will be marked using a GPS. To prevent unauthorized access, the area should not be marked on the surface. If required in the project work plan, the area may be clearly marked and then guarded when MEC/MPPEH is present. An EZ will be established based on the worst-case munition item and depth of water per the DDESB TP 16, or as provided by the ordnance and explosives safety specialist (OESS) or equivalent and authorized in the project work plan (WP) and associated ESS/ESP. MEC and MPPEH will not be transported from one munition response site to another within the Munitions Response Area unless authorized in the project work plan and applicable ESS/ESP.

4.5 FIELD COMMUNICATION

Two primary methods of communication will be used during field operations. Base station, vessel and / or marine hand-held radios will be used for communication during any routine field operations. A designated cell phone will be the primary means of notifying emergency responders (e.g., dialing 911). As most operations will be conducted on the open water, a marine very high frequency vessel or hand-held radio will be on-site and be capable of communicating with the area police, fire, medical or U.S. Coast Guard via channel 16 (or the designated channel for any local authorities as outlined in the project WP). If available, Tetra Tech site office landlines may also be used for off-site communication.

Communication (via hand-held radio) among the field teams, the UXOSO, UXOQCS, and the SUXOS/DS will be verified before commencing operations. Applicable telephone numbers will be found in the project work plan. Additionally, these will be posted in the site office and placed in all site vehicles and vessels. If necessary, a radio base station or repeaters will ensure reliable communications across the site.

4.6 MPPEH CHARACTERIZATION

Refer to the specific SOP for full details on MPPEH characterization.

- As the UXO diver(s) encounter anomalies, they will note the item’s location, status, and condition and take a photograph using the SM underwater camera. The first UXO diver who discovers the suspected MPPEH will conduct the initial classification as MEC: UXO, discarded military munitions (DMM) or Munitions Constituents (MC); Or if the target is not MPPEH (e.g., MD, RRD, NMRD). If the diver is a UXO Tech I, the suspected target, will have to have a UXO Tech II or higher verify the classification before further action is taken. If real time video is available from the diver, a UXO Technician III or above at the topside console can make the initial classification if visibility permits.
- The TL or at a minimum a UXO Tech III will inspect all MEC, MD, RRD, and NMRD before leaving the munitions response area.
- The UXO TL will determine whether the MPPEH, once visible, is MEC and notify the SUXOS and UXOSO. Note: Suspected MPPEH that is not inspectable will be treated as MEC.
- The SUXOS will make the final identification of any suspected MEC.

- The SUXOS and UXOSO will make a joint decision on the acceptable to move determination. The two must agree with the decision, and it will be documented.
- If MEC and MPPEH are determined by the SUXOS and UXOSO to be unacceptable to move, it will be blown-in-place (BIP) if authorized or moved remotely using high input mechanized operations after all appropriate precautions have been taken. MEC or MPPEH will not be left unsecured in the field at any time. Notifications to the PM, Ordnance, and Explosives Safety Specialist or equivalent, and client representative will be made as outlined in the Work Plan.
- Protective works will be implemented as described in the ESS/ESP for BIPs when applicable.
- If MEC is not intact upon discovery (e.g., has exposed high explosive or filler), this will be noted on the investigation datasheet and the MEC accountability log. If the MEC or MPPEH is judged to be acceptable for transport, it will be demolished by detonation at a location identified in the applicable work plan ESP or ESS.
- Any suspected hazardous material (not munitions-related related) identified will be assessed on a case-by-case basis by the SUXOS, UXOSO, and PM in consultation with the client representative. Hazardous material will be suspected to be hazardous if it emits a chemical odor, has caused soil staining, or is contained in an unidentified drum or other container commonly used (or marked) to store hazardous materials. If any doubt, materials will be reported for further investigation.

4.7 MEC, MPPEH, AND MDAS

Refer to the specific SOP for full details on MEC/MPPEH and MDAS disposal.

Targets identified as MEC or MPPEH (e.g., UXO, DMM, recovered bulk explosive, or MC) will be demolished by explosive detonation in-situ or relocated to a collection point. MEC and MPPEH will be demolished individually or as part of a consolidated shot. The day they are found, using a same-day donor explosives delivery service, placed at an approved unmarked underwater collection point, or guarded until disposal can be conducted. MEC and MPPEH will be documented from discovery to final disposal in the MEC accountability log.

Materials that cannot be certified and verified during the initial inspection as explosive free will have demolition or demilitarization activities performed on them in accordance with the project work plan.

Materials that cannot be certified and verified as inert (either following demolition disposal or otherwise) will have demolition activities performed on them again. MEC and MPPEH certified as explosive-free will be further classified as MDAS (materials documented as safe), then managed and recycled as scrap metal following the MPPEH and MDAS management SOP and project work plan.

5.0 DATA MANAGEMENT

The following sections describe the data that is needed to perform this SOP and the resulting data.

5.1 INPUT DATA REQUIRED

Target location geographic information systems files, quality program input, and AOI search polygons are needed to perform intrusive operations.

5.2 OUTPUT DATA

The primary output from this SOP is the quantities and locations of MEC, MPPEH, and the amounts of MD, RRD, and NMRD recovered. Secondary outputs include equipment inspection records and daily quality reports, and any other documentation outlined in the project work plan.

6.0 QUALITY CONTROL

Quality control will be achieved through three-phases of control as outlined in work plan definable features of work, completion of the three-phase inspections, completion of the quality control (QC) checklist for underwater intrusive investigation operation (Section 6.3), and performance metrics identified in the work plan are met. The checklist will be filled out and signed by the project UXOQCS upon completing the production unit.

6.1 MEASUREMENT QUALITY OBJECTIVES

The measurement quality objectives (MQOs) for Underwater Intrusive Investigation Operation are presented in the project work plans. Results will be documented in the daily quality control report.

6.2 REPORTING

Input to the project field management daily reports, MEC accountability log, disposal records, and any specific reporting outlined in the work plan is the reporting output from this SOP.

6.3 QC CHECKLIST FOR INTRUSIVE INVESTIGATIONS

TEAM INFORMATION						
Team:		Location:				Date:
Team Leader:						
Personnel Present:						
Contract #:						
Task Order #:						
QC CHECKLIST POINTS						
Item	Ref.	Inspection Points	Yes	No	N/A	Comments
1	UXO SOP	Have personnel read and signed the workers' statement?				
2	UXO SOP	Has the equipment been checked out, and is it documented correctly?				
3	UXO SOP	Have all intrusive results been fully and appropriately documented?				
4	UXO SOP	Have the appropriate MQOs been achieved for underwater Intrusive Investigation?				
5	UXO SOP	Were all blind seeds (if instituted) recovered?				
6	UXO SOP	Were all additional QC procedures correctly instituted and completed?				

FINDINGS	
Item	Comments

Signature:

UXOQCS or Designee: ______________________________ Date: ______________

TETRA TECH

Dive SOP 3 - Removal of MEC in a Marine Environment

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct the removal of munitions and explosives of concern (MEC), material potentially presenting an explosive hazard (MPPEH) and munitions debris (MD) in a marine environment when conducting underwater munitions response operations. This SOP covers high and low input mechanized and underwater demolition operations. Any changes or deviations will be included in the project specific work plan and approved by the Marine Operations Program Manager. SOPs will be reviewed annually.

TMR Senior Diving Supervisor, Don Schwalback		Date:	04/26/2022
TMR Director of Quality, Eugene Mikell III, CQA		Date:	04/26/2022
TMR Marine Operations Program Manager, Scot Wilson, PMP		Date:	04/26/2022
TMR Diving Safety Officer, Patrick Oberley		Date:	04/26/2022

Review Date	Reviewer	Next Review
02/10/2022	Don Schwalback, TMR Senior Diving Supervisor	02/2023
04/25/2022	Patrick Oberley, Diving Safety Officer	02/2023

SUPERVISOR'S STATEMENT

I have read and understood this SOP. To the best of my knowledge, the procedures described in this SOP can be performed in a safe, and environmentally sound manner. I have confirmed that all persons assigned to this process are qualified, have read and understood the requirements of this SOP, and have signed the worker's statement for this purpose. I will ensure the SOP contains current procedures. If a major change to the SOP is necessary, I will ensure active processes are suspended until the project specific work plan or this SOP is revised and approved. If unexpected safety, health, or environmental hazards are identified, I will make sure the process is stopped until the hazards have been eliminated.

________________________________ ________________

SUXOS/Diving Supervisor Date

WORKER'S STATEMENT

I have read Dive SOP Removal of MEC in a Marine Environment and have received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

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ACRONYMS AND ABBREVIATIONS

APP	accident prevention plan
BEM	buried explosion module
BIP	blow-in-place
DDESB	Department of Defense Explosives Safety Board
DOD	U.S. Department of Defense
DS	diving supervisor
DSPM	diving safe practices manual
EM	Engineer Manual
ESA	Endangered Species Act
ESP	explosives site plan
EZ	exclusion zone
GPS	global positioning system
HASP	health and safety plan
LED	light-emitting diode
MEC	munitions and explosives of concern
MFD	maximum fragment distance
MPPEH	material potentially presenting an explosive hazard
MQO	measurement quality objective
MRB	master reference buoy
MRDB	master reference disposal buoy
MSD	minimum separation distance
NONEL	Non-Electric
PM	project manager
QC	quality control
RFD	remote firing device
RTB	raise, tow, and beach
SM	shark marine underwater navigation system
SOP	standard operating procedure
SUXOS	senior unexploded ordnance supervisor
TL	team leader
TP	technical paper
U.S.	United States
USCG	U.S. Coast Guard
UXO	unexploded ordnance
UXOQCS	UXO quality control specialist

UXOSO UXO safety officer

1.0 PURPOSE AND SCOPE

1.1 PURPOSE

This standard operating procedure (SOP) provides basic procedures specific to the recovery of munitions and explosives of concern (MEC) in a marine environment identified during underwater munition response projects. Mechanized operations outlined in explosive safety planning are often referred to as raise, tow, and beach (RTB) operations in the field. Phases of this SOP include the following:

- Underwater target reacquisition and recovery of the MEC
- Mechanized operations - RTB MEC for further processing.
    - High input operations are higher risk removal activities for MEC that is categorized as unacceptable to move and completely remotely.
    - Low input operations are lower risk removal activities for MEC that is categorized as acceptable to move and completely both remotely and in situ.
- Processing/ treatment of the MEC using demolition procedures

The procedures above will be conducted following a project-specific Work Plan (of which this SOP will be a part), health and safety plan (HASP) or accident prevention plan (APP), and applicable United States (U.S.) Department of Defense (DOD) guidance, including Engineer Manual (EM) 385-1-1, EM 200-1-15, DOD 6055.09-M, EM 385-1-97, Explosives Site Plan (ESP) or Submission, and DOD Explosives Safety Board (DDESB) Technical Papers (TP)16 and TP18. In addition, underwater explosive detonation (blow-in-place [BIP], consolidated shot, or deep-water disposal) is not allowed unless coordination to address concerns of endangered marine life and associated habitat has been completed with the appropriate authorities. All mitigation requirements shall be coordinated and in place for this activity. This coordination will take place with the understanding that underwater detonation would take place as a last resort and only if minimization measures can be implemented in a way that avoids jeopardy of listed species or destruction and adverse modification of designated critical habitat. This procedure's diving aspects will be per the TMR corporate Diving Safe Practices Manual (DSPM), U.S. Army Corps of Engineers EM 385-1-1, section 30, and the project specific work plan.

1.2 SCOPE

This SOP provides the detailed information needed to safely perform the procedures above and protect personnel, equipment and the environment, particularly endangered species act (ESA) resources. Specific requirements are defined in the project specific work plan for notification procedures, personnel, training, equipment, material, field procedures, and documentation. This SOP will be used in conjunction with applicable regulatory guidance. These SOPs apply to Tetra Tech TMR employees who conduct recovery and processing of MEC.

The senior unexploded ordnance (UXO) supervisor (SUXOS)/UXO diving supervisor (DS), in collaboration with the project manager (PM), is responsible for the execution of this procedure during underwater munitions response projects. The final approval authority for changes to this SOP ultimately rests with the TMR Marine Operations Program Manager.

2.0 PERSONNEL, TRAINING, EQUIPMENT, AND MATERIALS

This section describes the minimum requirements for personnel, equipment, and materials to safely implement these procedures.

2.1 PERSONNEL

All field personnel will meet the requirements of DDESB TP 18, including UXO technicians qualified to perform diving operations. It is expected that all operations will occur in a marine environment or have a marine component; thus, field operations will be planned and conducted by the following personnel:

- SUXOS / diving supervisor (DS)
- UXO Quality Control (QC) Specialist (UXOQCS)
- UXO Safety Officer (UXOSO)
- UXO Dive Team (minimum of four personnel)

Note: Mechanized operations performed on MEC may need additional support personnel to conduct the simultaneous operations and coordination required.

A dive team that includes personnel who are qualified explosive handlers will conduct underwater demolition operations. Underwater explosive detonations (e.g., BIP, in water consolidated shot, or deep-water disposal) shall not be conducted unless coordination to address personnel safety, equipment, property protection and endangered marine life concerns have been completed with the appropriate authorities. All mitigation requirements that are required must be coordinated and in place prior to commencing operations. Underwater detonations would be performed in an emergency, as a last resort, and only if measures can be implemented that avoids personnel injury, equipment or property damage, jeopardy of any listed species or destruction and modification of any designated critical habitat.

The SUXOS/DS will be responsible for planning, directing, and executing all field operations. The SUXOS/DS may designate a UXO technician III as the Demolition Supervisor. An assigned demolition team will assist the demolition supervisor as required during the demolition operations. The SUXOS/DS may designate an alternate UXO Dive Supervisor as needed to assist with the mechanized operations in the MEC recovery phase.

The UXOSO will be stationed on-site and will maintain visual contact to the best extent possible with the dive and demolition teams downrange during field operations. The UXOSO will maintain communications with the field management team.

The UXOQCS will ensure all operations are performed correctly in accordance with this SOP, the QC plan, and all other applicable guidelines of the approved project work plan. He will also assist the UXOSO as an on-site safety observer.

2.2 TRAINING

All Tetra Tech UXO technicians will meet the qualification and professional training requirements presented in the DDESB TP-18 and the project specific work plan. Before conducting field operations, project-specific training will be provided to all involved personnel. The topics to be covered include, but will not be limited to, the following:

- Project summary and approach – Work Plan review
- HASP/APP review
- Dive Plan and relevant SOP review
- Demolition notifications
- Exclusion zone (EZ) management
- Type and condition of potential MEC
- MEC accountability
- Material potentially presenting an explosive hazard (MPPEH) management/handling/inspection procedure

- Review of donor charge placement
- Documentation and recordkeeping
- Logbook/personal digital assistants
- Demolition/dive team staffing (team assignments)
- Subcontractor management (same day explosives delivery procedures) if applicable
- Equipment training
- Mechanized Operations Equipment Checklist (Appendix 1)
- Demolition Equipment Checklist (Appendix 3)
- All-metals Detector
- Shark Marine underwater navigation system (SM)
- Daily health and safety briefing
- Emergency equipment review
- Talk through/walk-through of emergency procedures
- First aid/cardiopulmonary resuscitation
- Site-specific munitions training

Other pertinent documents, including publications for the various MEC that may be encountered, will also be reviewed, as required. A practical training exercise (rehearsal) with all team members shall be conducted prior to performing mechanized operations.

2.3 EQUIPMENT

The SUXOS/DS will be responsible for ensuring all required equipment and materials are on site. At a minimum, the following will be checked daily before commencing field operations:

- Mechanized operations equipment (Appendix 1)
- Health and safety equipment per Boat Pre-Operation Checklist (project work plan)
- Support vessels, small boats/inflatables as required
- Diving equipment per the project work plan and DSPM
- Demolition operations equipment (Appendix 3)
- Health and Safety equipment (Appendix 4)

3.0 PLANNING

The task-specific procedures for conducting each of the major field operations listed for removal of MEC in a marine environment are as follows:

3.1 GENERAL SAFETY

MEC removal activities shall not be conducted until the required training and proper equipment checks have been completed, documented, and the appropriate EZ is established, marked, and secured.

If applicable, all utilities will be marked by the appropriate authorities before any intrusive or mechanized operations commence.

When MEC is categorized as unacceptable to move, one tended UXO technician diver will attach any lifting system or explosive charge to minimize exposure to the explosive hazard. The SUXOS/DS will have the discretion to use additional divers (as needed) if additional divers are determined to be less hazardous to perform the required tasks.

Personnel who are not UXO trained shall be escorted by UXO-trained personnel, after receiving site orientation and 3R training, in areas potentially containing MEC.

- Do not expose MEC to radio, cell phone, or satellite phone transmissions within 25 feet.
- Do not smoke except in designated areas.
- Prohibit non-essential personnel from encroaching upon the site.
- Suspend all operations immediately if an electrical storm is observed or detected within 10-miles of the operation.

Additional and specific safety precautions are outlined in Appendix 5 and the project specific work plan.

3.2 NOTIFICATION AND COORDINATION

Coordination with the agencies and personnel listed below are required for the safe conduct of all field operations, including any additional requirements that must be met as determined by the appropriate authorities after completion of the environmental coordination process. Prior to conducting demolition operations, the disposition of MEC will be coordinated with the resource agencies. The coordination will include determining the method and location of treatment. The SUXOS/DS will be the coordinator for personnel safety, environmental, property and equipment protection for all field operations. Specific notifications, described below, will be required to be made before commencing mechanized operations. Notices are coordinated through the SUXOS/DS and the regulating authorities, which may include, but are not limited to:

- Local Police Department
- Local Fire Department
- U.S. Coast Guard (USCG) or applicable organization
- Federal Aviation Administration or applicable organization
- U.S. Fish and Wildlife Service or applicable organization
- U.S. Environmental Protection Agency or applicable organization
- National Oceanic and Atmospheric Administration or applicable organization
- Local municipality
- Tetra Tech PM or the SUXOS/DS will notify the regulatory authorities before treatment operations (as outlined in the approved project specific work plan)

Prior to the field operations, a coordination meeting will be conducted to establish roles and responsibilities, and meeting minutes will be prepared and submitted for approval. The meeting will address specific planning and organizational responsibilities, communication pathways, coordination, notification processes, and reporting requirements. Topics will include:

- Mechanized operation team make up and assignments
- Demolition team make up and assignments
- Explosive handling, storage, and transportation
- Required support services, fire, medical, security, etc.
- Emergency procedures

- Procedures for maintaining EZs
- Community impact
- Identification of project reporting requirements during all phases of project planning, execution, and closeout (e.g., Work Plans, Production Reports, Project Status Reports, Daily Quality Reports)
- Endangered species/critical habitat impact and mitigation requirements
- Notification process to stakeholders and regulating authorities

3.3 COMMUNICATIONS

Two methods of communication will be used during field operations. A designated cell phone will be the primary means of notifying emergency responders (i.e., dialing 911). As a secondary emergency communications measure, a marine very high-frequency radio will be on-site and available to communicate with the USCG (or local authorities). Communication (via radio) will be the primary means among the field team members. Communication checks between the supporting teams, team leaders (TLs), UXOSO, UXOQCS, and the SUXOS/DS will be verified before commencing operations. If available, Tetra Tech site office landlines can be an additional means of off-site communication.

3.4 EXCLUSION ZONES

Mechanized MEC processing operations may be considered high or low input operations per DOD 6055.09-M, Volume 7, depending on the risk assessment. If MEC is deemed to be unacceptable to move, and it may be relocated remotely using a lifting mechanism, this will be viewed as a high input operation due to a higher level of risk. If MEC is deemed acceptable to move and on-site transport using a lifting balloon is performed, this will be considered a low input operation. The Maximum Fragment Distance (MFD) will be used while towing a munition underwater for high and low input operations. The MFD will be calculated by the Buried Explosion Module (BEM) using the depth of water the MEC is being suspended while under tow. MEC must remain submerged at a water depth allowing the MEC to clear any obstructions on the bottom, but also provide enough tamping to be protective to the UXO team conducting the lift and tow operations. A marker buoy will be attached to the MEC to provide visibility if the MEC becomes separated from the lifting mechanism during the lift and tow procedures. If equipped, the tow vessel shall use the “track route” feature on the boats’ global positioning system (GPS) system.

During mechanized MEC processing operations, net explosive weight, depth of water, and burial depth for planned detonation will be used to calculate the appropriate EZ using the U.S. Army Munitions Response Actions – Minimum Separation Distances (Relative to Impulse Water Pressure) from Underwater Detonations (Safe Separation Distance for Swimmers and Divers) SAIE-ESOH Memorandum, and the most recent BEM model. EZs will be calculated and may be adjusted for the following situations:

- Initial EZs will be calculated for the specific MEC and will be observed during the mechanized operations.
- During tow operations, EZs will be adjusted on the surface using the BEM for the appropriate depth of tow. Underwater EZ will also be adjusted and maintained along the entire tow route considering the depth of tow.
- A support boat of adequate size to support operations will remain outside the EZ and be prepared to support the UXO dive team as required.
- Before the beaching operations, the SUXOS/DS shall ensure the predetermined surface EZ is established and maintained for the MEC. This EZ will be enforced until the MEC is buried (if using the BEM), which can then be further adjusted for the calculated BEM used.

MEC will be towed only on the approved routes based on the factors outlined above. This information will be provided to the regulating authorities for confirmation and approval. The EZ will remain intact until the SUXOS/DS has verified the site is safe and all field operations are complete. If EZ cannot be secured, guards will be posted, and work halted if non-essential personnel enter the minimum separation distance (MSD). Mechanized operations will not resume until non-essential personnel have exited the MSD.

3.5 WEATHER AND ENVIRONMENTAL CONSIDERATIONS

Prior to commencing field operations, the SUXOS/DS will obtain a local weather report. Operations will not be conducted above sea state 1 or if small craft warnings are forecasted. Demolition operations will not be conducted if electrical storms are within 10 miles of the demolition site or during any severe weather conditions that might impact safety.

Environmental monitoring will be conducted following the project specific work plan. Reconnaissance by the regulatory agencies, project biologists, marine mammal observers (if assigned), and the SUXOS/DS of the primary and alternate tow routes and the approved beaching sites will be conducted to ensure that:

- Minimum habitat impact to the landing area on the beach.
- Proper depth of tow and the tow route selected provide enough area to conduct the task safely and will not adversely impact or damage any habitat by these operations. Use of a floating line for the primary tow and beaching lines to minimize impact to habitat.
- The routes and beach landing areas will be marked physically using visible day shapes, markers, buoys, and line of sight guides and electronically using a GPS.

3.6 MEDICAL

Specific medical support requirements are identified in the project specific work plan HASP or APP. A person qualified to respond to medical emergencies will be on-site for all demolition shots and will have equipment capable of treating traumatic injuries resulting from an explosion. .

3.7 FIRE

All project support vessels and vehicles will have at least one fire extinguisher onboard. Additional firefighting equipment will be provided as outlined in Appendix 3, 4, and 6 and any additional requirements that are outlined in the project specific work plan.

3.8 PERSONAL PROTECTIVE EQUIPMENT

Unless otherwise directed, all land-based field operations will be conducted in Level “D” personal protective equipment. The SUXOS/DS in conjunction with the UXOSO/SSHO may modify the PPE level as required. UXO divers will be dressed following the project specific work plan and the DSPM.

3.9 RECORDKEEPING

For field operations, the SUXOS will ensure, at a minimum, complete the following:

- Field Team Logs (maintained by UXO technician III/TL)
- MEC Accountability Log
- Appropriate MPPEH Inspection Certifications
- Dive logs as required in the project specific work plan and DSPM

4.0 EQUIPMENT SETUP

4.1 RECEIPT ON-SITE

Materials or equipment received at the site will be inspected for serviceability and against purchase order requirements. Photos will be taken and filed with the daily QC reports or the Quality Receiving Inspection Report.

Handheld geophysical sensors will be tested. If applicable, search programs uploaded and verified in the applicable Functional Check Area or Instrument Verification Strip for functionality, following the approved project work plan and manufacturer's operator's manual.

Handheld or other GPS devises for use during these operations will be checked for the correct project and coordinate upload.

All cameras and video systems will have video cards, cables and batteries checked.

Vessels, project support vehicles and equipment will be inspected for damage and verified as operational. Photos will be taken and given to the site safety and health officer.

4.2 DAILY - PRIOR TO OPERATIONS

Electronic equipment will be tested prior to beginning operations each day, and the results recorded in the team logbook or on forms. All GPS and other navigation systems will be checked in accordance with the project specific QCP before use to ensure accuracy during use. Handheld geophysical sensors will be checked in accordance with the project specific QCP before daily operations begin. All tests will be reported to the UXOQCS for inclusion in the daily report.

Vessels, project support vehicles and equipment will be inspected daily for damage and operability. Inspection forms will be submitted to the site safety officer weekly.

5.0 OPERATIONS

5.1 PROJECT BRIEFS

The following briefs will be given and documented before conducting any mechanized and underwater demolition operations:

- Operation overview
- Team assignments
- Type and condition of expected MEC
- Dive Plan
- Demolition Plan
- Emergency procedures

In addition, a briefing by the project biologist and/or client regulatory representative may be required based on the requirements identified after completion of the ESA coordination process or outlined in the project specific work plan.

5.2 TARGET REACQUISITION

Targets will be reacquired by navigating to the target site using the SM or a GPS unit and deploying a master reference buoy (MRB) offset 10 feet down current from the location of the target. The anchor will be a soft anchor, such as a sandbag or soft dive weight, and lowered by hand to the bottom. The UXO diver will deploy on this MRB. If the target is buried or in case of low visibility, the diver may utilize manual search equipment (search patterns). The UXO diver will then navigate to the last known position indicated by the SM to reacquire the MEC. If a GPS is used, the diver will conduct a manual circle line search around the MRB to reacquire the MEC. Once the MEC is reacquired, the diver will affix a marker float directly to the target. The UXO diver will then proceed with mechanized procedures (described in 5.3) or underwater detonation procedures (described in 5.4).

5.3 RECOVERY USING HIGH AND LOW INPUT MECHANIZED PROCEDURES

When underwater detonation is not permitted, consolidated demolition operations must be carried out ashore. MEC categorized as unacceptable to move, or any MEC that is of a size and weight that are acceptable to move but cannot be lifted and recovered by the UXO diver (or manually/ mechanically hoisted by dive boat personnel), will be remotely raised, towed to beach site, and remotely beached for follow-on treatment by detonation. Appropriate earthworks and earthen tamping will be employed to reduce the blast and fragmentation distances for the specific munition involved. It should be noted that the EZ for the munition involved must be observed during mechanized operations, as there is a possibility of an unintentional detonation during such activities. Once beached, the MEC will be treated of as outlined in the Tetra Tech UXO SOP - MEC Management and Disposal. Utilizing a main charge, detonating cord, and remote positive control initiation (e.g., using Non-Electric (NONEL) detonators as the primary and electric detonators as the secondary, in conjunction with the radio-controlled firing device).

The general process for mechanized operations are as follows:

- Lifts for MEC that are categorized as unacceptable to move will involve the use of a remotely operated lifting device (e.g., Reverse cam rigging or SUBSALV Orca remote lifting balloon)
- Lifts for MEC categorized as acceptable to move can be manually transported to the designated treatment site using commonly used commercial salvage techniques. (e.g., commercial lifting balloons)
- UXO Diver/s will reacquire the MEC using the SM or GPS described in paragraph 5.2.
- UXO Diver/s will affix a lifting bridle, cargo net, or a mesh bag to the MEC if not part of the lifting system.
- UXO Diver/s will attach the remote lifting system if not part of the bridle to the MEC.
- UXO Diver/s will attach the transfer/ tow line to the MEC.
- UXO Diver/s surfaces, follows the transfer/ tow line to ensure clear, and attaches the transfer/ tow line to a preplaced transfer float (e.g., MRB used in reacquisition).
- After the dive team has recovered the UXO diver, the tow vessel will transit to the transfer buoy and connect the tow line to the towboat bridal or bollard if equipped.
- After the tow vessel verifies that the EZ is clear of other vessel traffic and non-essential personnel, the tow vessel captain will request permission from the SUXOS to actuate the remote lifting device or remotely lift the MEC using the reverse cam.

When the remote lift device reaches the surface, the tow vessel will ensure the MEC has been lifted, unintentional detonation has not occurred, and MEC is stable. The towboat then comes up to headway speed and begins to tow the MEC on the approved route to the selected beaching site. The tow boat will transfer the tow line using another preplaced transfer buoy holding the beaching line, connect the tow and beaching lines, and turn over the operation to the beach recovery team leader.

5.3.1 Upon Target Reacquisition

Upon target reacquisition, the UXO diver/s will configure the selected attachment system (mesh bag, cargo net, or bridle) outlined in the project specific work plan as required for the specific MEC being recovered.

5.3.2 Attach Remote Lifting Device (Reverse Cam/ MK V Orca/ Commercial Lift Bag)

If using the SUBSALV Orca Lift balloon set up the equipment using procedures outlined in the MK V Orca Operations and Maintenance Manual. For large MEC, Diver/s deploys on marker float carrying the lift balloon (with transfer line attached). A buoy will be clipped to the end of the transfer line. Diver attaches a lift balloon and opens the balloon air supply bottle. Diver/s ensures there are no obstructions to the valve release mechanism and returns to the surface following the transfer line.

When used, diver/s will rig commercial lift bags to MEC using approved methods outlined in the project specific work plan.

For small MEC, diver/s will rig MEC using a reverse cam rigging system. The reverse cam system consists of the tow rope, adequately sized tow buoy (Formula = 1 square feet for every 64 pounds), and a traxion pulley. This system will be attached to the bridle or other attachment system. The MEC will then be remotely pulled (by towboat) up to a designated depth using a stop knot, and the tow will commence using guidelines established in 5.3.3. ***Safety note*: *UXO Diver/s must return to the surface and be recovered before any tow operations or movement of the MEC.***

5.3.3 Actuate Remote Lifting Device/ Commence Tow

Towboat personnel will consist of: Coxswain, tender to handle lines, and safety observer, who continuously watches the MEC tow load. The crew shall have equipment onboard and must be ready to cut away or jettison the tow line in the event of an emergency.

Towboat personnel (an assigned tender) will attach a tow line to the transfer line. The buoy will be disconnected from the transfer line and clipped to the end of the tow line if the line must be jettisoned. When the SUXOS gives permission, the towboat will execute the remote lifting method. Once on the surface, and if authorized by the SUXOS, a support boat may be used to verify the load is secured, undertow, and at the proper depth of tow. The MEC's depth will be selected for the tow depending upon the size and explosive weight of the MEC. This method is used to reduce the hazards of fouling, unintentional detonation, and damage to habitat. This also takes advantage of the DDESB-TP-16 BEM model using the water tamp to reduce the EZ during the tow as outlined in the ESP. The EZ will return to the MFD-Horizontal outlined in the ESP when the beaching phase of the MEC is outlined in 5.3.4.

Only the pre-approved and planned route to the beaching site shall be used; alteration of the route is not authorized. Towboat should proceed only fast enough to maintain steerage. The towboat will initiate the tracking feature on the GPS if so equipped. The towboat will shorten the tow as required for safe navigation and maneuverability through restricted areas. Proper navigation day shapes, flags and signals will be displayed to alert nearby mariners of restricted maneuvering. Safety boats will provide security from any approaching vessels and any required observers for ESA species.

5.3.4 Beaching Operation

A basic beaching operation site setup is outlined in Appendix 2.

The towboat will connect the MEC being towed to the beaching line at the Transition Buoy. Lines will be attached using a shackle. If the tow boat "V" beaching option is used, the towboat will then move toward the second buoy and attach to the beaching line. If the pull is from the beach, then slack is taken up on the beaching line. The beaching team will ask permission from the SUXOS/DS to begin the pull. Begin the beaching operation pull until the MEC is on the beach at the preselected location. The towboat or beaching team will then slacken the line and disconnect from the beaching line. Refer to the project specific work plan and the UXO SOP MEC Management and Disposal for treatment procedures.

5.4 UNDERWATER MEC TREATMENT FOR PROCESSING

This section addresses identified/recovered MEC that will be treated for processing of using BIP or consolidated underwater shots. Underwater explosive detonations (BIP, consolidated shots, or deep-water disposal) are not authorized unless coordination with appropriate authorities has been completed to address personnel safety, property protection and endangered marine life or habitat concerns. All mitigation requirements shall be coordinated and in place prior to commencement of operations. This coordination will take place with the understanding that underwater detonation would take place only if measures can be implemented in a way that avoids injury to personnel, damage to property, and avoids jeopardy to listed species and destruction or adverse modification of designated critical habitat.

5.4.1 Blow-in-Place

MEC to be demolished using explosive demolition materials on the seafloor or bottom where the MEC is located. Formal approval must be obtained from the local regulatory agency for this operation. This procedure will require a diver to deliver a demolition charge consisting of donor explosives (amount and placement depending on the MEC encountered), primed with a shockwave transmission method (e.g., detonating cord). Shockwave transmitter shall be 1 ½ to 3 times the anticipated depth of water. This will provide an adequate scope to the surface and secured with a flotation device/buoy. The charge will be secured to the MEC, and a strain relief will be provided for the detonating cord. The detonating cord will not be secured to the marker anchor but will have its own anchor (dog stake, sandbag, etc.) offset from the MEC location to provide adequate strain relief. When ready for detonation, the designated support vessel will approach with the demolition firing system float and attach the demolition firing system for remote initiation. The demolition team shall obtain permission to "prime in" from the SUXOS prior to attaching the firing system to the main demolition charge.

5.4.2 Consolidated Shots

For MEC located in areas where BIP is not authorized, one of two options, depending on specific project requirements, will be employed for explosive demolition operations.

5.4.2.1 Shallow Water Disposal Area

A bottom survey will identify an underwater disposal area free of coral formations or other sensitive habitat that cannot withstand an underwater detonation. This area should have a hard sand bottom, be between 30 and 50 feet deep, and protected from weather and high-sea states, if possible. Once found and identified, this area will have a MRB installed to mark the area's center. An EZ will be established based on the worst-case munition and depth of water per the Buried Explosive Module DDESB TP 16, or as provided by the Ordnance and Explosives Safety Specialist or equivalate. The MEC will be raised, towed, and allowed to rest on the bottom within this disposal area. The disposal will then be conducted in accordance with Section 5.5.

5.4.2.2 Deep Water Disposal Area

For deep-water disposal, the MEC will be recovered remotely and towed to the designated deep-water disposal area, estimated to be more than 100 feet in depth. This area will include a semi-permanent master reference disposal buoy (MRDB), located in the center of the disposal area. From the MRDB, disposable buoys will be attached to the MRDB with 100 feet of line. The MEC will be suspended below these buoys at appropriate depths, depending on the MEC and water depth necessary to reduce the EZ to an acceptable level. This is assumed to be 30 to 50 feet in depth. Depending on the MEC, the donor charge can be placed on the MEC after being recovered into the designated support vessel. Then it can be lowered to the appropriate depth and suspended from the disposable buoys via a suspension line, not the detonating cord, which will be 3 times the depth of suspension, with the initiating end attached to a flotation device. If the MEC is not acceptable to move, it will not be recovered into the boat but towed and secured to the MRDB. A UXO diver will then attach the donor charge, as described above. Depending on the MEC size, a substantial flotation device may be required to support it in the water column (e.g., Buoy size reference = 1 cubic foot / 64 pounds buoyancy. Large MEC may require significant size buoys, bags or barrels to provide adequate buoyancy for detonation).

5.5 UNDERWATER MEC DISPOSAL PROCEDURES

5.5.1 Disposal Shot Initiation

Initiation will be performed for in-water demolition charges by placing and protecting the receiver of the remote firing device (RFD) in an improvised waterproof float assembly or appropriate floatation device. The NONEL or electrical leads connected to the receiver, and with adequate strain relief, so the NONEL or electric detonators are adequately protected when connected to the detonating cord. The RFD receiver must also be protected from the water environment, and a suitable separation provided from the detonating cord and RFD, when initiated, to protect the RFD receiver. The receiver is not an expendable item. All initiation components will be waterproofed using an appropriate sealant before deployment.

5.5.2 Shockwave Transmission Methods

The selected donor explosives are initiated by standard shockwave transmission methods using either a NONEL shock tube or a detonation cord. Detonation cord used for underwater demolition shall be reinforced and contain an explosive charge of at least 80 grams per foot. Shock tube and detonating cord components will be waterproofed using an appropriate sealant and reinforced with a strain relief method before deployment. Shock tube or detonating cord shall be 1 ½ to 3 times the anticipated depth of the donor explosive charge/ MEC. Longer lengths should be considered for deeper water depths if higher current or difficult sea conditions are anticipated.

5.5.3 Main Charge - Donor Explosives

The donor explosives used for MEC treatment are anticipated to include an appropriate main charge, detonating cord or shock tube, NONEL detonators as primary, standard electric detonators as primary, and a non-electric cap with time fuse as an alternative. A UXO technician/diver who is certified as an explosive handler will perform all setup procedures as outlined in the project work plan, explosive safety plan or submission, and applicable Tetra Tech UXO SOPs. All donor explosive main charges will be waterproofed before deployment as required. All donor explosives will be stored following the project ESP or submission.

5.5.4 Operation of the RFD

5.5.4.1 Preparation

Perform system preoperational tests and setup procedures using the operator's manual. **Do not insert the RFD key from the controller unit until ready to fire.** The SUXOS/DS will maintain custody of the key until the demolition shot is ready for initiation.

- Place the receiver in the flotation device and ensure it is watertight. Ensure there is enough standoff to protect the receiver.
- Ensure the receiver indicates a READY condition for the selected initiation method (***GREEN READY*** light-emitting diode [LED] on steady, ***RED ARMED LED*** off).
- When using electric blasting caps, cut off a firing wire length that will reach between the receiver and the detonating cord.
- Conduct a continuity check of the firing wire with a galvanometer. Shunt the free ends of the wire to prevent an electric charge from building up in the firing wire.
- Test each electric blasting cap 50 feet downwind of other explosives with a galvanometer.
- Place blasting caps behind a barricade or under a sandbag before removing the shunt and testing for continuity.
- Fully extend the leg wires and ensure the cap is pointing away from the person conducting the continuity test.
- Secure the leg wires to prevent the cap from moving during the test.
- Use only a special silver-chloride dry cell battery in the galvanometer. (Other types of batteries may provide enough voltage to fire the blasting cap.)
- Upon completion of testing, shunt the leg wires. The wires will remain shunted until ready to connect to the firing circuit.
- Retrieve caps from the barricade, ensure there is a strain relief on the firing wire.
- Approach the detonating cord float and connect the blasting caps to the detonating cord's priming loop and the strain relief to the float, so the caps cannot be pulled out of the priming loop of the detonating cord.
- For dual priming, connect blasting caps in a parallel circuit to the firing wire.
- Test the circuit with the galvanometer, and then connect the firing wire to the receiver.
- Allow the receiver float to trail downwind/current of the detonating cord float.
- Withdraw to the safe area outside of the EZ and prepare to fire the RFD.

5.5.4.2 Firing the RFD

The SUXOS will verify the EZ is clear, then give the pre-blast warnings. After sounding the 5- and 1-minute warnings on the air horn/siren and radio, the SUXOS/DS will insert the RFD key, turn the POWER switch on the controller to the right until the BATTERY LED illuminates, and perform the following procedures:

- Momentarily depress the controller STATUS button. The ***YELLOW TRANSMIT LED*** will flash for approximately 1 second. At the end of that time, a ***GREEN READY LED*** will become steady, indicating that the remote is on and in standby mode. The steady ***GREEN LED*** also indicates the remote is within range of the controller.
- Push the ARM/DISARM switch to the left and hold for 1 second. The ***RED ARMED LED*** will flash for approximately 18 seconds and then become steady. The remote is now armed.
- The SUXOS/DS will request permission to fire from the UXO Safety.

- The SUXOS/DS will then give three loud “Fire-in-the-Hole” warnings.
- The SUXOS/DS will give the command to fire the shot.
- The SUXOS/DS will then lift the safety cover on the FIRE switch and push the FIRE switch forward.

5.5.4.3 Misfire Procedures for the RFD

The SUXOS/DS will perform the following if there is a misfire:

- Make three successive attempts to fire.
- Turn off the controller and remove the key.
- Wait 60 minutes from the last initiation attempt if using NONEL or an electric firing train.
- After the wait time has elapsed, the SUXOS/DS and a safety observer will proceed via a small boat to inspect the float's firing system.
- If NONEL was used, do not remove the detonators from the detonating cord. Disconnect NONEL from the igniter tip on the receiver. Place a new NONEL detonator with lead on the igniter tip and attach it to the detonating cord priming loop.
- If electric caps were used, do not remove the old blasting caps from the detonating cord, but disconnect the firing wire from the receiver and shunt the firing wire.
- Prepare a new firing wire with dual caps. Attach to the detonating cord, as described above.

5.5.5 Non-Electric Blasting Cap and Time/ Safety Fuse

If the RFD is inoperable or not available, the secondary means of initiating the explosives will be a non-electric cap and time fuse. The SUXOS/DS will adhere to the following setup, firing, and misfire procedures.

5.5.5.1 Preparation

- Prior to each daily use, the time/safety fuse's burn rate must be tested to ensure the accurate determination of the length of time/safety fuse needed to achieve the minimum burn time of 5 minutes required to conduct demolition operations.
- Using approved crimpers, cut 6 inches off the end of the roll of time/safety fuse.
- Cut a 6-foot length of fuse from the roll and attach an igniter.
- In a safe location, ignite the fuse and measure the ignition time to spit at the 6-foot fuse end. Note this time in seconds. Divide by 6, which will give you the burn rate per foot of fuse.
- The minimum time to be used on any demolition shot will be no shorter than 5 minutes burn time, or, in this case, the minimum time required to travel outside the EZ from the time the igniters are pulled.
- Dual priming will be used. Cut two lengths of time/safety fuse from the same roll as needed to provide the required escape time. Attach igniters to one end of each length.
- Using an approved crimper, attach one No. 8 or equivalent non-electric blasting cap to the other end of each length of time/safety fuse.
- Tape the two systems together and add flotation along the length (bubble wrap works well for this). The firing system is now ready for priming.
- Cushion and protect the blasting caps for transit in the boat to the detonating cord priming loop.

5.5.5.2 Priming and Firing the Non-Electric Blasting Cap and Time/Safety Fuse System

- The SUXOS/DS will verify the EZ is clear with the UXOSO.

- The SUXOS/DS and one UXO technician/diver will approach the detonating cord float and attach the blasting caps to the detonating cord priming loop.
- The SUXOS/DS will request permission to fire from the UXOSO on the support vessel.
- The UXOSO will sound the 5- and 1-minute warnings on the air horn/siren and radio.
- The SUXOS/DS, when permission is granted, will provide three loud “Fire in the Hole” commands verbally and one via the radio, and then pull the igniters, noting the time when pulled.

5.5.5.3 Misfire Procedures for the Non-Electric Blasting Cap and Time/Safety Fuse System

The SUXOS/DS will perform the following misfire procedures:

- Observe a wait time of 60 minutes from the expected time of detonation.
- Prepare another firing system, as described above.
- After the wait time has elapsed, the SUXOS/DS and one UXO technician/diver will proceed to the detonating cord float to inspect the firing system.
- Leave the old caps and firing system in place. Attach the new system to a clean area on the detonating cord priming loop.
- Follow the procedures above for initiation.

5.5.6 Post-Demolition Procedures

Upon completion of the demolition operation, the procedures described below will be followed by all personnel or the designated UXO technicians, as appropriate:

- Wait a minimum of 5 minutes after a single shot or after a series of shots in which all detonations are accounted for. Wait a minimum of 30 minutes after shots that could not be counted.
- A confirmation dive may be required to confirm the MEC was successfully detonated depending on the MEC's size and depth of detonation, and whether the MEC was detonated on the bottom or in the water column. For larger MEC, this may be obvious from the detonation plume, but smaller MEC may not break the water's surface, again depending on the depth of water and position in the water column.
- The inspection dive will determine the MEC condition, a high order detonation, a low order detonation, or possibly mechanical damage. The inspection dive will also ascertain any damage to the bottom or surrounding area.
- If the MEC was low ordered, all pieces will be collected at the site, and a second attempt will be performed.
- The dive team will recover munitions debris after the disposal shot and will process the recovered metal following the material documented as safe screening process.

6.0 QUALITY CONTROL (QC)

QC for this SOP will be achieved through visual checks of the definable feature of work, completing the QC Checklist for removal of MEC in a marine environment, and performance metrics identified in the plans are met. The checklist will be filled out and signed by the on-site quality lead or designee upon completing the mechanized operations.

6.1 MEASUREMENT QUALITY OBJECTIVES

The Measurement Quality Objectives (MQOs) for removing MEC in a marine environment are presented in the project specific plans. Results will be documented in the team logbooks and the daily field management team's reporting.

6.2 REPORTING

The SUXOS/DS will provide input and updates to the project MEC Accountability Log, the SUXOS/DS, UXOQCS, and UXOSO will provide input and updates using reporting procedures from this SOP and as outlined in the project work plan.

6.3 QC CHECKLIST FOR REMOVAL OF MEC IN A MARINE ENVIRONMENT

TEAM INFORMATION		
Team:	Location:	Date:
Team Leader:		
Personnel Present:		
Contract #:		
Task Order #:		

QC CHECKLIST POINTS

Item	Ref.	Inspection Points	Yes	No	N/A	Comments
1	**Workers' Statement**	Have all MEC mechanized operations and disposal team members read this SOP?				
2	**QAPP**	Have assigned team members received training and demonstrated proficiency on all equipment?				
3	**SOP**	Did all personnel attending the morning safety/operational briefing sign-in?				
4	**SOP**	Did the Team Leader conduct and document the Tailgate Safety Briefing before beginning operations?				
5	**SOP**	Did all recovered MEC undergo the three-tiered inspection process?				
6	**SOP**	Did the SUXOS and UXOSO assess all MEC and agree that the risk associated with movement is acceptable or not?				
7	**SOP**	Was the decision to move MEC documented in writing before movement or transporting the items to the collection point or beaching site?				
8	**SOP**	Were all steps conducted correctly for reacquisition operations?				
9	**SOP**	Were all steps conducted correctly for MEC mechanized operations?				
10	**SOP**	Did the Demolitions Supervisor conduct and document the demolitions briefing?				
11	**SOP**	Was the EZ established and observed?				
12	**SOP**	Was the demolition sequence observed?				
13	**SOP**	Were donor charges properly prepared?				
14	**SOP**	Were post-demolition operations conducted?				

FINDINGS

Item	Comments

Signature:

UXOQCS or Designee: ______________________________ Date: ______________

APPENDIX 1 MECHANIZED OPERATIONS EQUIPMENT CHECKLIST

TETRA TECH

MECHANIZED OPERATIONS EQUIPMENT CHECKLIST

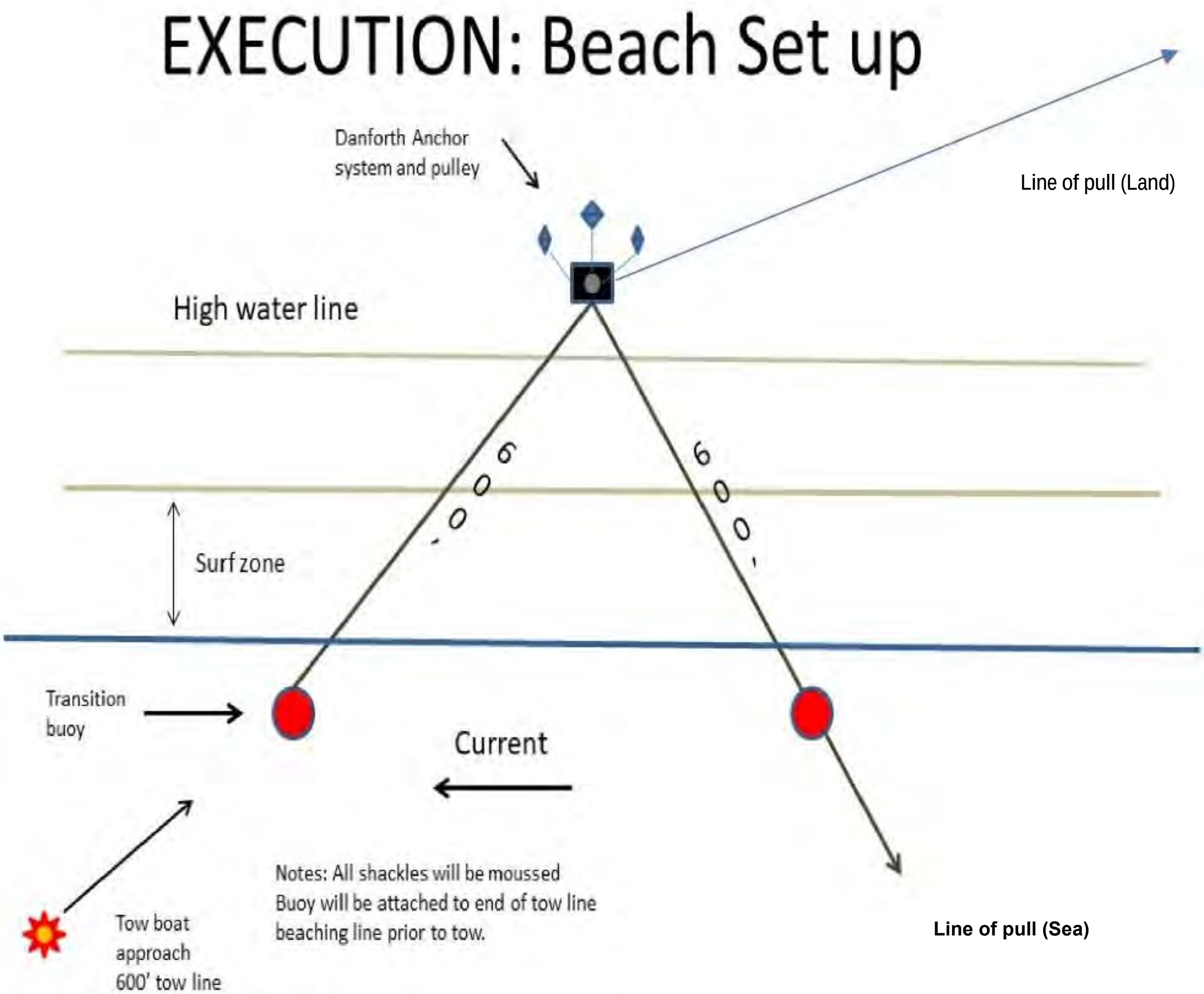
Equipment List

Equipment	Quantity	Comments
Dive Support Boat		
Tow – Transport Boat		
Towing Day Shape (Ball/Diamond/Ball)		
Support Vessel(s)		
Handheld Radios (Marine Band)		
Cellular Telephones		
GPS		
Lift System (MK V Orca)		
Towline - AMSTEEL FLOATING		
Beaching Line - AMSTEEL FLOATING		
Transition Buoy System		
Sandbags		
Shackles (assorted sizes)		
Fairlead/Pully		
3-Anchor System/ Deadman		
3’ Augers		
Shovel		
Buoys (small)		
Quick-release System/Pelican hook		
Load Attachment System (Bridle/Cargo		
Binoculars		
Knife		
U/W Locator		
Traxion Pulley/ (Reverse) Cam		

Checklist Verification

SUXOS Signature:	Date:

APPENDIX 2 MECHANIZED OPERATIONS BEACHING SETUP



EXECUTION: Beach Set up
Danforth Anchor system and pulley
Line of pull (Land)
High water line
600'
600'
Surf zone
Transition buoy
Current
Notes: All shackles will be moussed
Buoy will be attached to end of tow line
beaching line prior to tow.
Tow boat approach 600' tow line
Line of pull (Sea)

APPENDIX 3 DEMOLITION EQUIPMENT CHECKLIST

TETRA TECH

DEMOLITION EQUIPMENT CHECKLIST

Equipment List

Equipment	Quantity	Comments
Explosive Vessel(s)		
Support vessel(s)		
Camcorder/Digital Camera		
Siren		
Air Horn		
Handheld Radios		
Cellular Telephone(s)		
Electronic Firing Device		
Radio Controlled Firing Device		
Ruler, 24-inch		
Fisher U/W Locator		
Shovel, round point, long handle		
Shovel, round point, short handle		
Blasting Machine		
Tape, duct		
Tape, measuring, 50- or 100-meter		
Tape, plastic		
Toolbox, general hand tools		
Galvanometer		
Firing Wire		
Demolition Kit without Donor Explosives		
Knife		
Floats/buoys		
600’ ¼ inch nylon line		
Zip Ties		

Checklist Verification

Demolition Supervisor Signature:	Date:

APPENDIX 4 HEALTH AND SAFETY EQUIPMENT CHECKLIST

TETRA TECH

HEALTH AND SAFETY EQUIPMENT CHECKLIST

Equipment List

Equipment	Quantity	Comments
Air Horn, emergency		
Burn Blanket		
Burn Kit		
Emergency Eye Wash		
Fire Blanket		
Fire Extinguisher, 10-pound ABC		
Bloodborne Pathogen Kit		
First Aid Kit		
Gloves, leather		
Goggles		
Face Shield(s)		
Welders' Gloves		
Welders' Apron(s)		
Rain Suit(s)		
Safety Vest(s)		
Stretcher		
Water, 5-gal bottle (emergency shower)		
Water, drinking - 1 liter per person		
Personal Flotation Devices		
Other:		

Checklist Verification

Demolition Supervisor Signature:	Date:

APPENDIX 5 GENERAL SAFETY PRECAUTIONS

TETRA TECH

GENERAL SAFETY PRECAUTIONS

General and Pre-Detonation

1. Carry blasting caps in approved containers and keep them out of the direct rays of the sun. Keep the caps located at least 25 feet from other explosives until they are needed for priming.
2. Do not work with electric blasting caps or other electro-explosive devices while wearing clothing prone to producing static electricity (e.g., nylon, silk, synthetic hair).
3. Do not use explosives or accessory equipment that is obviously deteriorated or damaged. They may cause premature detonation or fail completely.
4. Always point the explosive end of blasting caps, detonators, and explosive devices away from the body during handling.
5. Use only standard blasting caps of at least the equivalent of a commercial No. 8 blasting cap.
6. Use electric blasting caps of the same manufacturer for each demolition shot involving more than one cap.
7. Do not bury blasting caps. Use detonating cord to transmit the explosive wave from the blasting caps, on the surface, to a buried/tamped explosive charge. Buried blasting caps are subject to unobserved pressures and movement, leading to premature firing or misfires.
8. Test electric blasting caps for continuity at least 50 feet from any other explosives before connecting them to the firing circuit. Upon completion of testing, the lead wires will be shunted by twisting the wires' bare ends together. The wires will remain shunted until ready to be connected to the firing circuit.
9. MECs with lugs, strong backs, tail-booms, base plates, etc., should be oriented away from personnel locations.
10. Consideration should be given to tamping the MEC to control fragments if the situation warrants. Fragments will be minimized to protect personnel and property, such as buildings, trees, etc.
11. Loose initiating explosives (tetracene, lead styphnate, mercury fulminate, and lead azide) manifest extreme sensitivity to friction, heat, and impact. Extra precautions are required when handling these types of explosives. Always keep initiating explosives in a water-wet condition until ready for final preparation for detonation. The sensitivity of these explosives is significantly increased when dry.
12. Exercise extreme care when handling and preparing high explosives for detonation. They are subject to detonation by heat, shock, or friction.
13. Do not pack bomb fuze wells with explosives unless it can be positively confirmed that the fuze well does not contain any fuze components.
14. Photo flash bombs must be handled with the same care as black powder-filled munitions.
15. Know and observe federal, state, and local laws/regulations, which apply to the transportation, storage, and use of explosives.
16. Do not permit metal, except approved metal truck bodies, to contact explosive containers.
17. Do not transport metal, flammable, or corrosive substances with explosives.

18. Do not allow smoking or unauthorized personnel in vehicles transporting explosives.
19. Carefully load and unload explosives from vehicles. Never throw or drop explosives from the vehicle.
20. Ensure the load is blocked and braced to prevent it from movement and displacement.
21. Do not drive vehicles containing explosives over public highways until all permits and certifications have been obtained from state enforcement agencies.
22. All routes must be approved in writing before transporting explosive materials over public highways.
23. Licensed commercial carriers will conduct the shipment of explosive materials over public highways.
24. Never leave a vehicle loaded with explosives unattended.
25. Do not store blasting caps, detonators, or other items containing initiating explosives in the same box or container with other explosives.
26. Do not use any alkaline material such as lye, washing soda, or soap to remove TNT exudate. Alkaline materials will react with TNT to render it more sensitive.
27. Do not permit smoking, matches, or other fire or flame sources within 100 feet of an area in which explosives are being handled.
28. Do not expose explosives or devices containing explosives to direct sunlight. Prolonged exposure can increase sensitivity and deterioration.
29. Do not carry explosives or explosive components in pockets or on the body.
30. Do not use pull rings or safety pins to lift or handle explosive devices.

Detonation

31. Do not use improvised methods for initiating blasting caps.
32. In the event of a misfire when disposing of explosives by detonation, do not approach the disposal site for at least 30 minutes after the expected detonation time when firing electrically. When conducting non-electric procedures, the wait time will be at least one hour from the expected time of detonation.
33. Anticipate a high-order detonation when burning pyrotechnic or incendiary-loaded MEC. Safety measures for personnel and property must be based on this possibility.
34. Maintain minimum safe distances between electromagnetic-radiating sources and electro-explosive devices in accordance with EODB/TM-TO 60A-1-1-12.
35. Do not conduct blasting or demolition operations during an electrical, dust, sand, or a snowstorm severe enough to produce atmospheric static electrical charges or when such a storm is nearby (within 10 miles). All operations will be suspended or terminated under such conditions, cap and lead wires shunted, and personnel removed from the demolition area. Demolition operations will also be terminated if visibility becomes less than 600 feet.
36. MEC containing white phosphorous will not be detonated into the ground. White phosphorous munitions will be counter-charged on the bottom centerline (CCBC) when possible.

37. Do not allow any wood, paper, or other materials used in packing explosives to be burned in a stove, fireplace, or other confined space or to be re-used for any other purpose. The donor explosives delivery subcontractor will remove such materials.
38. Do not insert anything but a time fuse or detonating cord into the open end of a blasting cap.
39. Do not strike, tamper with, or attempt to remove or investigate the contents of an electric/non-electric blasting cap, detonator, or other explosive initiating devices. A detonation may occur.
40. Do not pull on the electrical lead wires of electric blasting caps, detonators, or electro-explosive devices. A detonation may occur.
41. Do not attempt to remove an unfired or misfired primer or blasting cap from a base coupling. There is a high risk of an explosion.
42. Do not allow unauthorized or unnecessary personnel to be present when explosives are being handled.
43. Always point the explosive end of blasting caps, detonators, and other explosive devices away from the body.

Post-Detonation

44. Avoid inhaling the smoke, dust, or fumes of burning pyrotechnic or incendiary materials. The smoke, dust, and fumes from many of these materials are irritating and/or toxic if inhaled.
45. Do not use water on incendiary fires. Water may induce a violent reaction or be completely ineffective, depending on the mixture.
46. After the demolition operation, a search of the detonation site will be conducted to ensure complete disposal was accomplished.
47. Do not abandon any explosives.
48. Do not leave explosives, empty cartridges, boxes, liners, or other materials used in the packing of explosives lying where children, unauthorized persons, or livestock can approach them.
49. Do not fight fires involving explosive material. Evacuate all personnel to a safe location and secure the area.
50. Ensure all unused explosives are returned to their proper containers and ensure the container is closed after use.

APPENDIX 6 DEMOLITION OPERATIONS CHECKLIST

TETRA TECH

DEMOLITION OPERATIONS CHECKLIST

FUNCTION	DATE/TIME	SIGNATURE
Senior UXO Supervisor		
Assign Demolition Team		
Brief Demolition Team: - Review emergency procedures - Discuss MEC to be disposed - Describe disposal procedures		
Inspect range/EZ upon completion of operations		
Disposal Supervisor		
Verify roads are closed		
Verify EZ boundaries are in place		
Complete health and safety and equipment checklists		
Ensure the command center has completed the verification checklist: - Range Control - Medical Facility, - Fire Department, - Security/Police Department		
Demolition Supervisor tailgate safety brief: - Designate emergency vehicles - Designate emergency evacuation route - Review emergency-response		
Verify daily equipment inspection		
Verify detonators are separated from explosives		
Verify area has been evacuated		
Notify command center when operations are commencing		
Start demolition activities		
Inspect shot after the designated wait time		
Collect all metal fragments for later disposal		
Quality Control (QC) check performed		
Stop demolition activities		
QA check (if required)		
Tetra Tech notifications upon completion: - Notify client - Responsible activity - Medical facility - Fire department - Security/Police department		
Complete MEC Accountability Log		
Demobilize		
Record data in Explosive Demolition Log		
Approval		
Demolition supervisor signature:		Date:

APPENDIX 7 EXPLOSIVE DEMOLITION LOG

TETRA TECH

EXPLOSIVE DEMOLITION LOG

Project Information

Project Name:	Start Time:
Project Location:	Stop time:

MEC/MDEH Disposed of This Date (List items and quantity of each item.)

Donor Explosive Used (List types and quantity.)

Remarks

Approval

Demolition Supervisor:	Date:

TETRA TECH

UXO SOP for MEC Management and Disposal

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct MEC Management and Disposal operations for munitions response projects. Any changes or deviations will be included in the project plans and approved by the Director of Technical Operations and Explosives Safety. SOPs will be reviewed annually.

Director, Health, Safety, & Environmental Jim Streib, CSP, SMS, CQA, CHST		Date:	
Director, Technical Operations & Explosives Safety Patrick Tatman	P. Tatman	Date:	6/23/2020

Review Date	Reviewer	Next Review

WORKER'S STATEMENT

I have read UXO SOP MEC Management and Disposal and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

TABLE OF CONTENTS

1.0 PURPOSE AND SCOPE

This Standard Operating Procedures (SOP) provides Munitions and Explosive Concern (MEC) management and basic explosive demolition procedures for the treatment of MEC and material potentially presenting material potentially posing an explosive hazard (MPPEH) found during the MEC activities on Munitions Response Site (MRSs). These procedures will be conducted in accordance with the Quality Assurance Project Plan (QAPP) or equivalent planning documents.

This SOP provides the detailed information needed to safely configure, conduct demolition procedures, and perform post demolition inspection and area restoration. These operations include:

- Documenting the recovery, accountability, and management of MEC/MPPEH
- Conducting disposal operations involving MEC/MPPEH
- Post disposal operations

All training on equipment or software will be either formal or on-the-job training (OJT). Training will be documented by site personnel and subject to review for accuracy and completeness. The Unexploded Ordnance (UXO) Quality Control Specialist (UXOQCS) will verify training is completed and documented.

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials required to implement this SOP.

2.1 PERSONNEL REQUIREMENTS

Explosive demolition operations require specific organizational roles and personnel assignments, specifically:

- Senior Unexploded Ordnance Supervisor (SUXOS), to oversee all demolition operations.
- Demolition Supervisor (DS), an Unexploded Ordnance (UXO) Technician Level III or above, designated by the SUXOS. The DS is responsible for planning, directing, and executing all demolition operations. The SUXOS may perform duties of the DS based on the project manning.
- Unexploded Ordnance Safety Officer (UXOSO), ensures that all demolition operations are performed safely and following the approved site-specific plans.
- Two Unexploded Ordnance Technicians Level II or I, designated to assist the DS.

2.2 EQUIPMENT

The Demolition teams conducting MEC management and disposal tasks will be equipped with the following:

- Analog Geophysical Sensor
- Disposal equipment
- Donor explosives
- Logbook and/or personal digital assistant (PDA) for recording data
- Camera

3.0 PROCEDURES AND GUIDELINES

3.1 MEC/MPPEH MANAGEMENT

When MEC and MPPEH are discovered, they are inspected and positively identified using a three-tiered inspection process while the munitions are left in place.

1. Inspected first by the UXO technician discovering the munition(s) to determine if it is MEC or MPPEH,
2. Second by a UXO Tech II to independently classify the munitions(s), and
3. Third by the UXO Tech III, Team Leader.

For MEC/MPPEH, the SUXOS and UXOSO must assess and agree that the risk associated with the movement of MEC or suspected munition is acceptable and necessary. They will document the decision in writing. If necessary, the Director of Technical Operations and Explosives Safety will be consulted and concur with the decision to move the ordnance. Based on knowledge of the site, this may be accomplished before field operations beginning.

If MEC/MPPEH are determined by the SUXOS and UXOSO to be unacceptable to move, they will be conspicuously marked, secured, and scheduled for Blow-in-Place (BIP) treatment by a demolition team.

All MEC shall be secured or guarded by a UXO technician or approved security personnel until demolition operations.

All MEC will be photographed, and as much information as possible will recorded on the dig sheet or PDA. Recorded data to include nomenclature (if known), type (projectile, mortar, rocket, mine, etc.), size, physical condition, fuzed or unfuzed, fuze type by function (e.g., point detonating, mechanical time, etc.), condition (e.g., fired or unfired, armed or unarmed), filler if known, Global Positioning System (GPS) coordinates (if different from the relocated position) and depth.

3.2 NOTIFICATIONS

The SUXOS will ensure that the agencies responsible for emergency response are notified as far in advance as possible that demolition activities will be taking place. The notifications should address scheduling, evacuations, road closures, exclusion zones (EZs), and any other required support. Table 1 provides a list of emergency telephone numbers and contacts.

Table 1: Emergency Contact Numbers

Contact	Phone Number
Fire Department	
EMS	
Police	
FAA	
Base Operations	
Anyone else not listed….	

3.3 EXCLUSION ZONES, ENGINEERING CONTROLS, AND ROAD CLOSURES

Engineering controls should be employed whenever possible to minimize the damage from demolition operations. These controls may consist of sandbags, ecology blocks, trenching, buttressing, taping of glass, mounding, flooding and/or venting to reduce the effects of detonations.

The SUXOS will ensure EZ barricades are set up with signs at all access roads and marked appropriately: Danger, UXO Remediation Project in Progress, DO NOT ENTER, and list contact information on the barricade sign.

3.4 WEATHER AND ENVIRONMENTAL CONSIDERATIONS

Before commencing demolition operations, the SUXOS or UXOSO will obtain a local weather report.

Demolition operations will not be conducted if electrical storms are within 10 miles of the demolition site or during severe weather conditions that would impact safety.

The SUXOS and UXOSO will decide on whether wind speed and visibility will hamper the safe execution of demolition operations.

3.5 FIRE SUPPORT

The telephone number of the responding fire departments will be posted in plain sight at the site office and the disposal site.

The Fire Department nearest the disposal site location will be notified of disposal operations each day.

When the fire hazard is high due to dry conditions, disposal operations will not be conducted unless mobile fire-fighting equipment is standing by and the fire department is capable of responding within five (5) minutes.

Fire extinguishers, portable water tanks, and shovels will be on-site to fight small fires. Evacuate the area if the fire approaches ordnance or explosives. Do not fight grass fires in areas where there may be ordnance or kick-outs.

Conduct a fire risk assessment before conducting disposal operations to consider the type of ordnance to be disposed of, environmental conditions on the site, and appropriate preventative measures to be employed before initiation of explosive procedures.

Consider preventative measures to include: Movement of the MEC to a prepared site, if possible, ground preparation to include scraping and vegetation removal, wetting of the site just before the commencement of operations, and tamping of the shot with sand, or water.

3.6 DEMOLITION OPERATIONS

3.6.1 Demolition Briefing

The DS will brief all personnel involved in range operations in the following areas:

- General Safety Precautions
- Type of MEC or MPPEH being destroyed
- Type, placement, and quantity of demolition material being used

- Method of initiation (electric or Nonel)
- Team assignments
- Equipment being used (e.g., Remote Firing Device [RFD], galvanometer, blasting machine, firing wire, etc.)
- Misfire procedures
- Post-shot cleanup of range procedures
- Emergency procedures

3.6.2 Preparing Donor Charges for Initiation

One Pound Pentolite Booster

1. Insert the 80-grain detonating cord into the detonator well. Insert all the way through the first hole and back through the second hole, then tie an overhand knot to secure it.
2. When using more than one booster, insert the detonating cord through each of the booster's detonator wells and secure to keep it from sliding along the detonating cord.
3. Place the booster on the MEC/material documented as an explosive hazard (MDEH) using tape or other suitable material to prevent it from moving.

Jet Perforator

1. Using tape or detonating cord clips secure the detonating cord to the jet perforator.
2. Place the jet perforator on the MEC/MPPEH using tape or other suitable material to prevent it from moving.

Binary Explosives

1. Obtain part A and part B.
2. Mix per manufacturer requirements and the site where the operation will be conducted.
3. Place on item in same manner as booster and as discussed during demolition briefing.

3.6.3 Initiation Set-ups

The UXOSO will act as a safety observer during demolition set-ups and will depart the range/demolition area before the demo team priming the donor charge. He/she will maintain communications with the team, the SUXOS, and Site Field Office at all times.

A maximum of 2 people will prime the shot. All others will be located outside the EZ.

Electric Blasting Cap

- Prior to making a connection with the electric blasting cap, the firing circuit will be continuity tested.
- All parts of the firing circuit will be kept insulated from the ground or other conductors such as bare wires, rails, pipes, or other paths of stray current.
- The shunt will not be removed from the wires until the individual performing the operation has been grounded. Electric blasting caps will be connected to the firing circuit before connection to the main initiation charge.
- Electric blasting caps of different manufacturers or types will not be used in the same system.
- The electric blasting caps will be tested for continuity with a galvanometer at least 50-ft (15.2-m) downwind from any explosives before connecting them to the firing circuit. After the testing is completed, the lead

wires will be short-circuited by twisting the bare ends of the wires together. The wires will remain shunted until ready to connect to the firing circuit.

- The electrical lead wires of electric blasting caps, detonators, or other electro-explosive devices should not be pulled; detonation may occur.
- The legs should be unrolled so that the cap is as far as possible from the operator and pointing away from him before testing.
- The blasting cap will be placed in a hole, behind a barricade, or under a sandbag before removing the shunt and testing for continuity. The cap should not point toward other personnel or explosives. Always test at the extent of lead wires with ones back towards the blasting cap.
- Only authorized and serviceable testing equipment will be used.
- The remote receiver will not be connected to the firing wires until all pre-firing tests have been completed, and all preparations have been made to fire the charge.

Nonel Blasting Cap

- No testing required
- Blasting cap should be placed in a hole, behind a barricade, or under a sandbag before priming.
- The blasting cap should not point towards other personnel or explosives.

Nonel Lead Line Splicing

- Care should be taken to keep moisture from the cut end of the shock tube.
- The DS or designated UXO Technician will perform the following procedures to cut and splice the shock tube.
- Minimize the number of splices in a shock tube line to as few as possible.
- Lead Line splicing procedure as follows:
  1. Use a sharp knife or razor blade to squarely cut (at a 90-degree angle) approximately 12 inches from a new roll or the cut-off end of a partial roll.
  2. Loosely tie the two-shock tube ends to be spliced together. Leave at least 2 inches free at the end of each shock tube beyond the knot.
  3. Pull the shock tube lightly to tighten the knot, but not so tight as to significantly deform the shock tube in the knot.
  4. Use only the splicing tubes provided to make splices. Taping the two cut ends of the shock tubes together does not make a reliable splice.
  5. Push one of the free shock tubes, to be spliced, firmly into one of the pre-cut splicing tubes at least 1/4 inch.
  6. Push the other shock tube end firmly into the other end of the splicing tube at least 1/4 inch. Attempt to push the two ends up against each other or get as close as possible.

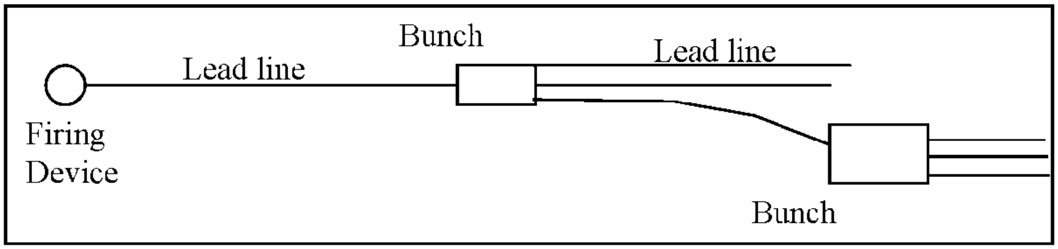
Nonel Lead Line Preparation

The DS or designated UXO Technician will perform the following procedures to set up the lead line.

1. Layout the required length of lead line from the demolition area back to the firing point.
2. Attach an EZTL 30 Bunch Block (or equivalent method) to the lead line at the demolition site using the supplied splicing tube.
3. Secure the bunch block or immobilize with sandbags.
4. Run additional lead line(s) from the bunch block to the MEC/MPPEH (see Figure 3-1).

Note: Only attach a maximum of six additional leads per bunch block. Use additional bunch blocks, if necessary.

Figure 3-1 Nonel Lead Line Setup



3.6.4 Initiation Systems

The firing system will use RFD with Nonel or electric blasting caps. As a back-up to the RFD, the Scorpion Electronic Blasting Machine with electric caps or Nonel will be used.

Remote Firing Device Preparation

1. Perform system pre-operational test and set up using the operator's manual. Remove key from controller unit until ready to fire.
2. Place the remote near the detonation site with the antenna in the vertical position. If using electric caps, the remote should be within 100 feet of the shot. Using the unit blast shield, sandbags, or natural cover to protect the remote.
3. Ensure the remote indicates a READY condition for the selected initiation method (green READY LED on steady, red ARMED LEG off).
4. If using Nonel, connect the shock tube to the igniter tip. The tube should be wrapped around through holes in the tip's molded casing to keep it from falling out. Prime the shot and return to the safe area.
5. If using electric caps, cut off a length of firing wire that will reach between the remote and the charges (100' or less).
6. Conduct a continuity check of the firing wire with a galvanometer. Shunt the free ends of the wire to prevent an electric charge from building up in the firing wire.
7. Test each electric blasting cap 50 feet downwind of other explosives with a galvanometer.
8. Place blasting caps in a hole, behind a barricade or under a sandbag before removing the shunt and testing for continuity.
9. Fully extend the leg wires and ensure the cap is pointing away from the person conducting the continuity test.
10. Secure the leg wires to prevent the cap from moving during the test.
11. Use only a special silver-chloride dry cell battery in the testing galvanometer. Other type batteries may provide sufficient voltage to fire the blasting cap.
12. Upon completion of testing, re-shunt the leg wires. The wires will remain shunted until ready to connect to the firing circuit.
13. For dual priming connect blasting caps in a parallel circuit to the extension wires.
14. Test the circuit with the Galvanometer, and then connect extension wires to the remote.
15. Retrieve caps from barricade, prime shot, and return to safe area.

Scorpion Electronic Blasting Machine Preparation

1. Perform pre-operational check as per instructions on blasting machine.
2. Layout firing wire or Nonel.
3. Conduct a continuity check of the firing wire with a galvanometer. Shunt the free ends of the wire to prevent an electric charge from building up in the firing wire.
4. Test each blasting cap with a galvanometer 50 feet downward of other explosives.
5. Place blasting caps in a hole, behind a barricade or under a sandbag before removing the shunt and testing for continuity.
6. Fully extend the leg wires and ensure the cap is pointing away from the person conducting the continuity test.
7. Secure the leg wires to prevent the cap from moving during the test.
8. Use only a special silver-chloride dry cell battery in the testing galvanometer. Other type batteries may provide sufficient voltage to fire the blasting cap.
9. Upon completion of testing, re-shunt the leg wires. The wires will remain shunted until ready to connect to the firing circuit.
10. For dual priming connect blasting caps in a parallel circuit to the firing wire.
11. Retrieve caps from barricade, prime shot, and return to safe area.

Initiation Sequence

The SUXOS or DS will ensure that the actions taken before initiating a demolition shot are completed as follows.

1. Ensure all required notifications have been made.
2. Set up EZ and post guards at the barricades.
3. Visually inspect EZ and surrounding area for unauthorized personnel.
4. **Five-minute warning**. The DS will give the five-minute warning on the radio, followed by a one-minute series of long blasts on the air-horn.
5. **One-minute warning**. The DS will give the one-minute warning on the radio, followed by a one-minute series of short blasts on the air-horn before the shot. At this time, the arming of the RFD or Blasting Machine will occur.
6. Before initiating the shot, the DS will give three loud "*Fire in the Hole!*" warnings and then give the “fire” command on the radio.

Firing the Remote Firing Device

1. Install the key and engage the "POWER" switch on the controller to the right until the BATTERY LED illuminates.
2. Momentarily depress the controller STATUS button. The yellow TRANSMIT LED will flash for approximately one second. At the end of this time, a green READY LED will come on steady, indicating that the remote is on and in the standby mode. The steady green LED also means the remote is within range of the controller.
3. Push the ARM/DISARM switch to the left and hold for one second. The red ARMED LED will flash for approximately 18 seconds then come on steady. The remote is now armed.
4. The SUXOS or DS gives three loud "Fire-in-the-Hole" warnings.
5. Then the SUXOS gives permission to fire the shot.
6. Lift the safety cover on the FIRE switch and push the FIRE switch forward.

Firing the Scorpion Electronic Blasting Machine

1. Connect the firing leads to the terminal posts of the blasting machine.
2. For Nonel plug in the shock tube adapter and attach Nonel.
3. SUXOS or DS gives three loud "Fire-in-the-Hole" warnings.
4. Then the SUXOS gives permission to fire the shot.
5. Degrees and hold CHARGE button (keep depressed throughout sequence).
6. Press DETONATE button when green ready light comes on. For non-electric shots hold DETONATE button down for one second and release.

3.6.5 Misfires

If a misfire does occur, it must be cleared with extreme caution. The responsible technician will investigate and correct the situation using the steps outlined below.

Misfire Procedures for the Remote Firing Device

1. Make three successive attempts to fire.
2. Turn off the controller and remove the key.
3. Wait 1 hour from the last initiation attempt.
4. After the wait time has elapsed, the SUXOS or DS and one other UXO technician will proceed downrange to inspect the firing system.
5. Disconnecting from RFD:
   - 5.1 If Nonel was used, do not remove the caps from the charge. Disconnect Nonel from the igniter tip on the remote firing device.
   - 5.2 If electric caps were used, remove the old blasting caps from charge and disconnect from extension wires. Shunt cap leg wires.
6. Set up new firing system.

Misfire Procedures for the Scorpion Electronic Blasting Machine

1. Make three successive attempts to fire.
2. If using firing wire and still unsuccessful disconnect wires and check continuity.
3. If continuity is good, reconnect to blasting machine and make three more attempts to fire.
4. If still unsuccessful check connections of firing wires to terminals and make three more attempts to fire.
5. Change blasting machine after third unsuccessful attempt.
6. If unsuccessful with new blasting machine disconnect and shunt firing leads.
7. If using Nonel disconnect from blasting machine.
8. Wait 1 hour from the last initiation attempt.
9. After the wait time has elapsed, the SUXOS or DS and one other UXO technician will proceed downrange to inspect the firing system.
10. Clearing the primed shot:
    - 10.1 If electric caps were used, remove the old blasting caps from charge and disconnect from firing wire. Shunt cap leg wires.
    - 10.2 If detonating cord was used cut detonating cord between cap and charge, disconnect cap from fire wire. Shunt cap leg wires.
    - 10.3 If Nonel was used, do not remove the caps from the charge. Place a new, primed explosive charge next to the misfired charge.
11. Set up new firing system.

3.6.6 Post Demolition Procedures

1. Wait the designated wait times specified by the SOP. A minimum of 5 minutes after a single shot or after a series of shots that can be counted. A minimum of 30 minutes after multiple shots that could not be counted.
2. The SUXOS or DS and one other UXO technician will return to the detonation site and check the results of the shot. If the procedure was successful, the demo supervisor will call in additional personnel to clean up the site. UXO personnel will conduct a visual sweep of the detonation site and the immediate area to gather fragments and explosive residue if present.
   2.1 Metal fragments will be examined to ensure complete consumption of explosive material.
   2.2 Explosive residue will be collected and detonated.
   2.3 Intact MEC items will be disposed of if they fail to detonate.
3. After the area is swept and cleared, the SUXOS or DS will notify the remaining personnel over the radio that the "All Clear" is given.
4. Backfill hole, as necessary.
5. Recover all equipment.

3.7 DOCUMENTATION

Forms and checklists should be generated and/or modified to meet site-specific requirements. The forms provided in this SOP may be used, or alternate forms containing the same information may be used. The SUXOS will make this determination. For disposal operations, the SUXOS or the UXO DS will, as a minimum, complete the following.

- General Safety Precautions
- Disposal Operations Checklist
- Explosive Disposal Log

4.0 QUALITY CONTROL

The MEC Management and Disposal operations will meet the quality control (QC) performance objectives identified in the QAPP or equivalent planning document and the attached quality control inspection checklist.

The QC team will verify the quality of the task through the three phases of the control process and document the results as described in the QAPP or equivalent planning document. Any tasks the QC team determines do not meet the quality control metrics, will be considered deficient or non-conforming. If a deficiency or nonconformance occurs, the UXOQCS will prepare a Deficiency Report or Nonconformance Report.

ATTACHMENTS

ATTACHMENT 1

DEMOLITION EQUIPMENT CHECKLIST

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DEMOLITION EQUIPMENT CHECKLIST

Equipment List

Equipment	Quantity	Comments
Explosive Vehicle(s)		
Personnel Vehicle(s)		
Digital Camera		
Air Horn		
Hand-held Radios		
Cellular Telephone(s)		
Remote Firing Device		
White XLT all-metals detector		
Shovel, round point, long handle		
Shovel, round point, short handle		
Blasting Machine		
Tape, duct		
Tape, measuring, 50- or 100-meter		
Tape, electricians, plastic		
Toolbox, general hand tools		
Galvanometer		
IME-22 container		
Knife		
Initiating explosives		
Donor explosives		
Fire Extinguishers, 20B:C		
Wheel Chocks		

Checklist Verification

Disposal Supervisor Signature:	Date:

ATTACHMENT 2

HEALTH AND SAFETY EQUIPMENT CHECKLIST

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HEALTH AND SAFETY EQUIPMENT CHECKLIST

Equipment List

Equipment	Quantity	Comments
Air Horn, emergency		
Burn Blanket		
Burn Kit		
Emergency Eye Wash		
Hand-held Radio and Satellite Phone		
Lightning Detector		
Fire Extinguisher, 20-pound ABC		
Bloodborne Pathogen Kit		
First Aid Kit		
Gloves, leather		
Goggles		
Face Shield(s)		
Fire Retardant Gloves		
Fire Retardant Apron(s)		
Rain Suit(s)		
Safety Vest(s)		
Stretcher		
Water, 5-gal bottle (emergency shower)		
Water, drinking -- 1 liter per person		

Checklist Verification

Disposal Supervisor Signature:	Date:

ATTACHMENT 3

GENERAL SAFETY PRECAUTIONS

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GENERAL SAFETY PRECAUTIONS

1. Carry blasting caps in approved containers and keep them out of the direct rays of the sun. Keep the caps located at least 25 feet from other explosives until they are needed for priming.
2. Do not work with electric blasting caps or other electro-explosive devices while wearing clothing prone to producing static electricity such as nylon, silk, synthetic hair, etc.
3. Do not use explosives or accessory equipment that is obviously deteriorated or damaged. They may cause premature detonation or fail completely.
4. Always point the explosive end of blasting caps, detonators, and explosive devices away from the body during handling.
5. Use only standard blasting caps of at least the equivalent of a commercial No. 8 blasting cap.
6. Use electric blasting caps of the same manufacturer for each demolition shot involving more than one cap.
7. Do not use improvised methods for initiating blasting caps.
8. Do not bury blasting caps. Use detonating cord to transmit the explosive wave from the blasting caps, on the surface, to a buried/tamped explosive charge. Buried blasting caps are subject to unobserved pressures and movement, which could lead to premature firing or misfires.
9. Test electric-blasting caps for continuity at least 50 feet from any other explosives before connecting them to the firing circuit. Upon completion of testing, the lead wires will be shunted by twisting the bare ends of the wires together. The wires will remain shunted until ready to be connected to the firing circuit.
10. In the event of a misfire when disposing of explosives by detonation, do not approach the disposal site for at least 60 minutes after the expected detonation time, when firing electrically.
11. Items with lugs, strong backs, tail-booms, base plates, etc., should be oriented away from personnel locations.
12. Consideration should be given to tamping the UXO to control fragments if the situation warrants. Fragments will be minimized not only to protect personnel but also property, such as buildings, trees, etc.
13. Avoid inhaling the smoke, dust, or fumes of burning pyrotechnic or incendiary materials. The smoke, dust, and fumes from many of these materials are irritating and/or toxic if inhaled.
14. Do not use water on incendiary fires. Water may induce a violent reaction or be completely ineffective, depending on the mixture.
15. Anticipate a high order detonation when burning pyrotechnic or incendiary-loaded MEC. Safety measures for personnel and property must be based upon this possibility.
16. Inert ordnance will not be disposed of, or sold for scrap, until the internal fillers have been exposed and unconfined. The heat generated during a reclamation operation can cause the inert filler, moisture, or air to expand and burst the sealed casings. Venting or exposure may be accomplished in any way necessary to preclude rupture due to pressure from being confined. All requirements of the UXO Procedure for the Management and Disposition of MPPEH will be met before releasing any inert ordnance material.
17. Maintain minimum safe distances between electromagnetic-radiating sources and electro-explosive devices (IAW EODB/TM-TO 60A-1-1-12).
18. Do not conduct blasting or demolition operations during an electrical, dust, sand, or snowstorm severe enough to produce atmospheric static electrical charges, or when such a storm is nearby (within 6 miles). Under such conditions, all operations will be suspended or terminated, cap and lead wires shunted, and personnel removed from the demolition area. Demolition operations will also be terminated if visibility becomes less than 600 feet.
19. Loose initiating explosives: lead azide, mercury fulminate, lead styphnate, and tetracene, these explosives manifest extreme sensitivity to friction, heat, and impact. Extra precautions are required when handling

these types of explosives. Keep initiating explosives in a water-wet condition at all times until ready for final preparation for detonation. The sensitivity of these explosives is significantly increased when dry.

20. Exercise extreme care when handling and preparing high explosives for detonation. They are subject to detonation by heat, shock, or friction.
21. Do not pack bomb fuze wells with explosives unless it can be positively confirmed that the fuze well does not contain any fuze components.
22. Photo flash bombs must be handled with the same care as black powder-filled munitions.
23. MEC containing white phosphorous will not be detonated into the ground. White phosphorous munitions will be counter-charged on the bottom centerline (CCBC) when possible.
24. A search of the detonation site, after the demo operation, will be conducted to assure complete disposal was accomplished.
25. Do not abandon any explosives.
26. Do not leave explosives, empty cartridges, boxes, liners, or other materials used in the packing of explosives lying around where children, unauthorized persons or livestock can get at them.
27. Do not allow any wood, paper, or other materials used in packing explosives to be burned in a stove, fireplace, or other confined space, or be re-used for any other purpose. Such materials will be destroyed by burning at an isolated location out of doors, with no one allowed within 100 feet of the burning operation.
28. Do not fight fires involving explosive material. Evacuate all personnel to a safe location and secure the area.
29. Know and observe international, federal, state, and local laws/regulations that apply to the transportation, storage, and use of explosives.
30. Do not permit metal, except approved metal truck bodies, to contact explosive containers.
31. Do not transport metal, flammable, or corrosive substances with explosives.
32. Do not allow smoking, or the presence of unauthorized personnel, in vehicles transporting explosives.
33. Carefully load and unload explosives from vehicles. Never throw or drop explosives from the vehicle.
34. Assure the load is blocked and braced to prevent it from movement and displacement.
35. Do not drive vehicles containing explosives over public highways until all permits and certifications have been obtained from the state enforcement agencies.
36. All routes must be approved in writing before transporting explosive materials over public highways.
37. Licensed commercial carriers will conduct the shipment of explosive materials over public highways unless Tetra Tech UXO personnel have been specifically licensed and certified to make the shipment.
38. Never leave a vehicle that is loaded with explosives unattended.
39. Do not store blasting caps, detonators, or other items containing initiating explosives in the same box, container, or magazine with other explosives.
40. Store explosive materials in military or ATF-approved magazines only. Ensure the magazines used for the storage comply with quantity distance requirements, for the class of explosive material they contain. Reference documents include: NAVSEA OP-5, TM 9-1300-206, AMCR 385-100, ATF - Explosives Law and Regulation, ATF P 5400.7, and 49 CFR.
41. Do not store spark-producing metal/tools in an explosive magazine.
42. Do not permit smoking, matches, or any source of fire or flame within 100 feet of an explosive magazine.
43. Do not allow leaves, grass, brush, or debris to accumulate within 50 feet of an explosive magazine.
44. Do not permit the discharge of firearms within 300 feet of an explosive magazine.

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GENERAL SAFETY PRECAUTIONS

45. Do not use any alkaline material such as lye, washing soda, or soap to remove TNT exudate. Alkaline materials will react with TNT to render it more sensitive.
46. Do not permit smoking, matches, or other sources of fire or flame within 100 feet of an area in which explosives are being handled.
47. Do not expose explosives or devices containing explosive to prolonged exposure to direct sunlight. Such exposure can increase sensitivity and deterioration.
48. Ensure all unused explosives are returned to their proper containers, and the container closed after use.
49. Do not carry explosives or explosive components in pockets or on the body.
50. Do not strike, tamper with, or attempt to remove or investigate the contents of an electric/non-electric blasting cap, detonator, or other explosive initiating device. A detonation may occur.
51. Do not pull on the electrical lead wires of electric blasting caps, detonators, or their electro-explosive devices. A detonation may occur.
52. Do not attempt to remove an unfired or misfired primer or blasting cap from a base coupling. There is a high risk of an explosion.
53. Do not allow unauthorized or unnecessary personnel to be present when explosives are being handled.
54. Do not use pull rings or safety pins to lift or handle explosive devices.

ATTACHMENT 4

DISPOSAL OPERATIONS CHECKLIST

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DISPOSAL OPERATIONS CHECKLIST

FUNCTION	DATE/TIME	SIGNATURE
SUXOS		
Assign Disposal Team		
Brief Disposal Team Review emergency procedures Discuss MEC/MPPEH to be disposed Describe Disposal procedures and method		
Inspect Range/Exclusion Zone upon completion of operations		
Disposal Supervisor		
Assign demolition task to team members		
Verify Not Later Than (NLT) disposal time includes wait time for misfire procedures		
Verify roads are closed		
Verify Exclusion Zone boundaries in place		
Complete health and safety and equipment checklists		
Ensure Field Site Office has completed the verification checklist Responsible activity Medical Facility Fire Department Security/Police Department		
Disposal Supervisor tailgate safety brief: Designate emergency vehicles Designate emergency evacuation route Review emergency response procedures		
Verify daily equipment inspection		
Verify detonators are separated from explosives		
Verify area has been evacuated		
Verify engineering controls are correct		
Notify Field Site Office that operations are commencing		
Start disposal activities		
Inspect shot after designated wait time		
Collect all metal fragments for later disposal		
QC check performed		
QA check (if required)		
Tetra Tech to notify upon completion: Client Responsible Activity Medical Facility Fire Department Security/Police Department		
Complete MEC/MPPEH Accountability Log and record data in Explosive Disposal Log		
Demolition Supervisor signature:		Date:

ATTACHMENT 5

EXPLOSIVE DISPOSAL LOG

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EXPLOSIVE DISPOSAL LOG

Project Information

Project Name: ______________________ Start Time: ______________

Project Location: Stop Time:

MEC Disposed of This Date (List items and quantity of each item)

QTY	NOMENCLATURE	GRID	MEC	MDAS	DATE LOCATED	DATE DISPOSAL

Donor Explosive Used (List types and quantity)

QTY	TYPE
	ELECTRIC DETONATORS
	DETONATNG CORD
	COMMERCIAL SHAPED CHARGES

Remarks

Approval

Demolition Supervisor (Signature):

Print Name ______________________________

Date:

ATTACHMENT 6

QUALITY CONTROL INSPECTION CHECKLIST

MEC MANAGEMENT AND DISPOSAL

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Contract #:		
Task Order #:		

QC CHECKLIST POINTS

ITEM	REF.	INSPECTION POINT	YES	NO	N/A	COMMENTS
1	**Workers' Statement**	Have all MEC Management and Disposal Team Members read this SOP?				
2	**QAPP**	Have assigned disposal team members received training on and demonstrated proficiency with the RFD?				
3	**SOP**	Did all personnel attending the morning safety/operational briefing sign-in?				
4	**SOP**	Did the Team Leader conduct and document the Tailgate Safety Briefing before beginning operations?				
5	**SOP**	Did all recovered MPPEH undergo the three-tiered inspection process?				
6	**SOP**	Did the SUXOS and UXOSO assess all MEC and agree that the risk associated with movement is acceptable or not?				
7	**SOP**	Was the decision to move MEC documented in writing before movement or transporting the items to the storage magazines for temporary storage?				
8	**SOP**	Were MPPEH items further classified as or MDAS, as appropriate?				
9	**SOP**	Were all MEC items photographed?				
10	**SOP**	Did the Demolitions Supervisor conduct and document the demolitions briefing?				
11	**SOP**	Was the EZ established and observed?				
12	**SOP**	Was the demolition sequence observed?				
13	**SOP**	Were donor charges properly prepared?				
14	**SOP**	Were post-demolition operations conducted?				

FINDINGS

Item	Comments

Conducted By: ______________________ **Reviewed By:** ______________________

TETRA TECH

UXO SOP MPPEH and MDAS Management and Disposal

RECORD OF DEVELOPMENT, REVIEW, VALIDATION AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct MPPEH and MDAS management and disposal operations for munitions response projects. Any changes or deviations will be included in the project plans and approved by the Director of Technical Operations and Explosives Safety. SOPs will be reviewed annually.

Director Health, Safety, & Environmental Jim Streib, CIH, CSP, CHMM, SMS, CQA,		Date:	11/09/2022
Director, Technical Operations & Explosives Safety Timothy Idom		Date:	11/09/2022

Review Date	Reviewer	Next Review

WORKER'S STATEMENT

I have read UXO SOP – MPPEH and MDAS Management and Disposal and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

TABLE OF CONTENTS

1.0 PURPOSE AND SCOPE

The purpose of this standard operating procedure (SOP) is to provide procedures and technical guidance for material potentially presenting an explosive hazard (MPPEH) inspection, management, safety, security and certification during munitions response activities, and applies to all Tetra Tech Unexploded Ordnance (UXO) Technicians involved in the inspection and management process for certifying MPPEH as material documented as safe (MDAS) before transfer within or release from U.S. Department of Defense (DOD) control.

This SOP is not a stand-alone document and should be used together with the Quality Assurance Project Plan (QAPP) or equivalent planning documents, other Tetra Tech SOPs, applicable Federal, State, local regulations, and contract restrictions and guidance.

All training on equipment or software will be either formal or on-the-job training (OJT). Training will be documented by site personnel and subject to review for accuracy and completeness. The UXO Quality Control Specialist (UXOQCS) will verify training is completed and documented.

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials required to implement this SOP.

2.1 PERSONNEL

The following individuals may be involved in MPPEH and MDAS Management and Disposal activities:

- Senior Unexploded Ordnance Supervisor (SUXOS)
- Unexploded Ordnance Quality Control Specialist (UXOQCS)
- Unexploded Ordnance Safety Officer (UXOSO)
- UXO Technicians, Levels III, II, and I
- Government or third-party Quality Assurance personnel

2.2 EQUIPMENT

- MDAS containers (e.g., 55-gallon drums, 20yd roll-off, etc.)
- Unique Numbered Seals
- Expray Kit
- Logbook and/or PDA for recording data
- Bottled water
- Camera
- Communications equipment
- First-aid kit
- Level D personal protective equipment (PPE)
- Fire extinguisher

3.0 PROCEDURES AND GUIDELINES

3.1 UXO TECHNCIAN RESPONSIBILITIES AND PROCEDURES

The objective of the following procedures is to ensure that an inspection of the exterior and interior surfaces of all recovered MPPEH is safely conducted to ensure these items do not present and explosive hazard and are not transferred from DOD or Tetra Tech custody.

Personnel will be trained and experienced in the identification, safe handling, and potential explosive hazards associated with the specific MPPEH or MDEH they are processing. Personnel qualifications vary greatly based on the material involved. Personnel processing MPPEH or MDEH will be technically qualified to determine the material's explosives safety status, including documenting the material as MDAS. During the inspection of MPPEH, if a cavity cannot be viewed clearly to verify explosive safety status, the MPPEH will be classified as MEC.

Probing of MPPEH to verify if a cavity is free of explosive is not authorized.

3.1.1 Unexploded Ordnance Sweep Personnel (UXOSP)

Not authorized to perform MPPEH assessment.

3.1.2 UXO Technician I

Initial MPPEH assessment with confirmation by a UXO Technician II or III.

3.1.3 UXO Technician II

A. Will perform a 100 percent inspection of all MPPEH and determine the following:
   (1) Is the MPPEH MEC, munitions debris (MD), range-related debris (RRD) or non-munition related debris (NMRD)?
   (2) Does the MPPEH contain explosives hazards or other dangerous fillers?
   (3) Does the MPPEH/MEC require detonation?
   (4) Does the MPPEH/MEC require demilitarization or venting to expose dangerous fillers of cavities not inspectable?
   (5) Does the MPPEH require removal of batteries, mercury seals, or switches; the draining of engine fluids, illuminating dials and other visible liquid hazardous, toxic, or radiological waste (HTRW) materials?
B. Will segregate material MPPEH requiring demilitarization or venting procedures from those items ready for certification.
C. Will process any MPPEH found to contain explosives hazards or other dangerous fillers in accordance with applicable UXO SOP – MEC Management and Disposal.

3.1.4 UXO Technician III:

A. Will perform the *initial* 100 percent inspection of all MPPEH recovered to determine if MPPEH is free of explosives hazards, dangerous fillers, engine fluids, illuminating dials, and other visible liquid HTRW materials.
B. Will supervise detonation/venting of MEC/MPPEH recovered as required to complete MPPEH inspection.

3.1.5 UXO Quality Control Specialist (UXOQCS)

A. Will conduct daily audits of the procedures used by UXO teams and individuals for processing MPPEH.

B. Will perform and document random sampling (by pieces, volume, or area) of all MPPEH collected from the various teams to ensure no MD, RRD or NMRD contains an explosive hazard, engine fluids, illuminating dials and other visible liquid HTRW.

C. Only after witnessing the 100 percent re-inspection of all MD or RRD conducted by the SUXOS, the UXOQCS will sign as the verifier on the DD Form 1348-1.

3.1.6 UXO Site Safety Officer (UXOSO)

A. Will ensure all procedures for processing MPPEH are being performed safely and consistent with applicable project documents as well as State and Federal regulations.

3.1.7 SUXOS:

A. Will be responsible for ensuring work and Quality Control (QC) Plans specify the procedures and responsibilities for processing MPPEH for final disposition as MD or RRD.

B. Will perform the *final* 100 percent re-inspection of all recovered MPPEH.

C. Will ensure a Requisition and Turn-in Document DD Form 1348–1A is completed for all MDAS and RRD to be transferred for final disposition.

D. Will be responsible for ensuring that inspected debris is secured in a closed, labeled, and sealed container and documented as follows:

   (1) The container will be closed and clearly labeled on the outside with the following information: Unique identification number that will start with the applicable DOD component/Installation Name/Tetra Tech/0001/Seal's unique identification and continue sequentially.

   (2) The container will be closed in such a manner that a seal must be broken to open the container. The container will be clearly marked with the seal's identification number.

E. Will establish a secure location for collection, processing, and storage of MD, RRD, and NMRD until transferred off site.

3.2 MD CERTIFICATION AND CONTAINERIZATION

MPPEH procedures will be in accordance with DoDI 4140.62, DoDM 4140.72, EM 385-1-97, DESR 6055.09, or OP-5. All MPPEH will be assessed, and its explosive safety status determined and documented prior to transfer within the DOD or release from DOD control. Before release to the public, MPPEH will be documented by personnel who are authorized in writing and technically qualified to certify or verify MDAS after a 100 percent inspection, and an independent 100 percent re-inspection to ensure that material is safe from an explosive perspective. The following certification and verification procedures will be followed for material suspected or determined as MPPEH:

- The UXO Technician III will conduct initial 100 percent inspection of all debris.
- The SUXOS will conduct a 100 percent independent re-inspection of all debris and certify that the debris is free of explosives hazards.
- The UXOQCS will witness the 100 percent re-inspection and verify that the debris is free of explosive hazards.

- DD Form 1348–1A Issue Release/Receipt Document will be used as the certification/verification documentation. The DD Form 1348–1A must clearly show the names and contact numbers of the SUXOS and the UXOQCS and will be completed with the following information:

  Block 2: Site Address

  Block 3: Address where the MDAS will be shipped

  Block 5: Document date

  Block 8: Cargo type (MDAS or NMRD – non-munitions related debris)

  Block 9: Mandatory Entry - Enter "U" if Unclassified material. For more Controlled Inventory Item Codes (CIIC) see DOD 4100.39-M, Volume 10, Chapter 4**,** Table 61.

  Block 10: Actual quantity received. Entered by Receiver

  Block 11: Number of items for this unit. Enter "1" if only one container is listed on the form.

  Block 12: Enter the weight of the container listed on the form

  Block 15: Mandatory Entry – Enter "0" for No Shelf-life. For more codes see DOD 4100.39-M Volume 10, Chapter 4, Table 50

  Block 16: Leave blank for the transport company

  Block 17: Basic material content such as Material Documented as Safe or Non-Munitions Related Debris with the type of metal (steel or mixed)

  Block 18: Type of container

  Block 19: Number of containers that make up the shipment

  Block 20: Total weight of all containers that make up the shipment

  Block 22: Signature of receiver

  Block 23: Date received

  Block 24: Site Name, Site Location, Company Name, and Contract Number

  Block 25: Container number - DOD component/Installation Name/Tetra Tech/0001/Seal's unique identification

  Block 26:

  - The following certification/verification will be entered on each DD Form 1348–1A for MD or RRD transferred within or release from DOD control and will be signed by the SUXOS and the UXOQCS. This statement will be used on any ranges where range related debris is to be processed along with MD:

    "The material listed on this form has been inspected, processed by DDESB-approved means, or undergone the application of expert knowledge, in compliance with DoD policy,

and to the best of my knowledge and belief the listed materials are free of engine fluids, illuminating dials, HTRW materials and do not pose an explosive hazard."

- The following certification/verification will be entered on each DD Form 1348–1A for turnover of MD and will be signed by the SUXOS and the UXOQCS where only munitions debris is being processed:

  "The material listed on this form has been inspected, processed by DDESB-approved means, or undergone the application of expert knowledge, in compliance with DoD policy, and to the best of my knowledge and belief, does not pose an explosive hazard."

Block 27:

- Certified by: SUXOS Name / Verified by: UXOQCS Name
  Tetra Tech (OU Name Here), Munitions Response Services
  Applicable OU Address
  Home Office: XXX-XXX-XXXX
  SUXOS phone number / UXOQCS phone number
  Signature of SUXOS / Signature of UXOQCS

Upon receipt of the material identified on the DD Form 1348–1A, the PM is responsible for ensuring the following blocks are completed by the qualified recycler:

- Block 10: Quantity of material received;
- Block 22: Signature; and
- Block 23: Date.

3.3 MAINTAINING CHAIN OF CUSTODY AND FINAL DISPOSITION

Tetra Tech will arrange for maintaining the chain of custody and final disposition of the certified and verified materials. The certified and verified material will be released only to an organization that will ensure MDAS will not be sold, traded, or otherwise given to another party until the contents have been smelted and are only identifiable by their basic content.

A. MDAS processing facility requirements:

- Verify container is unopened.
- Confirm containers unique Seal ID is consistent with the DD Form 1348-1A.
- Confirm Chain of Custody has been maintained.
- Sign Chain of Custody and DD Form 1348-1A
- Provide signed originals of Chain of Custody, DD form 1348-1A, and a certificate of destruction on company letterhead stating the contents of sealed containers have been smelted and are now only identifiable by their basic content.

B. If the chain of custody is broken, the affected shipment must undergo a 100 percent inspection, a second 100 percent re-inspection, and be documented to verify its explosives safety status.

C. A legible copy of inspection, re-inspection, and documentation must accompany the material through final disposition and be maintained thereafter for a period of three years.

4.0 QUALITY CONTROL

The MPPEH and MDAS Management and Disposal operations will meet the QC metrics outlined within the QAPP or equivalent planning document and the Compliance Checklist in this SOP.

The UXOQCS will verify the quality of the task through the three-phase of control and document the results as described in the QAPP or equivalent planning documents. Any tasks the UXOQCS determines to not meet the QC metrics will be considered deficient or non-conforming. If a deficiency or nonconformance occurs, the UXOQCS will prepare a Deficiency Report or Nonconformance Report.

4.1 QC CHECKLIST: MPPEH/MDAS MANAGEMENT AND DISPOSAL

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Contract #:		
Task Order #:		

QC CHECKLIST POINTS

Item	Ref.	Inspection Points	Yes	No	N/A	Comments
1	SOP	Have all personnel read and signed the workers' statement?				
2	SOP	Do all personnel performing this DFW meet the minimum qualifications required?				
3	SOP	Have all personnel performing this DFW been trained on this SOP and is it documented?				
4	SOP	Have the teams been provided maps of the overall project site and evacuation routes?				
5	SOP	Are all equipment and materials required to perform the DFW inspected, available on-site, and is it documented?				
6	SOP	Was each received container marked as MPPEH or MDAS, sealed and contained in a cleared area?				
7	SOP	Is the PPE serviceable and worn properly?				

FINDINGS

Item	Comments

Conducted By: ______________________ **Reviewed By:** ______________________

TETRA TECH

AGC SOP 11
Civil Survey

Rev. No.	Effective Date	Revision Description	Process Owner Approval	Quality Director/Manager Approval
0	6/09/17	Initial Issue		
1	7/02/17	Title change, add battery check requirement		
2	5/04/18	Procedure reviewed; minor revisions		
3	8/02/18	Minor revisions		
4	5/30/19	Procedure reviewed. Updated QSR Appendix references and Reporting section.		
5	10/06/20	Procedure reviewed. Removed requirement for monthly resurvey of all control points. Updated format.		
6	9/09/21	Procedure reviewed. Minor revisions. Included use of SLAM positioning. Included statement of impartiality.		
7	03/20/22	Procedure revised as part of the Annual Review. Minor revisions.		

TABLE OF CONTENTS

1 PURPOSE AND SCOPE

The purpose of this SOP is to identify the means and methods for acquiring land survey data to facilitate a variety of tasks. Tasks which are not solely civil survey operations will have additional requirements as detailed in their respective SOPs. These operations may be conducted using either Real Time Kinetic (RTK)-Global Positioning System (GPS), Robotic Total Station (RTS) or Simultaneous Location and Mapping (SLAM) technologies. These operations may include the following:

- Establishment of site-specific control for use during follow-up tasks;
- The establishment of area site boundaries and the internal grid infrastructure prior to survey operations;
- Marking and recording saturated response and inaccessible areas;
- Recording recovered Munitions and Explosives of Concern (MEC) / Material Potentially Presenting an Explosive Hazard (MMPEH);
- Recording QC seed locations; and
- Reacquisition of targets.

These operations may also include recording of the Instrument Verification Strip (IVS) location, the construction of which is addressed in AGC SOP 2.

2 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials required to implement this SOP. The following is a list of required equipment and materials:

- Base station and Rover GPS (for RTK)
- Radio modem (for RTK)
- Repeater (for RTK, as needed)
- Robotic Total Station (RTS), if needed
- SLAM system (e.g., Stencil-2), if needed
- Survey stakes or flags, and paint if needed

The following individuals may be involved in civil survey activities:

- Professional Land Surveyor (PLS) subcontractor
- Project Geophysicist
- Site Geophysicist
- Field Technician
- Quality Control (QC) Geophysicist
- Unexploded Ordnance (UXO) Technicians
- Unexploded Ordnance Quality Control Specialist (UXOQCS)
- Data Manager

Prior to beginning the civil survey operations, all personnel must sign off that they have read and understood this SOP. Personnel will act impartially, without bias or conflict of interest and will report results objectively based on collected evidence.

3 PROCEDURES AND GUIDELINES

Anomaly avoidance procedures will be carried out during this procedure if a MEC hazard exists at the site. Control points will be established either by reference to existing National Geodetic Survey benchmarks or by reference to High Accuracy Reference Network (HARN), Continuously Operating Reference Station (CORS), Virtual Reference Station (VRS) network, or Online Positioning User Service (OPUS) networks.

Boundary markers and grid corners will be marked at project defined intervals. These features will be marked with a wooden stake (or similar) with the appropriate identifier (e.g., Grid ID) number written on it if applicable. When staking grid corners, the IDs will be included on the southwest corner marker unless otherwise specified in the project-specific Quality Assurance Project Plan (QAPP).

When performing reacquisition of targets, the target locations will be loaded on the system controller so the technician can navigate to the location. Once the location has been reacquired, the point will be stored, and a non-metallic flag with the target number should be placed at the location.

3.1 Equipment Set-Up

Instruments will be set-up according to manufacturer instructions, which will be shipped with the equipment or provided by the Site or Project Geophysicist. If a PLS is utilized and provides their own equipment they will set it up according to their internal procedures.

Equipment shall be set up in the project defined coordinate system (e.g., NAD83 UTM meters). All survey data should be temporarily stored in the GPS/Geophysical system, downloaded daily and submitted to the project data manager, geophysicist, or Geographic Information System (GIS) manager. For OPUS confirmation, raw ephemeris and range data will be collected on the base station and submitted to the Project Geophysicist.

Prior to set-up all equipment will be verified to be in good working condition. This includes batteries, which must be verified to be fully charged.

3.2 Equipment Operations

Geodetic accuracy and functionality must be demonstrated prior to all civil surveying activities. The position offset of a known/temporary control point must be verified daily for each positioning system in use. The procedure for this is as follows:

- For RTK GPS:
  - Set up base station over a documented, independently-established control point and rover according to manufacturer instructions;
  - Ensure the rover has “lock” and is receiving corrections from the base station;
  - Ensure the rover is level and record a data point over a known, independently-established control point to ensure the accuracy meets the Measurement Quality Objective (MQO);
  - If offset exceeds the MQO, follow response action in the governing project work plan;

- For RTS:
  - Set up RTS gun over a documented control point and perform backsight in accordance with the equipment manual; or
  - Set up RTS gun at any location and perform a resection in accordance with the equipment manual;
  - Record a data point at a known, independently-established control point to ensure the accuracy meets the MQO; and
  - If offset exceeds the MQO, follow response action in the governing project work plan
- For SLAM:
  - Set up visible stakes or reflectors over known reference points;
  - Conduct mapping survey to collect a point cloud of the objects within the survey grid;
  - Process data to adjust for instrument drift;
  - Import corrected point cloud data into the SLAM unit;
  - Re-register the instrument on reference points within the point cloud;
  - Record a data point at a known, independently-established control point to ensure the accuracy meets the MQO; and
  - If offset exceeds the MQO, follow response action in governing project work plan

Where applicable, real-time data feeds (GPGGA strings and associated quality parameters) during equipment operations should be verified and monitored according to the relevant SOP.

4 DATA MANAGEMENT

The following sections describe the input and output data associated with this SOP. The field team will utilize TetraForms to record field notes and to document completion of the steps in this SOP. These data are uploaded to a cloud-based database after each field day. The Data Manager will download the daily logs and any completed SOP Checklists and save them to the project files.

4.1 Input Data Required

The following data will include a Point ID and X,Y coordinates. The specific survey task will determine which of these lists is relevant for each operation.

- Local National Geodetic Survey (NGS) benchmarks
- Survey boundary coordinates
- Grid corner coordinates
- QC seed coordinates
- Reacquired target coordinates (i.e., emplaced flag positions)

4.2 Output Data

The following items will be saved in the project files:

- GPS raw static or rover files (as applicable);

- GPS data export files;
- Completed field logs;
- Completed Field Checklist; and
- Completed QC Checklist.

The Field Checklist will document required steps in the SOP are completed. The QC Checklist will document the system was assembled and operated correctly and the resulting data meets project MQOs.

5 QUALITY CONTROL

The QC Inspection Checklist will be completed and delivered as part of the reporting requirement for this SOP Reporting. Geodetic functionality will be verified to meet the project MQOs. Positions of QC seeds will be provided only to the QC Geophysicist and/or UXOQCS. The seed registry will be firewalled in accordance with corporate procedure UXO-07.

5.1 Measurement Quality Objectives (MQOs)

The MQOs for civil survey tasks are provided in the governing project work plan. Results will be documented in the project database or equivalent running QC summaries.

6 REPORTING

The project files will contain all civil survey records. Survey data (e.g., project specific site control point information) will be saved in the master project database. Control documentation will be provided to verify Geodetic Accuracy. For any work performed by a land surveyor subcontractor, a surveyor's report will be generated as part of the subcontract agreement with Tetra Tech.

TETRA TECH

AGC SOP 13
Technical Reporting

Rev. No.	Effective Date	Revision Description	Process Owner Approval	Quality Director/Manager Approval
0	5/31/19	Initial Issue		
1	10/24/19	Revision to include statement on “opinions” as per DOC CAR.		
2	10/06/20	Procedure reviewed. Minor changes. Updated format.		
3	9/09/21	Procedure reviewed. Included statements on objectivity and impartiality. Removed requirement for signatures internal to reports. Removed checklist as redundant to DRFs.		
4	3/20/22	Procedure revised as part of the Annual Review. Minor revisions.		

TABLE OF CONTENTS

1 PURPOSE AND SCOPE

The purpose of this SOP is to provide the procedures and requirements for preparation and review of written technical reports or memoranda (herein collectively referred to as "reports") generated in support of an advanced geophysical classification (AGC) project. These procedures apply to reports provided to the Government client or project stakeholders (as applicable, according to the contract). This SOP applies only to those reports which discuss or impact the use or quality of AGC data. Non-AGC related reports are outside the scope of this SOP. Working versions of documents circulated between technical team members during document development and prior to submittal to the Corporate Quality Manager are also outside the scope of this SOP.

2 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials required to implement this SOP.

2.1 Personnel and Qualifications

The following individuals may be involved in development and internal review of technical reports prior to delivery to the Government client:

- Project Manager
- Technical Manager
- Project Geophysicist
- Site Geophysicist
- Data Processor
- Corporate Quality Manager
- Quality Control Geophysicist
- Project Quality Manager (if different than previously listed personnel)
- Unexploded Ordnance (UXO) Personnel
- Field Technicians
- Subcontractor personnel

Prior to assisting with report development, personnel must sign off that they have read and understood this SOP. Personnel contributing to development of technical reports will be experts in their respective subject matter and will be qualified to present, discuss, and justify technical results. Personnel will act impartially, without bias or conflict of interest and will report results objectively based on presented evidence.

The following individuals may be involved in external review of technical reports, as stipulated by the contract documents and project planning documents:

- Government Quality Assurance Geophysicist
- Government Project Manager
- Government Ordnance and Explosives Safety Supervisor (OESS)
- Project Stakeholders

2.2 Equipment

The following is a list of required equipment and materials:

- Computers and necessary word processing software,
- Adobe software to generate PDF documents or combine multiple PDF documents into one,
- Access to designated project Share Point site or other client-accepted file storage location,
- Portable hard drives or recordable DVD/CDs for sending large report files to clients.

3 PROCEDURES AND GUIDELINES

All technical reports involving discussion of AGC data and results will be prepared by the Project Geophysicist, or their designee, before being issued to the Project Manager. The Project Manager will perform a review, facilitate appropriate quality reviews and work to resolve comments with technical authors prior to delivery to the client. Procedures for data reviews and their respective documentation are described in the relevant SOPs.

Exceptions to this requirement are when a report presents firewalled information, such as QC seed locations, or when a specialty subcontractor is supporting the project and generates the technical report instead of the Project Geophysicist. In the case of firewalled information, the QC Geophysicist will be responsible for preparing the technical report and working with the Corporate Quality Manager (or other designated quality personnel) to resolve review comments. In the case of a technical report from the subcontractor, the subcontractor will prepare the report and provide to the Project Geophysicist (or designee) and the Project Manager for review. The Project Manager will subsequently facilitate resolution of internal review comments and getting necessary quality reviews before submitting to the client.

Report preparation will include a check for completeness and factual checks of data presented and will be documented in comments and corrections applied to pre-release versions of the report. Reports will be written impartially, without bias or conflict of interest and will report results objectively based on collected evidence. The opinions and interpretations expressed in reports will be based on the recorded data and will be clearly identified as such. In addition to the procedures of this SOP, all reports issued to the client will conform to corporate policy PO-07 (Deliverable Review) and PO-08 (Document Control and Records Management). Specific deliverable requirements, including review procedures and document formats may be modified by the contract or project planning documents.

Client and stakeholder comments will be responded to in writing with each subsequent report version. Necessary changes to a report issued as Final will be addressed through Amendments and will include a modified title which references the original document (e.g., Amendment #1 to Final Report).

3.1 Minimum Requirements

Unless stipulated otherwise by the governing contract, project planning documents or DoD-managed templates for technical documents, written reports will minimally include:

- Report title,
- Contract and task order numbers,
- Reference to project control documents,
- Address of Tetra Tech office holding the contract,
- Report date,

- Project name and location,
- Statement of completeness,
- Client name and contact information,
- References to governing project work planning documents,
- Descriptions of equipment used during the project,
- Applicable dates or date range associated with data collection and testing,
- Results and concluding statements, including applicable statements of conformity to the governing project plans,
- Discussion of factors influencing the results, particularly as they pertain to data usability and measurement uncertainty,
- Relevant non-conformance reports and supporting documentation,
- Discussion of deviations from project planning documents and supporting client approval documentation.

4 DATA MANAGEMENT

The following sections describe the input and output data associated with this SOP. The field team will utilize TetraForms to record field notes and to document completion of the steps in this SOP.

4.1 Input Data Required

Inputs include the governing contract, project planning documents (including project schedule) to understand which technical reports are required, due dates, and number of required drafts. Additional inputs may include the following:

- Raw and processed data packages,
- QC test results,
- SOP checklists,
- Copies of field logbook entries,
- Test results generated as part of the data processing work flow,
- Applicable non-conformance reports and supporting documentation,
- Applicable field change requests,

Additional inputs that may be required, depending on the nature of the specific technical report and the supporting content required to accompany the report, may include the following:

- Production reports,
- Quality control and inspection reports,
- Subcontractor reports.

Data supporting report preparation will have been collected, processed, and reviewed in accordance with the governing project planning documents, task-specific AGC SOPs, and procedure UXO-07. AGC Reports will be written using data which have undergone review by the QC Geophysicist (or designee), and, as applicable, the UXOQCS.

4.2 Output Data

The output data from this SOP include written reports with applicable supporting appendixes. In addition to this SOP, the written report will be prepared in accordance with corporate procedures PO-07 and PO-08.

5 QUALITY CONTROL

Written reports will be reviewed in accordance with corporate procedure PO-07 and UXO-07. This procedure will be documented through the completion of the Document Review Form.

6 REPORTING

The primary delivery method for written reports will be as PDF documents submitted to the Government client electronically. In cases where supporting data files are too large to send/receive through the Internet, the report may be copied to a CD/DVD or portable hard drive and sent to the client via a shipping method with delivery confirmation and tracking.

NAEVA/3Dg SOP 1

Side Scan Sonar and Bathymetry Mapping Data Collection

Rev#: 0

NAEVA GEOPHYSICS INC.

THE LEADER IN SUBSURFACE DETECTION

Subsurface Geophysical Surveys

3Dgeophysics

1. OBJECTIVE

The purpose of this Standard Operating Procedure (SOP) is to provide specific procedures and information regarding data collection and equipment to be used for the Side-Scan Sonar (SSS) and Bathymetry (Bathy) surveys.

2. EQUIPMENT AND THEORY

This SOP is applicable for the Edgetech, Inc. 4125 Side-Scan Sonar, ImpactSubsea ISA500 echosounder, Hemisphere, Inc. Vector VS330 Global Navigation Satellite System (GNSS) compass, and a HYPACK navigation system.

Edgetech 4125 Side-Scan Sonar

The 4125 SSS System is a fully digital, simultaneous, dual frequency sonar system designed to identify subsea contacts and analyze seabed conditions in real time. The 4125 series SSS system consists of three main parts; Towfish, Topside Processor and Tow Cable. The 4125 Towfish is towed through the water with transducer arrays on both sides which radiate and receive ultrasonic CHIRP pulses, it also contains the associated digital signal processing electronics. The Topside Processor provides an interface between a field rugged notebook computer running Edgetech's Discover side-scan acquisition software and the Towfish. The Edgetech Discover software provides the user with the means to control the acquisition parameters and display and record the echo data from the towfish. The echo data are used to create real-time, two-dimensional images of structures on the river bottom. A GNSS is interfaced directly with the 4125 SSS to provide position control.

Edgetech 4125 Side-Scan Sonar System

The 4125 SSS will be deployed with a hull mount on a 17-ft Jon boat. When fully loaded the boat drafts less than 2 feet in the water.

17-ft Jon boat on which Side-scan Sonar and Bathymetry Equipment will be deployed

<u>ImpactSubsea ISA500 Echosounder</u>

The ISA500 is a single-beam hydrographic echosounder with a PC interface. An Echosounder is a type of sonar used to determine the depth of water by transmitting sound pulses into water (bathymetric survey). The time intervals between emission and return of the pulses are recorded, which after post processing is used to determine water depths. The ISA500 is a variable frequency, 400-600 kiloHertz (kHz), shallow water transducer with a depth range of 0.1 – 120 meters. The same field-rugged notebook PC that is used to perform the SSS survey will be used to record the echosounder data. A serial data port on the ISA500 will be used to interface it to the PC, which will also record GNSS data for position control. The ISA500 will be deployed with a hull mount on the 3Dg survey vessel during the SSS/Bathy survey. The SSS and Bathy data will be collected simultaneously.

The ISA500 will be deployed on the same 17-ft Jon boat to be used for the SSS and underwater DGM surveys.

ImpactSubsea ISA500 Echosounder

Hemisphere, Inc. Vector VS330 GNSS Compass

The SSS/Bathy survey will use a dual-channel Real-time Kinematic (RTK) GNSS receiver to accurately measure the exact position and heading of the boat. The SSS towfish and the echosounder transducer will be hull-mounted to the boat in a fixed position so that accurate geolocation of the sensors can be achieved. As a dual-channel RTK receiver the Hemisphere Vector VS330 directly measures boat heading. To achieve RTK position quality the VS330 operates utilizing a GPS base station. The base station, which can either be a local GPS receiver or part of a Continuously Operating Reference Station (CORPS) network, sends differential GPS corrections to the VS330 via radio link or a cellular data connection; thus, maintaining a 3cm horizontal accuracy and a 5cm vertical accuracy.

HYPACK Navigation Software

Navigation is facilitated by the HYPACK navigation system and the RTK GPS. The HYPACK system creates virtual survey lines based on operator-defined seed lines. The seed lines are set by recording navigation points in the field or by importing a Geographic Information System (GIS) .shp file. Once a line has been established, the HYPACK system calculates a virtual grid using an operator supplied line spacing. HYPACK provides a light bar display to assist the boat operator in guiding the boat along the virtual survey lines, and a swath coverage display that shows the boat operator the current survey line and previous lines on which data have already been collected.

3. INSTRUMENT STANDARDIZATION

All instruments and sensors will be assembled as specified in their specific User Manuals. Additionally, each instrument will be field tested daily to ensure that the instrument is operating properly (Section 4.4).

4. DATA ACQUISITION

The purpose of the SSS and Bathy surveys is to identify any bottom obstructions and inaccessible portions in the survey area that may impede or pose a hazard to the equipment to be used for the underwater DGM that will later be performed at the site.

The SSS and Bathy data will be collected simultaneously during the project. The systems will be setup to maximize the resolution of the imagery based on the environmental conditions. 100% of the survey transects will be imaged with the SSS during the surveys. Bathy data will be collected only along the SSS transects. Water and bottom conditions will be evaluated to select operating parameters and survey geometry to provide best possible level of record detail. Maximum data sampling rates allowed by the instruments will be used to acquire the highest resolution data. HYPACK hydrographic survey software will be used to design the survey line geometry. **Table 1** lists the preliminarily proposed survey parameters; however, these parameters may change as the result of site conditions. Data will not be collected in heavily vegetated areas that prevent boat propulsion, in extreme shallow water areas (less than 2.5 feet), or in areas with visible near surface obstructions that prevent safe operation of the equipment. On-water work cannot be performed in inclement weather (high winds, thunderstorms, waves > 2 ft.).

TABLE 1: PRELIMINARY DATA ACQUISITION PARAMETERS

Parameter	Value
Side-Scan Frequency	400 / 900 kHz
Echo-Sounder Frequency	400 - 600 kHz
Survey Line Spacing	To be determined based on project DQOs

4.1 START-UP PROCEDURES

The following steps describe the daily startup procedures prior to data collection:

1. Setup GPS base station (if required)
2. Prepare boat (on trailer)
   - Remove rigging safety chains and straps
   - Install drain plugs
   - Engage battery systems
   - Visually inspect all mechanical systems for defects; repair/replace if necessary
   - Inventory boat safety equipment (Personal Flotation Devices [PFDs], fire extinguisher, first aid kit, etc.)
   - Turn on all electrical systems
3. Perform land-based system Quality Assurance/Quality Control (QA/QC) tests (Section 4.4)
4. Test communications equipment (marine radio, mobile phones, walkie-talkie, etc.)
5. Launch boat
6. Prepare boat (in water)
   - Engage primary motor
   - Start and test secondary motor
   - Test all boat electrical systems
   - Deploy all sensors/transducers
7. Inform Responsible Parties of boat deployment
8. Perform on-water system Quality Assurance/Quality Control (QA/QC) tests (Section 4.4)
9. Mobilize to survey area

4.2 DATA COLLECTION STEPS

Below are the generalized steps used to perform the SSS and Bathy surveys:

1. Turn on instruments, data logging PCs and cooling fans
2. Allow the systems to warm up in water for at least 10 minutes
3. Prepare data acquisition field log. During data collection the system operator will maintain a detailed field log. The log will be used to document all data collection activities.

4. Setup / calibrate instrument data loggers
5. Deploy sonar and bathymetric transducers
6. Measure static draft offsets
7. Measure GPS / layback offsets (if necessary)
8. Prepare data files for recording
9. Navigate to appropriate survey line / transect
10. Log data
11. At the end of each transect confirm successful data acquisition and storage, navigation and equipment calibrations and settings

4.3 DATA STORAGE AND PROCESSING

The SSS and Bathy data are temporarily stored in a ruggedized PC during data collection. At the end of each field day, the data are transferred to a PC workstation for further on-site processing using HYPACK hydrographic survey software. Initial data processing (pre-processing) will be performed by the field team and includes reviewing data for integrity and repeatability.

After the SSS and Bathy surveys are concluded the field crew will demobilize from the site while the data is analyzed. Identified bottom obstructions will be catalogued in a spreadsheet that provides geographic coordinates for each potential obstruction. Exclusion zones for DGM surveying will be determined from a synthesis of bottom depth and obstruction data. GIS shapefiles will be created from the list of obstructions and exclusion zones for later navigational use during the DGM surveys.

The following is a list of deliverables that will result from the data processing:

- Mosaic image of the SSS data
- Color-coded contour map of the bottom depth data
- Target map showing interpreted bottom obstructions and survey exclusion zones
- SSS bottom obstruction target table including geo-referenced locations and target dimensions

4.4 QUALITY CONTROL - INSTRUMENTATION

The following quality control (QC) procedures are performed and documented during the data collection process and reviewed by a qualified geophysicist on a daily basis. Depending on the logistics of the project site these tests may be performed on land prior to boat launch or in water after boat launch.

1. <u>Equipment Warm-up</u>: Minimum 10 minutes
2. <u>Record Sensor Positions</u>: Accuracy of the GPS will be demonstrated by operating the GPS over a known control point. The accuracy of the data positioning will be assessed by calculating the difference between a known location over which the GPS antennas are held and the recorded positions. The sensor position test will be conducted at the beginning of the survey operation for each workday. Maximum position error for successful completion of the test is 10 cm.

3. Rub Test: Prior to deploying the SSS towfish in the water the port and starboard transducers of the towfish will be tested. The system operator will start the SSS system software and monitor the "waterfall" display of each transducer while another crew member touches the transducer surfaces. If the SSS is operating properly a distinctive "streaking" signature will be observed in the waterfall display, as shown in the picture below. This test is an observed qualitative test of basic system functionality.

Example of 'Rub Test' Functionality Test Results

4. Sonar Positioning Test: The sonar positioning test will provide daily evidence of the SSS system response and positioning repeatability. Daily a single line of data will be collected to image a known, fixed-position target object such as a pier piling. The accuracy of the data positioning will be assessed by calculating the difference between the known location of the target object (as measured with an RTK GPS) and the position of the object as calculated by the sonar processing and analysis software. The sonar position test will be conducted prior to survey operation each workday. Maximum position error for successful completion of the test is 1 meter.

SOP Signature Page

The following persons have read and understand this SOP:

Signature:	**Date:**

APPENDIX A

Example Field Log

Marine Geophysical Survey – Data Acquisition Log

Date:		**Vessel:**	3Dg UUTA / UUTA-LT	**Instrument:**	Geonics EM61-Flex3	**Page:**	____ of ____
Project:		**Captain:**		**# Sensors:**	2 / 4		
Client:		**Observer:**		**Sensor Size:**	1.0 x 0.5 m	**Survey Type:**	Grid / Transects
Location:		**Crew:**		**Separation:**	1.0 m	**Spacing:**	1.5 m / 3.0 m / NA

Data Type	Nav Line	Data Line	File	Dir	Tx I	Note

Wave Ht: ____________ **Wind Speed:** ____________ **Weather:** ____________

Onsite: ____________ **Begin Data:** ____________ **Misc Notes:**

Offsite: ____________ **End Data:** ____________

NAEVA/3Dg SOP 2

Underwater Electromagnetic Data Collection, Processing and Analysis

Rev#: 0

3D geophysics

NAeVA GEOPHYSICS INC.

THE LEADER IN SUBSURFACE DETECTION

Subsurface Geophysical Surveys

Underwater Electromagnetic Data Collection, Processing and Analysis | **SOP Number: 02** | **Effective Date: 7/1/2022**

1. OBJECTIVE

The purpose of this Standard Operating Procedure (SOP) is to provide specific procedures for data collection, processing and equipment for underwater Digital Geophysical Mapping (DGM).

2. EQUIPMENT AND THEORY

This SOP is applicable for the Geonics, Ltd. EM61-Flex3 time domain metal detector, operated using the 3Dgeophysics (3Dg) Underwater UXO Towed Array "Light" (UUTA-LT), Hemisphere Vector VS330 Global Navigation Satellite System (GNSS) compass, and a HYPACK navigation system.

The EM61-Flex3 is a high-resolution time-domain electromagnetic instrument designed to detect, with high spatial resolution, shallow ferrous and non-ferrous metallic objects. The EM61-Flex3 system is based on the standard Geonics EM61-MK2 metal detector. A single EM61-Flex3 consists of 2 air-cored receiver coils, a grand air-cored transmitter coil, a digital data recorder, batteries and processing electronics. The 1.0 x 0.5-meter receiver coils are arranged side by side and are encompassed by the transmitter coil. The EM61-Flex3 uses a transmitter repetition rate of 140 Hertz (Hz) and a 24-volt transmitter pulser; both specifications are doubled in comparison to the standard EM61-MK2. The EM61-Flex3 transmitter generates a pulsed primary magnetic field, which then induces eddy currents in nearby metallic objects. Each of the two spatially separated receiver coils measures these eddy currents. The EM61-Flex3 offers the ability measure the eddy currents at two operator selected time gates (firmware). The "early" time gate provides enhanced detection of smaller metallic objects. The "late" time gate is analogous to the 3rd time gate from the standard EM61-MK2. Secondary voltages induced in both coils are measured in millivolts (mV). Data is collected using the MLFXmarine acquisition program (Geomar Software, Inc.) and temporarily stored in a rugged PC.

The Electromagnetic (EM) system will be deployed using a UUTA-LT ("Utah Light") developed by 3Dgeophysics (Chaska, MN). The UUTA-LT includes an EM coil support platform (whale tail) and a rigid down-rigging system. The downrigger is equipped with a control surface (hydrofoil or "elevator") and an electric winch system that allows the system operator to control the height of the coil above the riverbed during data acquisition. Several sensors are integrated with the UUTA-LT to provide position control of the Flex3 coil platform. A pressure transducer on the platform measures the accurate depth of the receiver coils. An inclinometer measures the exact angle of the downrigger and is used to determine horizontal offset of the coil platform from the boat. A bow-mounted side scan sonar and bottom finder are used to map seafloor depth and image potential bottom obstructions during the survey.

The UUTA-LT uses a dual channel Real-time Kinematic (RTK) GNSS receiver to accurately measure the exact position and heading of the boat. The rigid downrigger is designed to keep the sensor platform inline with the keel of the boat so that accurate geolocation of the platform can be achieved. The Hemisphere Vector VS330 is a dual channel RTK receiver that directly measures boat heading. To achieve RTK position quality the VS330 operates utilizes a GPS base station. The base station, which can either be a local GPS receiver or part of a Continuously Operating Reference Station (CORPS) network, sends differential GPS corrections to the VS330 via radio link or a cellular data connection; thus, maintaining a 3cm horizontal accuracy and a 5cm vertical accuracy.

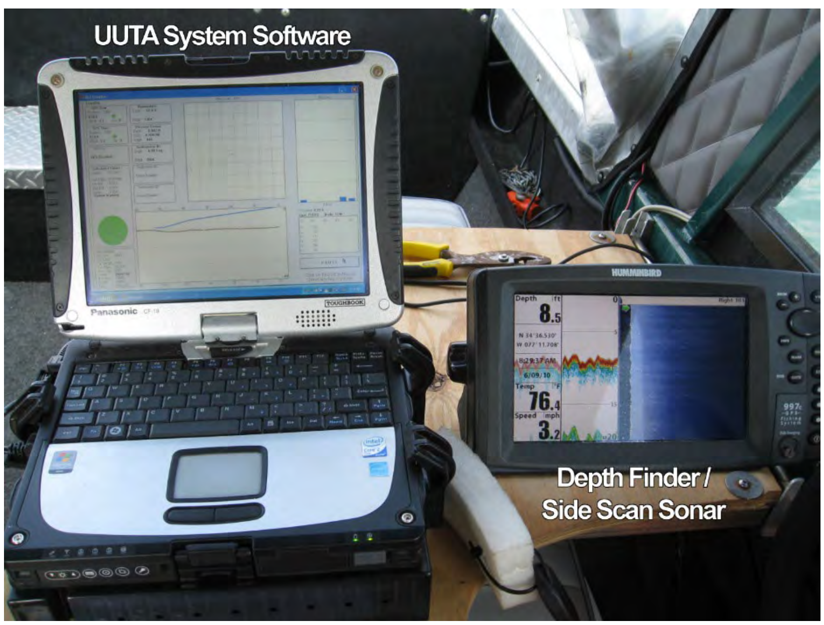
The MLFXMarine program captures the GPS, pressure transducer, inclinometer, and sonar bottom depth data and performs the position calculation of the sensor platform. The sonar transducer is mounted on the bow of the boat providing the system operator advance warning of water bottom changes, and allowing time to use the elevator and winch systems to adjust and maintain the sensor height above bottom. When boat speed and elevator angle remain constant the depth of the sensor platform does not change.

Navigation is facilitated by the HYPACK navigation system and the RTK GPS. The HYPACK system creates virtual survey lines based on operator-defined seed lines. The seed lines are set by recording navigation points in the field or by importing a Geographic Information System (GIS) .shp file. Once a line has been established, the HYPACK system calculates a virtual grid using an operator supplied line spacing. HYPACK provides a light bar display to assist the boat operator in guiding the boat along the virtual survey lines, and a swath coverage display that shows the boat operator the current survey line and previous lines on which data have already been collected.

Shown below are several photographs of the UUTA-LT deployed on a 17-ft Jon boat. Several of the important subsystems have been labeled in the photographs. When fully loaded the boat drafts less than 2 feet in the water.

UUTA-LT deployed on a 17-ft Jon boat during data acquisition

UUTA-LT sensor platform



UUTA control systems and data displays

3. INSTRUMENT STANDARDIZATION

All instruments and sensors will be assembled as specified in their specific User Manuals. Additionally, each instrument will be field tested daily to ensure that the instrument is operating properly (explained in Section 5).

4. EM DATA ACQUISITION

Data will be collected along tightly spaced transects to cover the defined survey areas with the exception of areas containing navigational hazards, water surface or bottom obstructions.

The boat will be operated at an average velocity of 2 to 4 miles per hour (MPH). Data will be recorded automatically along each survey line using up to 18 readings/second for each receiver coil. In addition to the EM data, the output of the RTK GPS, pressure transducer, boom angle sensors (inclinometers) and the bottom finder transducer are logged to the hard drive by the acquisition software. Data will not be collected in heavily vegetated areas that prevent boat propulsion, or in areas with significant bottom obstructions that prevent safe operation of the equipment. On-water work cannot be performed in inclement weather (high winds, thunderstorms, waves > 2 ft.). Data will be collected in a minimum water depth of 2.5 ft. to prevent the boat or sensor platform from touching the bottom, and a maximum water depth of 15 ft. Ninety-five percent (95%) of EM data will be collected within 1 m of the river bottom except when avoiding bottom obstructions.

Transect locations and orientations will be determined after the initial Side Scan Sonar (SSS) and Bathymetry surveys are performed in advance of the DGM. Transects will be spaced to meet the data quality objectives (DQOs) of the project. Transect orientations may be altered during data collection as a result of changing field conditions (e.g. wind direction and strength, wave state, etc.).

4.1 START-UP PROCEDURES

The following steps describe the daily startup procedures prior to data collection:

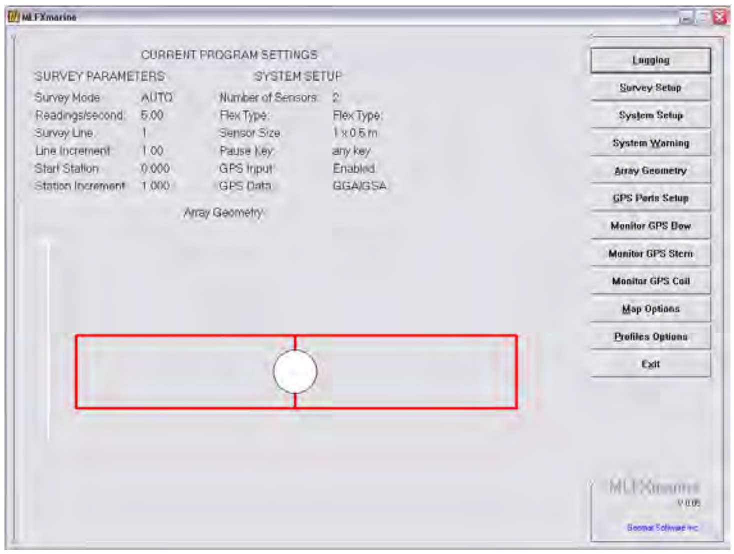
1. Setup GPS base station (if required)
2. Prepare boat (on trailer)
   - Remove rigging safety chains and straps
   - Install drain plugs
   - Engage battery systems
   - Visually inspect all mechanical systems for defects; repair/replace if necessary
   - Inventory boat safety equipment (Personal Flotation Devices [PFDs], fire extinguisher, first aid kit, etc.)
   - Turn on all electrical systems
3. Perform land-based system Quality Assurance/Quality Control (QA/QC) tests (Section 7)
4. Test communications equipment (marine radio, mobile phones, walkie-talkie, etc.)
5. Launch boat
6. Prepare boat (in water)
   - Engage primary motor
   - Start and test secondary motor
   - Test all boat electrical systems
   - Test UUTA-LT winch and elevator operation
   - Deploy sonar transducer
7. Inform Responsible Parties of boat deployment
8. Perform water-based system Quality Assurance/Quality Control (QA/QC) tests (Section 7)

9. Mobilize to survey area

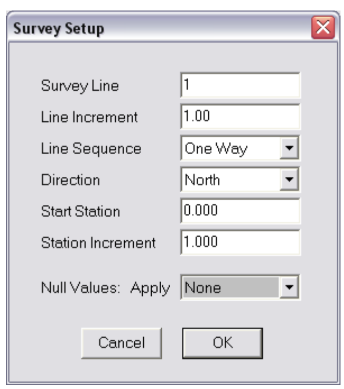
4.2 DATA COLLECTION STEPS

Below are the steps to begin surveying with the EM61-Flex3 and UUTA system:

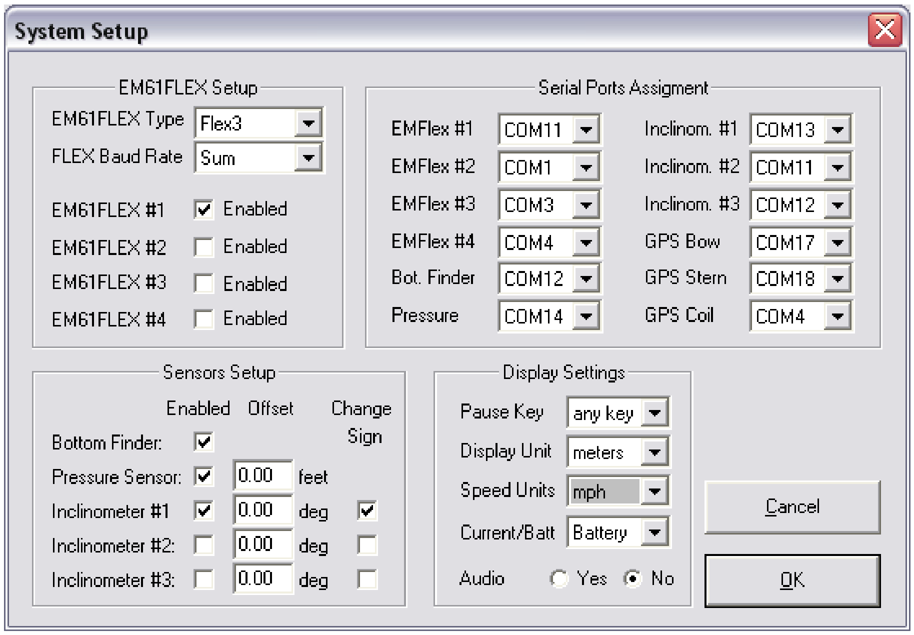
- Turn on instrument and cooling fans by engaging the power switches.
- Allow the system to warm up for at least 15 minutes
- Prepare data acquisition field log
- Turn on the Toughbook PC and open MLFXMarine program. The screen below will be displayed.



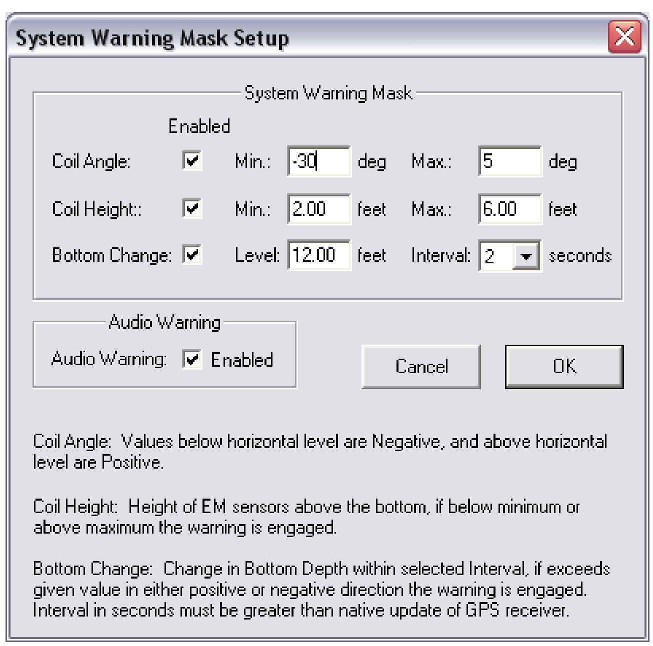
- Click on "Survey Setup" and specify the below options. The important option is 'Survey Line'. Survey Line will initially be set to 1 and then will be changed to the current grid line as data collection progresses. Instrument nulling will be performed periodically throughout the survey.



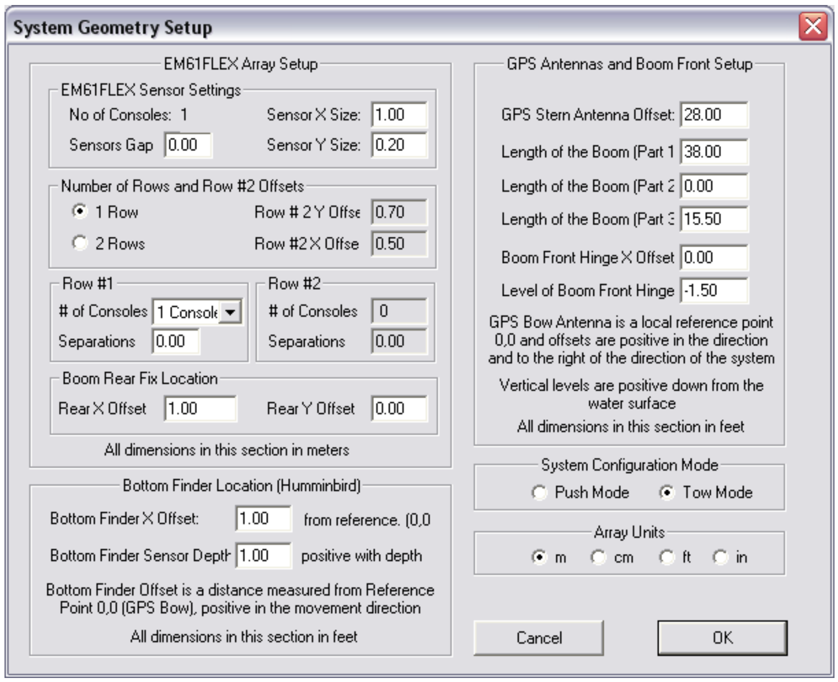
- Click on "System Setup" and correctly configure the settings (an example is shown below). These settings will be determined at project startup. After initial setup these settings will remain the same throughout the project.



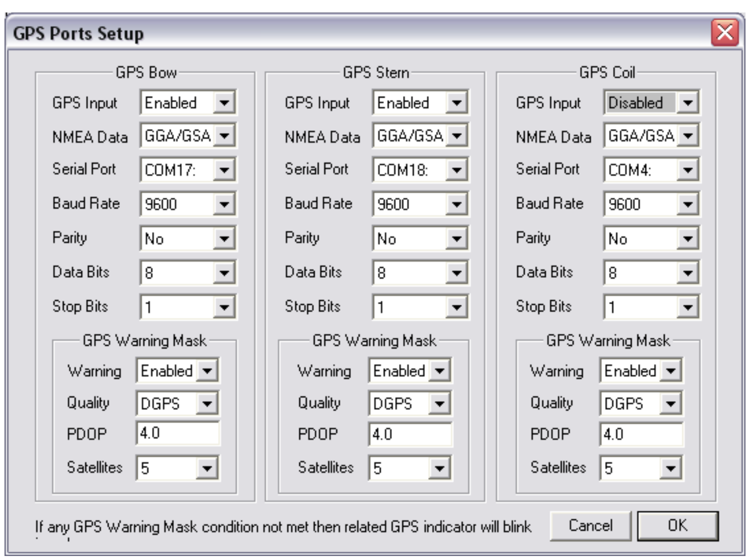
- Click on "System Warning" and correctly configure the settings (an example is shown below). These settings will be determined at project startup, and will remain the same throughout the project.



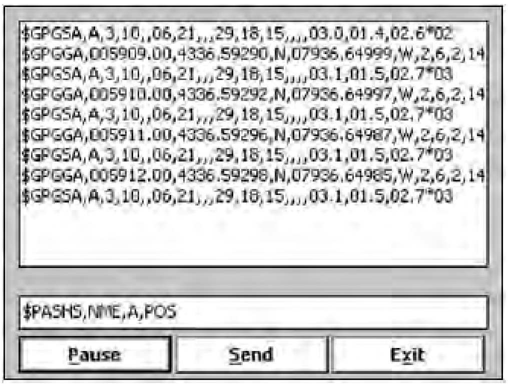
- Click on “Array Geometry” and specify the dimensions of the sensor array, the UUTA platform, and the towing options. These settings will be measured and determined at project startup, and then they will remain the same throughout the project. It is critical that all values in this dialogue box are correctly entered. The position calculation of the array platform is determined by the values entered here.

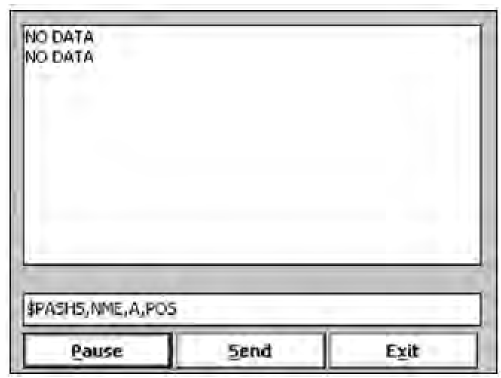


- Click on “GPS Ports Setup” and correctly configure the settings (an example is shown below). These settings will be determined at project startup, and will remain the same throughout the project.

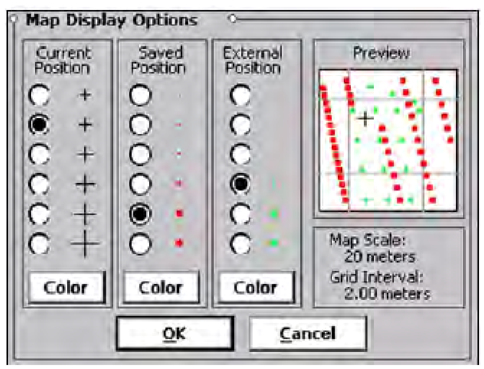


- Click on “Monitor GPS Bow” and “Monitor GPS Stern” in succession; the below window will open. If the NMEA strings are being output correctly, the screen will appear like the one on the left. If there is a problem with the baud rate, “No Data” will appear once a second. If there is nothing coming through “No Data” will flash once every 6 seconds.



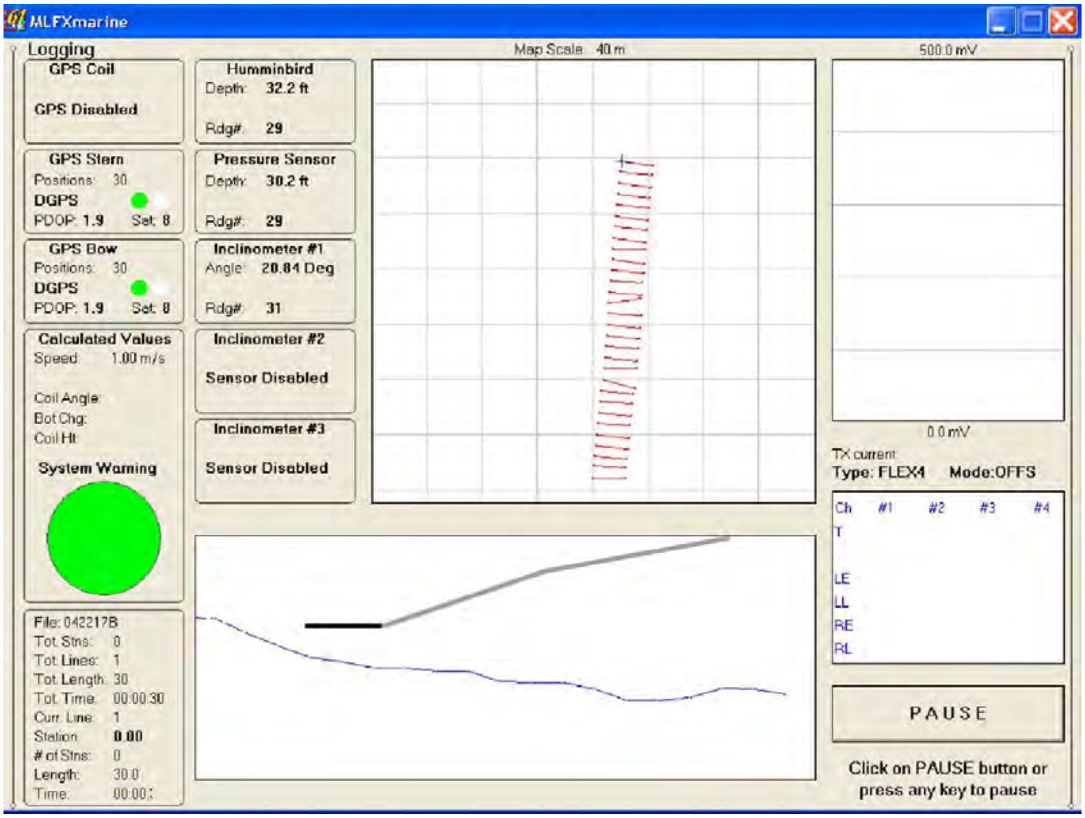


- Click on “Map Options” and adjust options to the operator’s preferences. These options are for data display aesthetics and do not affect data quality.



- Click on “Profile Options” and adjust options to the operator’s preferences. These options are for data display aesthetics and do not affect data quality.

- Once all the parameters are set click on the “Logging”. The screen below will be displayed. Click on File and name your file and save it. Navigate the vessel to the current survey line according to the HYPACK navigation display and select Go. The software will start logging the EM readings and a large Pause button will appear on the screen. At the end of the line, tap the Pause button or hit enter on the keypad to stop logging.



On the above screen, the EM data, positional sensor data, the data coverage and platform location map, and a scrolling bottom depth profile are monitored. Operator defined system warnings, including sensor platform angle, change in bottom depth, and coil height above bottom depth, are also monitored.

- At the end of the file, the Exit button is selected. The file automatically saves at the end of every line.

- During data collection the system operator will maintain a detailed field log. The log will be used to document all data collection activities. A sample field log is provided in Appendix A.

5. DATA STORAGE AND PRELIMINARY PROCESSING

The EM61-Flex3 array data are temporarily stored on a Rugged PC during data collection. At the end of each field day, the data are transferred to a PC workstation for further on-site processing using Geosoft Oasis Montaj software.

Initial data processing (pre-processing) will be performed by the field team and includes reviewing data for integrity and repeatability. The following data pre-processing steps will be performed on the collected underwater DGM and QC/QA data:

1. Convert binary field files
2. Apply appropriate data channel template

3. Perform Georeferencing (UTM meters, NAD83 datum)
4. Output Geosoft XYZ format

6. DATA PROCESSING STEPS

Once the initial editing steps have been performed, as described above, the data are turned over to NAEVA's processors for analysis, target selection, and preparation of deliverables. The processor will go through five steps before the final data packages are delivered.

6.1 QC OF FIELD FORMS

Inspect the contents of the field forms that have been uploaded into the database to ensure that the forms contain the following information:

- The appropriate dataset ID
- QC test file names (Static/Spike Tests and IVS)
- Grid ID(s)
- Instrument used
- Collection/navigation method (RTK-GPS)
- Daily conditions
- Cultural features

6.2 DATA PROCESSING WORKFLOW: FUNCTION TESTS

This section describes the workflow for processing EM data function tests.

6.2.1 DAILY FUNCTION TESTS

Worksheet 22 in the UFP-QAPP defines the measurement quality objectives (MQOs) to be checked for EM function tests to ensure proper equipment function and usage, and to verify that all acceptance criteria are met for each daily test.

6.2.1.1 STATIC TESTS – STATIC BACKGROUNDS AND SPIKE, CABLE SHAKE, AND TOW-VEHICLE

For each team and equipment system, an AM/start of day test (ID) and a PM/follow on test (ID) are performed. Line IDs in each raw data file are standardized to correspond with the same test for each file for the duration of a project. Deviations from the standard naming are to be included in field notes.

The AM test file includes Static Background/Spike, Cable Shake, and Tow Vehicle tests. This is performed once a day before the start of production survey data collection.

The PM test file includes Static Background/Spike test. This is performed once a day after production survey data collection. Additional static tests may be performed during the survey day. Processing steps include:

- Import the raw data into a new Geosoft .gdb (database).
- Record the coil ID and raw filenames into channels in the .gdb.
- Perform drift corrections to all EM data channels, as defined by project planning team.
- Run the Static Calibration Test tool for the Static Background/Spike test lines.
    - Create maps for all test lines, coils, and required channels.

- For the AM test only: Run the Static Calibration Test tool for the Cable Shake test line.
- For the AM test only: Run the Static Calibration Test tool for the Tow Vehicle test line.
- Calculate and export static background and static spike statistics.
- Print/export .map files to image files.
- Export data to ASCII format.
- Consolidate deliverables for submittal.
  - Background/Spike test Geosoft .maps
  - Background/Spike test images/pdfs
  - Geosoft .gdb
  - ASCII .xyz
  - Static Background/Spike test stats text file
- Check and record MQOs specified in Table WS #22 of the QAPP as described in section 6.2.2.1.

6.2.1.2 INSTRUMENT VERIFICATION STRIP (IVS)

For each team and equipment system, an AM/start of day test (ID) and a PM/follow on test (if applicable) (ID) are performed. Each test file includes IVS Background and IVS Item lines. Line IDs in each raw data file are standardized to correspond with the same test for each file for the duration of a project. Deviations from the standard naming are to be included in field notes. Processing steps include:

- Import the raw data into a new Geosoft .gdb (database).
- Record the coil ID and raw filenames into channels in the .gdb.
- Assign the correct projection and set the X and Y coordinate channels.
- Perform drift corrections to all EM data channels.
- Apply lag and/or filtering corrections to all EM data channels.
- Grid the appropriate corrected data channel(s) in preparation for target selection and data presentation. Gridding settings will appropriately represent the data collected. All tests will use the same gridding settings.
- Create a Geosoft map with appropriate scale, orientation, base map elements, and data layers.
- Calculate and export statistics for the IVS background data, if required in the project MQOs.
- Pick targets in accordance with the project target selection method and correlate pick locations with seed item locations.
- Print/export IVS .map to image file.
- Export data and targets to ASCII format.
- Consolidate deliverables for submittal.
  - IVS color contour .map
  - IVS color contour image/pdf
  - IVS gridded data .grd
  - Geosoft .gdbs
  - ASCII .xyz
  - Selected target list
- Check and record MQOs specified in Table WS #22 of the QAPP as described in section 6.2.2.2.

6.2.1.3 GPS CHECK

The processor applies any needed conversions or corrections to the raw data point, then checks and records MQOs specified in Table WS #22 of the QAPP as described in section 6.2.2.3.

6.2.2 ENTER DAILY FUNCTION TEST RESULTS IN ACCESS DATABASE

Fill in the processor form in the MS Access database to document the processing and MQO checks for each test. Field form information must be present in the Access database before the processor enters additional metadata related to the day's particular tests.

6.2.2.1 STATIC TESTS

- Open and complete the static test form
- Select the appropriate test and verify the test ID and pertinent field information
- Enter test results, perform calculations and check that the test passes MQO requirements for the project (specified in WS #22 of the QAPP)

6.2.2.2 IVS

- Open and complete the IVS form
- Select the appropriate test and verify the test ID and pertinent field information
- Enter test results, perform calculations and check that the test passes MQO requirements for the project (specified in WS #22 of the QAPP)

6.2.2.3 GPS QC CHECK

- Open and complete the GPS QC Check form
- Select the appropriate test and verify the test ID and pertinent field information
- Enter test results, perform calculations and check that test passes MQO requirements for the project (specified in WS #22 of the QAPP)

6.3 DATA PROCESSING WORKFLOW: SURVEY DATA

This section describes the workflow for processing EM survey data obtained from field data collection.

6.3.1 IMPORT DATASET DATA

Create a workspace for each dataset ID and save an Oasis montaj project in the corresponding folder.

6.3.1.1 SURVEY DATA

- Import the raw data into a new Geosoft .gdb (database).
- Record the coil ID and raw filenames into channels in the .gdb.
- Assign the correct projection and set the X and Y coordinate channels.
- Create a preliminary Geosoft map showing raw data and survey line path.
- Review the data.
    - Ensure there are no areas of gross data quality loss that might not be

identified during the MQO check process as described in section 5.2 such as data spikes, noise levels beyond those specified as acceptable in project guidelines, or inconsistent lag values.
  - For data with gross quality loss: Report to project manager what data are affected.
  - For data with gross quality loss: Reject any data that does not meet project guidelines. Rejected data should not be processed any further.

6.3.1.2 CULTURE DATA (OBSTRUCTIONS)

- Import the raw data into a new .gdb.
- Assign the correct projection and set the X and Y coordinate channels.
- Plot the culture locations and labels on the .map.
- Review the culture.
  - Check that culture points are noted for all data gaps.
  - Adjust culture locations and labels if needed.
- Request additional culture notes from field personnel for all unlabeled gaps.
- Import and review all subsequently submitted culture received.
- Create a polygon file that describes all gaps with noted culture.

6.3.2 MQO CHECKS

Worksheet 22 in the QAPP defines the required MQOs to be checked for survey data to ensure only quality data are used, and to verify that all acceptance criteria are met for each dataset. Deliverables for each required MQO check include a finalized map with printed/exported image file and calculated statistics for submittal to the client. Dataset MQO check results are reported to the QC geophysicist.

6.3.2.1 ALONG LINE MEASUREMENT SPACING

- Along line data density is checked for all valid data readings.
- One of the following methods is used to determine along line spacing:
  - The math expression tool in Oasis montaj is used to calculate along line spacing and then flag any values outside the maximum allowed
  - The Sample Separation tool in Oasis montaj is used to calculate along line spacing and flag any values outside the maximum allowed.
- Data readings are flagged according to project design requirements specified in WS #22 of the QAPP
- Along line spacing is reviewed to confirm MQOs are met
  - If requirements are not met for a dataset, large downline gaps are removed by splitting lines or interpolating locations through straight lines as appropriate.
  - Surrounding data readings are reviewed for noticeable trends in along line spacing, associated irregularities in recorded time, and readings flagged for GPS quality issues. Invalid data is removed.

6.3.2.2 SPEED – WHEN REQUIRED

- Sample speed is checked for all valid data readings when required in the project planning documentation.
- The Velocity Calculation tool in Oasis montaj is used to calculate the sample speed
  - Includes Time channel and units
  - Includes maximum speed allowed
- Data readings are flagged according to project design requirements specified in WS #22 of the QAPP.
- The sample speed is reviewed to confirm MQOs are met.
  - If requirements are not met for a dataset, flagged readings are removed as needed.
  - Flagged readings associated with invalid positioning that cannot be interpolated through will be removed.

6.3.2.3 GPS QUALITY

- GPS fix quality is checked for all valid data readings.
- When required in the project planning documentation, additional GPS quality indicators are reviewed for all valid data readings. Possible requirements may include:
  - Dilution of precision (DOP, HDOP)
  - Satellites
- Data readings are flagged according to project design requirements specified in WS #22 of the QAPP.
- The GPS quality is reviewed to confirm MQOs are met.
- If requirements are not met for a dataset, poor-quality data readings are removed or interpolate through where appropriate according to the project planning documentation.

6.3.2.4 COVERAGE

- Coverage should be checked for all valid data readings.
- Use the Footprint Coverage tool to determine the area and percent coverage.
- Footprint coverage parameters should reflect project design requirements specified in WS #22 of the QAPP.
  - Include an appropriate survey boundary
  - If present, include the cultural mask polygon
- The coverage is reviewed to confirm MQOs are met.
- If requirements are not met for a dataset, fill-in collection is required.
  - A polygon that describes all excluded coverage areas (culture and recollection) is created to the extent that the MQO requirements will be met.
  - The Oasis montaj Footprint tool is rerun with the final survey boundary and gap mask file and shows that MQO requirements are met.

- Data gaps are finalized for recollection (section 6.3.3).
- The final line path is exported to a shapefile and submitted with culture polygon to the GIS manager.

6.3.3 FINALIZE DATA GAPS

- Using the gap polygon created for coverage determination (section 5.2.4) to identify gaps, accessible areas with required fill-in defined.
- IDs are assigned for each gap area to fill.
- A fill-in package is created and sent to the field crew for location and recollection of all required areas. The fill-in files are labeled with the date and locations of fill-in and include:
  - File with fill-in (x,y) locations and IDs
  - Map image with fill-in locations displayed
- Fill-in data is processed to confirm data meets all requirements in WS #22 of the QAPP.
- Track completion of received fill-in and notify field crew of fill-in status.
- Fill-in collection resolves all accessible data gaps for the project.

6.3.4 DATA PROCESSING

Corrections to the raw data during processing will be saved to new channels in the database to preserve the raw data. Note processing parameters used to record in Access database.

6.3.4.1 LEVEL

- Perform preliminary drift corrections to all EM data channels, as defined by project planning team.
- Review all data and adjustment drift corrections where needed.
- Corrected data preserves intrinsic characteristics of response features of interest and improves the resolution of features of interest.

6.3.4.2 FILTER – WHEN NEEDED

- Perform preliminary filtering to all EM data channels, as defined by project planning team.
- Only if needed, use a filter(s) where there are repeatable unwanted features present that should be removed. Repeatable features include but are not limited to:
  - Data spikes
  - Geological trends from non-munitions related sources
  - Noise from outside electrical interference
- Review all data and adjustment filters where needed.
- Take care with the use of any filters (similarly to the drift correct function) to ensure that data characteristics are appropriately preserved for munitions

detection.

6.3.4.3 LAG

- Perform preliminary lag corrections to all EM data channels, as defined by project planning team.
- Review all data and adjust lag value where needed.
  - Corrected data shows no unwanted chevron effects that occur during recording.
  - Lag value will be consistent for a dataset.

6.3.4.4 Grid Data and Finalize Map

- Grid the appropriate final processed data channel(s). Gridding settings will appropriately represent the data collected. All datasets will use the same gridding settings.
- Finalize a map with appropriate scale, orientation, base map elements, and data layers and print/export it to an image file.

6.3.5 BACKGROUND NOISE

- Noise levels are sampled for the required final EM data channel(s).
  - Create a polygon to subset a representative sample of the data.
  - Exclude response features with metallic characteristics.
- Calculate and save background statistics for input into the Access database.

6.3.6 ENTER DATASET PROCESSING RESULTS AND NOTES IN ACCESS DATABASE

Fill in the processor form in the MS Access database to document the processing and MQO checks for each dataset. Field form information must be present in the Access database before the processor enters additional metadata related to the dataset. Processing information for all associated daily tests must be present in the Access database (section 4.2) before the processor prints a dataset processing report.

- Open and complete the dataset processing form
- Select the appropriate dataset and enter processing parameters
- Enter results of MQO checks and perform calculations to show requirements for the project are met (specified in WS #22 of the QAPP)
- Print a processing report and check that it shows all dataset information, (all MQO checks must pass), and all associated daily function tests (all must pass)

6.3.7 DATASET DELIVERABLES

Deliverables will be consolidated for submittal, checking that all files are present and complete. Each file name should include the unique dataset identifier.

- Dataset color contour and MQO plot .maps
- Dataset color contour and MQO plot images/pdfs
- Dataset gridded data .grd
- Geosoft .gdbs
- ASCII .xyz
- Culture polygon
- MQO check stats and background stats text files (if required)
- Processing report with dataset information and all associated daily function tests

6.4 UPDATE SITE MOSAIC FILE

This section describes the workflow for preparing processed EM survey data to display on a site mosaic. All survey data and associated culture, once processed, will be merged into the site mosaic in Oasis montaj. Compiled data can then be subset into full coverage locations if specified in the project design documentation. Exported locations will contain all required coverage, notes for all data gaps, and be documented as complete.

6.4.1 SETUP MASTER WORKSPACE

- Before merging processed data, create a master workspace in Oasis montaj intended to contain all pertinent processed data. Include the following:
    - Master survey data Geosoft .gdb (database)
    - Master culture points database
    - Mosaic site .map of survey area with applicable boundary
- Master database sizes must be sufficient for a large volume of expected data.
- Organization of the master workspace (or workspaces) should reflect the project-specific design.

6.4.2 MERGE PROCESSED DATA INTO MASTER

6.4.2.1 MERGE DATASET(S)

- Select a processed dataset survey database.
- Add a unique dataset ID identifier prefix to each survey line.
- Use the Merge Databases tool to add data channels to the master survey database.
- Check that the survey data is merged properly into the master database.
    - All processing complete data should be merged into the master.
    - There should be no duplicate data in the master.
- There should be no processing incomplete data in the master.

6.4.2.2 MERGE CULTURE

- Culture polygons and points must be merged into the master if they exist for a dataset.

- Select a processed dataset culture database.
- Add a unique dataset ID identifier prefix to each culture line.
- Use the Merge Databases tool to add culture points to the master culture database.
- Check that the culture data is merged properly into the master database.
    - All processing complete data should be merged into the master.
    - There should be no duplicate data in the master.
- Merge dataset culture polygon features into a single culture polygon to generate a cumulative boundary for the culture gaps.

6.4.3 REVIEW CUMULATIVE COVERAGE

- Display the cumulative survey data coverage on the master site map with applicable survey boundaries, culture boundaries, and culture points.
- Review the cumulative coverage with the plotted culture points and gaps.
    - Find all sliver gaps between datasets and along site boundaries.
    - Find and record locations that are coverage complete.
    - Update existing polygon culture boundaries along overlapping datasets.
- Request additional culture notes for any unlabeled gaps from the field crew.
- Review all subsequently submitted culture received.
- Create a fill-in package for areas of required fill-in (section 5.3).
- Export a cumulative master culture file to display on final targeted location maps.

6.4.4 EXPORT LOCATIONS FOR FINAL DELIVERABLES

- Use the Subset Database tool to individually subset data for each selected location.
    - Export locations recorded as coverage complete during cumulative coverage review (section 6.4.3).
    - Only include completed locations not previously exported.
- Use the Footprint Coverage tool to determine the area and percent coverage for each subset location.
- Footprint coverage parameters should reflect project design requirements specified in WS #22 of the QAPP.
    - Include an appropriate survey boundary.
    - Include the master cultural mask polygon.
- Review the coverage to confirm MQOs are met.
- If MQO appears to not meet requirements, check for errors in the culture polygon. If no errors exist, remove the grid from the complete list until needed culture or fill-in is completed and merged into the site mosaic.
- Update Access database with the list of exported grids ready for targeting.

6.5 LOCATION MAPS

This section describes the workflow for creating locations maps with EM survey data, if required, in project planning documentation. Location maps contain all relevant processed complete data within the selected location.

Create individual location map(s) with full coverage locations.

- Select individual full coverage complete location(s).
- Create a Geosoft location map with appropriate scale, orientation, base map elements, and data layers.
- Print/export location .map to image file.
- Export color contour data layer to the georeferenced image file.

6.6 TARGETING

- This section describes the workflow for targeting processed EM survey data, if required, in project planning documentation. Targeted locations contain all relevant complete processed data within the selected location. Pick targets in accordance with the project target selection method.
- Review the target selections for validity and position.
    - Refine target selections with consistency according to project planning documentation.
    - Add/remove/move target locations to ensure detection of items of interest.
    - Add relevant targeting comments.
- Sort targets and assign unique IDs.
- Export selected target list. Include all relevant data columns in the target list: location ID, target ID, (x, y) coordinates, EM response value, comments, and any other parameters define in the project documentation.

6.7 LOCATION DELIVERABLES

This section describes the workflow for preparing location deliverables with EM survey data, if required, in project planning documentation. Deliverables contain all relevant complete processed data within the selected location. Include all elements required in project planning documentation.

6.7.1 LOCATION DELIVERABLES

Check that all files are present and complete. Each file name should include the unique location identifier.

- Location color contour .map
- Location color contour images/pdf
- Location georeferenced color contour image
- Geosoft .gdb
- Selected target list
- Processing report with targeting information

6.7.2 ENTER TARGETS AND LOCATION DELIVERABLES IN ACCESS DATABASE

Fill in the processor form in the MS Access database to document targeting for each location. Field form information must be present in the Access database before the processor enters additional metadata related to the targeting.

- Open and complete the targeting form
- Select the appropriate location and enter the processing parameter.
- Record statistics from the Geosoft QCReport.log for input into the Access database
- Print a targeting report and check that it shows all location information

7. QUALITY CONTROL - INSTRUMENTATION

The following quality control (QC) procedures are performed and documented during the data collection process and reviewed by a qualified geophysicist on a daily basis. Depending on the logistics of the project site these tests may be performed on land prior to boat launch or in water after launch.

1. Equipment Warm-up: Minimum 15 minutes
2. Personnel Test: Will not be performed. The sensor platform is a rigid structure that is remains at a constant distance from the tow vessel. Boat personnel do not operate within the influence of the sensor platform.
3. Cable Shake Test: Will not be performed. All the cables are securely fastened and cannot be shaken without shaking the entire system.
4. GPS Position Test: Positioning accuracy of the final processed data will be demonstrated by operating the GPS system over a known control point. The accuracy of the data positioning will be assessed by calculating the difference between a known location over which the GPS is held and the recorded position. The GPS position test will be conducted daily prior to data collection. The recorded GPS position is required to be within 10 centimeters (3.9 inches) of the known location.
5. Static Background / Standard Response (“spike”) Test: A test jig will be manufactured using small-size Industry Standard Objects (ISO) spaced 1 meter apart so that all EM receiver coils can be tested simultaneously. The test jig will be held in a fixed position below the array platform during the spike test. The standard response test will be performed on land prior to data collection each day. The test will be performed by partially extending the downrigger structure to move the sensors beyond the magnetic influence of the boat and trailer. The sensor platform will be positioned parallel to the ground surface using a non-conductive support structure in an area free of metallic contacts. The test will consist of collecting data for a 3-minute period. During the test the sensors will be held in a fixed position for 1 minute without the test jig (background test), for 1 minute with the test jig in place, and finally for another minute without the test jig. The purpose of the static test is to determine whether unusual levels of instrument or ambient noise exist. To proceed with data collection the measured EM response for the test jig is required to be within 20% of the first project day’s measured response.
6. Pressure Sensor Test: Prior to daily data collection the accuracy of the pressure sensor (i.e. EM sensor platform depth) will be tested. Two data points will be recorded during the test to verify the functionality of the pressure sensor. The test will be performed on land with the boat held in a

fixed position. The pressure sensor's depth results are required to be within 3 inches of the known depth.

7. Dynamic Repeatability Test / IVS: The IVS test will provide daily evidence of system response and positioning repeatability. Daily a single line of DGM data will be collected over two test objects. The objects (10 lb dumbbell weight or similar) will be seeded underwater near the survey area in water depths less than 10 ft. There are two objectives for this test. First, to demonstrate positioning repeatability that meets the DQO of 2-meter accuracy. Second, to demonstrate repeatability of the seed item response that meets the DQO of general repeatability (detection above background).

Positive completion of the daily tests provides assurance that the EM instrumentation, the UUTA, the RTK GPS, HYPACK navigation software, and the MLFXMarine system software will collect DGM data that meets the project DQOs.

SOP Signature Page

The following persons have read and understand this SOP:

Signature:	Date:

APPENDIX A

Example Field Log

Marine Geophysical Survey – Data Acquisition Log

Date: ____________ Vessel: 3Dg UUTA / UUTA-LT Instrument: Geonics EM61-Flex3 Page: ______ of ______

Project: ____________ Captain: ____________ # Sensors: 2 / 4

Client: ____________ Observer: ____________ Sensor Size: 1.0 x 0.5 m Survey Type: Grid / Transects

Location: ____________ Crew: ____________ Separation: 1.0 m Spacing: 1.5 m / 3.0 m / NA

Data Type	Nav Line	Data Line	File	Dir	Tx I	Note

Wave Ht: ____________ Wind Speed: ____________ Weather: ____________

Onsite: ____________ Begin Data: ____________ Misc Notes: ____________

Offsite: ____________ End Data: ____________

APPENDIX D
Scope of Work

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Section C - Descriptions and Specifications

PWS (24FEB2022

PERFORMANCE WORK STATEMENT
Munitions and Explosives of Concern Investigation for
Nashua River Former Fort Devens
Devens, Massachusetts

Date: 24 FEB 2022
REV: 0

1.0 Introduction and Background

This requirement is for munitions response services to complete a Munitions and Explosives of Concern (MEC) investigation to address Areas of Potential Interest (AOPIs) along a stretch of the Nashua River near Former Fort Devens, which borders Devens, Massachusetts. This is a performance-based, firm fixed price task order. The project area encompasses an approximate 3-mile stretch of the Nashua River from the area immediately south of State Route 2 to the area immediately north of West Main Street. This stretch of the river is located east of the former South Post and mostly west of the former Main Post and North Post.

This task order will require the following activities:

- Establish AOPIs along the approximate 3-mile stretch of the Nashua River between the State Route 2 and West Main Street bridges for investigation of Discarded Military Munitions (DMM) resulting from potential Department of Defense (DoD) military munitions items discarded in the river. Five AOPIs are estimated in proximity to the Bill Ashe Trail and the four bridges along the identified stretch of the river. The extent of the AOPIs should be defined by an approximate 35-meter radius exclusive to the waterway, conservatively based on the average hand grenade throwing distance per Field Manual 3-23-30. The AOPI parallel to the Bill Ashe Trail shall be extended along the river beyond the 35-meter radius, in association with locations of previous munitions discovered within the river. The approximate maximum water depth ranges from 4 to 12 feet, with deeper depths reported near the State Route 2 bridge.
- *Optional Task* – Perform side scan sonar and bathymetric surveys to evaluate site-specific conditions prior to underwater geophysical survey.
    - Perform a side scan sonar and bathymetric surveys over 100% of the approximate 3-mile stretch of the Nashua River between the State Route 2 and West Main Street bridges. The bathymetric survey shall use a nominal 25 foot spacing. If portions of the bathymetric survey are necessary for the success of the planned Digital Geophysical Mapping (DGM) investigation, the associated level of effort should be included with the fieldwork task below.
- Complete an underwater geophysical survey as outlined below.
    - Conduct DGM, using a magnetometer or electromagnetic metal detector, in transects with a minimum of 25% coverage within the established AOPIs to determine potential high-density areas. DGM investigation shall meet the minimum requirement to identify a hand grenade at a depth of 1 foot below the river bottom. As the AOPIs are present within the water, it has been determined that Advanced Geophysical Classification is not appropriate.
    - Conduct DGM, using detector identified above, to provide coverage outside the AOPIs with transects up and down the river. DGM coverage shall reach the extents of the approximately 3-mile stretch of the Nashua River between the State Route 2 and West Main Street bridges. Data shall be collected over a cumulative distance of approximately 6 linear miles of transects, assuming a single sensor.
    - Process and interpret DGM data to evaluate anomalies/targets and delineate high-density areas. Upon completion of the geophysical investigation, the identified high-density areas and

anomaly/target selection will be evaluated by government stakeholders for approval prior to subsequent reacquisition and anomaly investigation.

- *Optional Task* – Provide munitions anomaly avoidance for volunteers conducting intrusive species removal activities in the Nashua River.
- Complete underwater intrusive investigation, classify MEC/ Material Potentially Presenting Explosive Hazard (MPPEH) and appropriate disposition, and disposal in accordance with DoD, State and local regulations.
    - Perform dive operations to reacquire and intrusively investigate no more than 500 selected anomalies/targets at an estimated 30 anomalies a day with an intrusive depth of no more than 2 feet below the river bottom.

This MEC investigation will be conducted in close coordination with U.S. Environmental Protection Agency (USEPA) and Army experts. All elements of this investigation need to be described with a clear, defensible technical basis including the selection of equipment, survey design, and site-specific conditions.

1.1 Site History

The Nashua River runs through a portion of former Fort Devens. The former Fort Devens was active from 1917 to 1996. The river flows in a northern direction and is slow moving, with a river bottom composed of heavy layers of silt and sand. The project area defined in **Section 1.0** includes the following four bridges from south to north: State Route 2, Jackson Road, Hospital Road, and West Main Street. The river is primarily used by recreational users (i.e., canoeing, kayaking, fishing), with trails along some of its banks used for hiking. Massachusetts Department of Transportation (DoT) divers perform bridge inspections and associated maintenance along the Nashua River. The Nashua River is also known to have an infestation of water chestnut, a non-native, invasive aquatic plant. Active management of this invasive species has been performed by volunteers with the Nashua River Watershed Association (NRWA) since 2014.

The former Fort Devens was placed on the National Priorities List in 1991. The Army and the USEPA signed a Federal Facility Agreement in May 1991, which does not alter the Army's authority with respect to removal actions conducted pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In the summer of 2020, munitions were recovered by recreational magnetic fishing along portions of the Nashua River formerly considered Fort Devens Main Post. Subsequently, the USEPA Region 1 initiated an Informal Dispute with the Army and a Removal Site Evaluation (RSE) was conducted in response to the findings of recovered munitions to evaluate the potential for DoD military munitions. The 2021 RSE involved tasks typically consistent with a Military Munitions Response Program (MMRP) Preliminary Assessment.

The munitions recovered from the Nashua River were restricted to the three distinct events: two related to magnetic fishing on the river near Bill Ashe Trail and Hospital Road Bridge in the July and August of 2020 and one associated with an inspection of the State Route 2 bridge by Massachusetts DoT in March 2021. The magnetic fishing related events involved the discovery of two MK-II hand grenades and an un-fuzed 60-millimeter (mm) mortar, which were disposed of by the Massachusetts State Police. The DoT inspection resulted in the discovery of three practice 2.36-inch M6A1 rockets, a practice 60mm mortar, and an expended M18 smoke grenade, which were demilitarized by Navy Explosive Ordnance Disposal (EOD). Based on the findings in the RSE, the MEC discoveries in the Nashua River did not constitute a Munitions Response Site and, therefore, were screened out of the MMRP based on the weight of evidence approach.

The RSE included an analog survey to assess the river for potential MEC, which scanned both sides of the river, the riverbanks, and the accessible shallow water areas (not more than 2 feet in depth) with hand-held metal detectors from Hospital Road Bridge south for approximately 0.75 miles. The RSE did not find evidence that the Army used the banks of the Nashua River or the river itself for munitions-related operations and indicated that DMM were the most likely source of potential munitions in the Nashua River. The probability for encountering MEC was considered "Low" consistent with the Defense Explosive Safety Regulation (DESR) 6055.09 Edition 1.

As DMM was considered the most likely source of potential munitions in the Nashua River, it was recommended a MEC investigation be conducted to involve a targeted geophysical survey with equipment to be deployed in the river to further assess the potential for military munitions in areas based on prior munitions discoveries where exposure pathways are likely. Prospectively, this would most likely include a specific distance around each bridge that crosses the Nashua River on the former Fort Devens and along the river near the Bill Ashe Trail.

On 16 December 2021, a Formal Dispute was invoked by the USEPA pursuant to paragraph 13.4 of the Federal Facility Agreement (FFA) for the Fort Devens Army Installation. The Formal Dispute was resolved on 20 January 2022, with an agreement by the Dispute Resolution Committee at the former Fort Devens to complete a MEC investigation, which will be conducted in close coordination with USEPA and Army experts with emphasis on the timely execution of the investigation.

Public outreach for MEC has been initiated to remind the public of MEC safety and a magnet fishing ban has been put in place within parts of the Nashua River that border former Fort Devens. Outreach includes education on the 3Rs of explosive safety (Recognize, Retreat, Report), which continues to be implemented through the Community Involvement Program, including any updates to the Community Involvement Plan.

2.0 Requirements

The Contractor shall be responsible for fully executing the Firm Fixed Price approach under a Performance-Based Acquisition (PBA) by: conducting required environmental investigative services for which the DoD is statutorily responsible; addressing any and all unforeseen environmental, explosive safety, scheduling, and regulatory issues; and, assuming contractual liability and responsibility for the achievement of the performance objectives identified in this Performance Work Statement (PWS).

The Contractor must possess all the required expertise, knowledge, equipment and tools required to meet or exceed the Government’s objectives identified in this PWS in accordance with established industry standards. The Contractor must have the capability and experience to perform, or provide investigative services required for MEC. Work will include conducting a MEC investigation.

All environmental services will comply with CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA), and National Oil and Hazardous Substances Contingency Plan (NCP) in coordination with the Massachusetts Department of Environmental Conservation Protection, Massachusetts Department of Health and the USEPA Region 1 requirements, as applicable.

To perform munitions responses, the DoD primarily uses CERCLA. However, CERCLA has no special provisions for dealing with explosive safety. Under this task order, the contractor shall perform munitions response actions for military munitions. Activities may involve MEC which includes unexploded ordnance (UXO), DMM, and Munitions Constituents (MC) if found in high enough concentrations to cause an explosive hazard. All activities involving work in areas potentially containing MEC hazards will be conducted in full compliance with DoD, Department of the Army and U.S. Army Corps of Engineers (USACE) safety regulations. Specific requirements concerning explosives safety are further clarified in DESR 6055.09 Edition 1, Department of Defense Instruction (DODI) 4140.62, Engineer Regulation (ER) 385-1-95, and Engineer Manual (EM) 385-1-97. Munitions Response Actions – Minimum Separation Distances (Relative to Impulse Water Pressure) from Underwater Detonations Memorandum dated 16 September 2013 provides additional information. The Munitions Response Quality Assurance Project Plan (MR-QAPP) and EM 200-1-15 will be utilized for work planning deliverables.

It is the Contractor's responsibility to comply with all applicable federal, state and local laws and regulations and to fulfill the performance objectives of this PWS in a manner that is consistent with any applicable orders or permits, all existing agreements or guidance, and relevant DoD and USACE policy, for the duration of the contract.

3.0 Types of Services Required

This PWS includes the following types of services as authorized in the basic contract:

- CERCLA Studies and Reports
- DGM
- MEC Removal

4.0 Task Order Type

This is a firm fixed price task order without environmental insurance. The period of performance on this Task Order is 36 months from notice to proceed (NTP).

5.0 Performance Objectives and Standards

The Contractor shall be required to furnish all plant, labor, materials and equipment necessary to meet the performance objectives and standards identified in **Table 1** below. The current status of site activities can be found in documents provided **Attachment A**. The information in **Section 1.1** is provided for background information only.

Table 1: Performance Requirements Summary.

Performance Objective	*Performance Measure*
CLIN 0001: Approved Project Management Plan (PMP): • Draft PMP within thirty (30) days of NTP. • Final PMP within fifteen (15) days of receipt of Contracting Officer's Representative (COR) comments on the draft. • The Contractor should assume that updates will be required as options are exercised and modifications are made.	• Army approval through the COR.
CLIN 0002: Approved MR-QAPP and Accident Prevention Plan (APP) / Site Safety and Health Plan (SSHP): • Draft MR-QAPP and APP/SSHP within 90 days of NTP • Final MR-QAPP and APP/SSHP within 180 days of draft submittal, per the FFA timeline for regulator review.	• Army approval through the COR. • Regulator concurrence (e.g., receipt of documentation confirming approval of MR-QAPP).
CLIN 0003: Underwater DGM Survey. Approved DGM Report: • Draft DGM Report within 60 days of fieldwork • Final DGM Report within 180 days of draft submittal, per the FFA timeline for regulator review.	• Army approval through the COR. • Regulator concurrence (e.g., receipt of documentation confirming approval of DGM Report).
CLIN 0004: Underwater Intrusive Investigation. Approved RSE Addendum: • Draft RSE Addendum within 60 days of fieldwork • Final RSE Addendum within 180 days of draft submittal, per the FFA timeline for regulator review.	• Army approval through the COR. • Regulator concurrence (e.g., receipt of documentation confirming approval of RSE Addendum). • Compliance with the Government provided, DoD Explosives Safety Board (DDESB) approved Explosives Siting Plan (ESP).
CLIN 0005 (OPTION): Side Scan Sonar/Bathymetry Survey.	• Army approval through the COR.
CLIN 0006 (OPTION): Munitions Anomaly Avoidance.	• Army approval through the COR.

5.1 Assumptions

- The government will provide a DDESB approved ESP for this work. The ESP will describe, in detail, the appropriate safety criteria involved for the work included in this PWS. The Contractor shall be responsible for conducting all work in accordance with the approved ESP.
- The objective of this work is to conduct a MEC investigation, involving an underwater DGM survey and subsequent intrusive investigation, within the identified project area of the Nashua River for the former Fort Devens. The primary objective of this investigation is to address explosive safety hazards that may exist within the AOPIs considering the public use of the Nashua River.
- As the investigation area does not constitute a Munitions Response Site, this work is not being conducted under the Defense Environmental Restoration Program.
- Regulator review shall meet the requirements of the FFA and will provide the opportunity for planning documents and reports (i.e., DGM Report and RSE Addendum) to receive regulatory approval.
- The specific activities associated with the project objective are detailed in **Section 1.0**. This PWS requires the use of DGM. The performance metric for this DGM survey requires a detection threshold to detect a hand grenade at 1 foot below the river bottom. Analog instrumentation will only be used where DGM methods cannot be effectively utilized. Excavations shall not exceed a depth of 2 feet below the river bottom.
- No Advanced Geophysical Classification is required.
- No vegetation removal is expected for this investigation.
- If DGM survey results in selected anomalies for investigation, munitions anomaly avoidance shall be provided by the Contractor during the Spring/Summer 2023 season for NRWA volunteers conducting intrusive species removal activities, which include wading in the Nashua River. As multiple NRWA volunteer teams are expected, at least 2 UXO Tech II's shall be provided for a duration up to 1 week. Munitions anomaly avoidance for these activities will be provided by the government for the Spring/Summer 2022 season, but not for the 2023 season.
- The subsurface anomaly density at the AOPIs is unknown. The government assumes that geophysical surveying will identify no more than 500 anomalies requiring reacquisition and intrusive investigation with an estimated 30 anomalies a day. The requirement for the dive/dig team composition is as follows:
  - **<u>Dive/Dig Team</u>**: One 6-man team with safety and supervisor: Tender (1), Diver (1), Standby Diver (1), Senior UXO Supervisor (SUXOS) (1), UXO Safety Officer (UXOSO) (1), Dive Supervisor (1), or comparable.
- All "acceptable to move" MEC will be disposed of in accordance with the ESP.

6.0 Project Management

The PBA approach requires careful coordination of project activities to ensure that all stakeholders are kept informed of the project status, existing or potential problems, and any changes required to prudently manage the project and meet the needs of the project stakeholders and decision-makers. The Contractor shall be responsible for the following project management activities:

6.1 Project Management Plan and Schedule

The Contractor shall develop and maintain a detailed PMP. The PMP, based on the schedule prepared as part of the Contractor proposal, shall specify the schedule, technical approach, and resources required for the planning, execution, and completion of the performance objectives. The first draft of the PMP will be due within thirty (30) calendar days of contract award. The draft PMP and subsequent revisions shall be subject to Army review and approval through the COR. The final PMP shall be due within fifteen (15) calendar days of comments received from the COR. A payment milestone will be established for Army approval of the final PMP through the COR.

As part of the PMP, the Contractor shall develop and maintain an activity-based schedule that fully supports the technical approach and outlines the due dates for all milestones and payable deliverables. A payment plan shall be included with the schedule that allows for payments to the Contractor based on successful completion of interim milestones proposed by the Contractor. It is the Army's intent to make all payments after verification of progress in accordance with this schedule. The Contractor shall coordinate activities with the COR to ensure that the proposed project schedule does not conflict with other contractor activities on site.

As part of the PMP, the Contractor shall identify and implement a means for providing project status reports to the COR. The PMP shall address the frequency and content of status reports.

6.2 Milestone Presentations

Milestone presentations shall be made to the COR at the completion of each milestone below to provide analysis and lessons learned, and to present approaches for completion of future milestones. At the COR's request, the Contractor may also make milestone presentations to the other project stakeholders, consistent with the applicable regulatory drivers listed in **Section 2.0** of this PWS, to show achievement of the performance objectives.

The Contractor may propose a revision of the milestones below to reflect their PMP and provide for interim milestones. Interim milestones will only be accepted if they represent significant progress toward milestone completion, and completion of these interim steps can be measured and demonstrated. Payments will be tied to the successful completion major milestones listed below or an interim milestone plan approved by the Army, through the COR. To that end, all proposed interim milestones should be associated with easily demonstrated metrics tied to performance measurements (e.g., resolution of comments on a draft, acceptance of a final report, or acceptance of a data submittal or meeting minutes). All milestones must have a defined means for demonstrating completion in order to facilitate certification and approval (see *Section 8.3. Certification and Approval of Project Milestones and Deliverables*).

Major Milestones

- Approval of the Project Management Plan
- Approval of the MR-QAPP and APP/SSHP
- Approval of the DGM Report
- Approval of the RSE Addendum

6.3 Environmental Requirements

The Contractor shall perform contract tasks in areas which potentially contain MEC hazards and shall comply with all applicable federal, state and local laws and regulations; and applicable site-specific orders, agreements, or rules; as well as Army and DoD requirements, such as those established by the DDESB; while performing these contract tasks. The Contractor shall ensure that all activities performed by its personnel, subcontractors and suppliers are executed in accordance with these requirements. Any incident of non-compliance noted by the Contractor shall immediately be brought to the attention of the COR telephonically and then by written notice. Nothing in this contract shall relieve the Contractor of its responsibility to comply with applicable laws and regulations. The Contractor will obtain all approvals and permits (i.e., excavation, wetlands, cultural resources, etc.), necessary to accomplish the work. When the work to be performed requires facility clearances, the Contractor will obtain them prior to any work and coordinate all work with that point of contact (POC) prior to initiation. Contractors are required to perform their own utility checks. The Contractor shall comply with all site-specific time and procedural requirements (federal, state, and local) described in the permits obtained. The Army technical experts will also independently review Contractor work to ensure compliance with all applicable requirements.

The Contractor shall be required to review and adhere to all related environmental policy.
The Contractor shall review and fully understand "Executive Order 13423 -- Strengthening Federal Environmental, Energy, and Transportation Management," in particular those requirements pertaining to environmental management system.

6.4 MEC Related Guidance

MEC includes, but may not be limited to: UXO, as defined in 10 United States Code (U.S.C.) 101(e)(5); DMM, as defined in 10 U.S.C. 2710(e)(2); or MC, as defined in 10 U.S.C. 2710(e)(3), present in high enough concentrations to pose an explosive hazard.

MEC distinguishes specific categories of military munitions that may pose unique explosives safety risks. Because MEC that is being actively managed may be determined to be hazardous wastes, 29 Code of Federal Regulations (CFR), Hazardous Waste Operations and Emergency Response, Section 1910.120 may apply.

The Contractor shall comply with all site-specific time and procedural requirements (federal, state, and local) described in the approvals obtained.

The contractor will comply with all applicable guidance for conducting munitions response including the MR-QAPP and EM 200-1-15. Avoidance and intrusive investigation procedures will be utilized as in accordance with procedures outlined in EM 385-1-97 with onsite support by UXO-qualified personnel. The management and disposition of MEC/MPPEH will be performed in accordance with DODI 4140.62, DESR 6055.09, Edition 1, and EM 385-1-97.

6.5 Health and Safety Requirements

The contractor must have a written Safety and Health Program that is compliant with federal, state, and local laws. Prior to beginning any fieldwork, the Contractor shall submit an APP in accordance with EM 385-1-1 (current version) that details how the contractor will implement their Safety and Health Program on this specific project. The APP shall be accepted by the COR before work can begin. The Contractor shall ensure that its subcontractors, suppliers and support personnel comply with the accepted APP. The APP must contain at a minimum the applicable sub-plans listed in EM 385-1-1 Appendix A and a SSHP. The Army reserves the right to stop work under this contract for any violations of health and safety requirements at no additional cost to the Army. Once the Army verifies through the COR that the violation has been corrected, the Contractor shall be able to continue work.

All activities involving work in areas potentially containing MEC hazards shall be conducted in full compliance with Department of Army, state, and local requirements regarding personnel, equipment and procedures, and DoD Standard Operating Procedures and safety regulations.

6.6 Quality Management

The Contractor must ensure that the quality of all work performed or produced under this contract meets Army approval, through the COR. Quality control/assurance plans must be prepared and approved by the COR prior to performance of physical work.
The government has developed a Draft Quality Assurance Surveillance Plan (QASP) and is included as part of the RFP. Any input on the Draft QASP shall be submitted with the PMP deliverables within fourteen (14) calendar days of award. The Final QASP will be prepared by the Army.

The QASP should highlight key quality control activities or events that the COR will use to determine when Army (COR or Contracting Officer (KO)) inspections can be conducted to assess progress toward and/or completion of milestones. Activities identified in the QASP should be appropriately coded in the project schedule to allow for planning of quality assurance (QA) inspections.

6.7 Quality Control

The Contractor shall be held responsible for quality control to the quality standards set forth in MR-QAPP and EM 200-1-15. The Government shall be held responsible for quality assurance.

Following task order award and during project implementation, the Contractor shall develop and submit documentation of project-specific QA and Quality Control (QC) activities prepared in accordance with the MR-QAPP. The Government will review and return the quality systems documentation, with comments, indicating acceptance or rejection. If necessary, the Contractor shall revise the documentation to address all comments and shall submit the revised documentation to the Government for acceptance. In addition, the Contractor shall develop and submit QC Summary Reports to summarize the quality control details of the task order project. The problems and successes of the work done to control the quality of the activities shall be included in the summary reports.

6.8 Project Repository and Administrative Record

There are no project repository or administrative record requirements for this work.

6.9 Additional Site Plans

Prior to beginning any field work, the Contractor shall prepare any additional plans or documents (e.g., dive operations plan, waste minimization plans) consistent with **Section C** of the basic contract, the applicable regulatory drivers listed in **Section 2.0** of this Task Order, and any other agreements, orders, or regulations that apply. These plans and documents shall be subject to Army review and approval, through the COR.

6.10 Protection of Property

The Contractor will be responsible for any damage that may be caused to property of the United States (Federal property) or any other property owned by others during the activities of the Contractor under this contract and will exercise due diligence in the protection of all property located on the premises against fire or damage from any and all other causes. Any property of the United States or owned by others damaged or destroyed by the Contractor incident to the exercise of the privileges herein granted will be promptly repaired or replaced by the Contractor to a condition satisfactory to the COR or reimbursement is made by the Contractor sufficient to restore or replace the property to a condition satisfactory to the COR in accordance with Federal Acquisition Regulation (FAR) Clause 52.245-2.

6.11 Project Stakeholders

For the purposes of this PWS, project stakeholders will include but are not limited to:

- the Army;
- the USEPA;
- the Massachusetts Department of Environmental Protection;
- MassDevelopment; and
- the U.S. Fish and Wildlife Service.

Specific Army stakeholders include the following: DDESB, US Army Technical Center for Explosive Safety (USATCES), and USACE – Baltimore and New England Districts.

The Contractor shall be responsible for obtaining comments with appropriate approval on project deliverables consistent with applicable regulatory drivers and agreements.

6.12 Public Involvement

Coordination with the public is not required under this PWS. However, the Contractor is responsible for providing a description of finds and obtaining photos that can be used for public notification should MEC be found. Photos and associated descriptions should be provided to USACE – New England District for public notification and inclusion in Restoration Advisory Board (RAB) meetings with community members and other organizations.

6.13 Communications

The Contractor shall not make available or publicly disclose any data or report generated under this contract unless specifically authorized by the KO through the COR. If any person or entity requests information from the Contractor about the subject of this scope of work or work being conducted hereunder, the Contractor shall refer them to the COR. All reports and other information generated under this scope of work shall become the property of the Government, and distribution to any other source by the Contractor is prohibited unless authorized by the KO.

6.14 Deliverable Requirements

All documents must be produced with at least draft, draft final, and final versions. The Army, through the COR, will receive draft documents and will provide comments to the Contractor within thirty (30) calendar days for the PMP and forty-five (45) calendar days for the remaining draft documents per the FFA. Once initial comments are addressed, the Army will review draft documents before submission to stakeholders. The Contractor shall ensure that review periods are consistent with the requirements noted in **Section 2.0** of this PWS. All documents shall be identified as draft final until completion of stakeholder coordination, when they will be signed and finalized.
The Contractor shall follow the substantive requirements for all subject areas of the USACE guidance applicable to deliverables required for achievement of performance objectives identified in this PWS. If versions of Engineer Manuals, Data Item Description (DID), etc. are updated, the substantive requirements of the most recently approved version will apply to this PWS. It is the responsibility of the contractor to be familiar with applicable laws, regulations, and references. It is not intended that the links provided to be a complete listing: https://www.publications.usace.army.mil/; https://www.denix.osd.mil/; https://ddesb.altess.army.mil/; www.fedcenter.gov"

Geophysical Data Deliverables: All geophysics shall be in accordance with EM 200-1-15 and site-specific Standard Operating Procedures, with the following exceptions and additions: final, processed data shall be delivered in Geosoft databases that can be opened and viewed without the need of external or additional formatting and all data packages will be made available at the electronic data delivery system developed for the project.

The Contractor shall propose deliverables and payment milestones as part of its proposal, and if approved by the Army, included as part of the PMP. Final decisions regarding the adequacy of milestone and deliverable completion resides with the COR (see *Section 6.2, Milestone Presentations*) and will be based on the appropriate acceptance and approval of required documentation, as defined by this PWS.

6.15 Geographic Information System

The Contractor shall utilize a geographic information system (GIS) to maintain and manage all project and geospatial data in accordance with EM 200-1-2, ER 1110-1-8156, EM 1110-1-2909, EM 1110-1-1200, and EM 200-1-15 and applicable Interim Guidance Documents. The Contractor shall adhere to all applicable federal, DoD, and Army geospatial data standards for tasks and deliverables in this PWS. Spatial data must be compliant with the Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE) v4.0. Spatial data must meet the requirements of the associated Quality Assurance Plan. Each geospatial data set shall be accompanied by metadata conforming to the Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata (CSDGM). The horizontal accuracy of any geospatial data created by the contractor shall be tested and reported in accordance with the National Standard for Spatial Data Accuracy (NSSDA) and the results shall be recorded in the metadata. All data must have a datum of WGS84 and a projection of Universal Transverse Mercator (UTM) Zone 19N. USACE technical experts will independently review Contractor work to ensure compliance with all spatial data requirements.

Any data with a vertical component must be referenced to the North American Vertical Datum of 1988 (NAVD88). The spatial reference must have a precision of 1000.

All GIS data will be provided to USACE upon completion of the performance objectives as established in Table 1, or as requested by USACE.

6.16 Monthly Progress Reports

The contractor shall submit by the first day of each month a monthly progress report summarizing activities of the preceding month (if at least 15 days of contract performance occurred in that month) and planned activities for the following month. The report shall be a concise summary and include at a minimum, the following information:

(1) Contracting Office, KO, COR;
(2) Contract number, including task and delivery order number;
(3) Beginning and ending dates covered by the report;
(4) Date of the report;
(5) Contract completion date and list of all CLIN period of performance dates;
(6) Contractor name, address, phone number, e-mail address, identity of contractor employee entering data;
(7) Summary of accomplishments for the report month and planned accomplishments for the following month;
(8) Safety reporting including field exposure hours and recordable and/or reportable accidents;
(9) Summary of waste and/or recycled materials generated during fieldwork during the reporting period.
(10) Record of deliverables submitted;
(11) record of communication, correspondence, and invoices;
(12) Estimate of percentage complete for each task and overall percentage complete;
(13) Personnel changes, and,
(14) If applicable an updated network analysis schedule.

Reports shall be submitted to the COR in electronic format via email. Email attachments, if any, shall be in Adobe pdf or Microsoft Word format only. Email submittals shall include the project manager and emdc.admin@usace.army.mil on the cc line. The subject of the email shall be the contract number with task order followed by "Monthly Progress Report" followed by the year and month of the report (for example "W912DR-99-D-9999 9999 Monthly Progress Report YYYY MM").

7.0 Expertise and Necessary Personnel

The Contractor shall provide the necessary personnel and equipment to execute this PWS successfully. The Contractor shall be responsible for determining the requirements for licensed professionals and certifications.

The Contractor shall furnish all plant, labor, materials and equipment necessary to meet the performance objectives. The Contractor shall provide personnel trained as required by the Occupational Safety and Health Administration (OSHA) and all other applicable federal and state regulations. The Contractor shall provide all support activities necessary to ensure the safe and effective accomplishment of all work. For all work performed under this contract, the Contractor shall also develop and implement quality control measures consistent with all applicable federal and state regulatory requirements and standards.

7.1 Key Personnel

The Army requires that the following positions, at a minimum, be designated as "key personnel", subject to the terms and conditions for such set forth in the basic contract. The Contractor shall notify the COR of any changes in key personnel. The change of key personnel is subject to approval by the KO, although such approval will not be unreasonably withheld provided replacement personnel are of the same quality as originally proposed.

- Senior Geophysicist
- SUXOS
- UXOSO
- Dive Supervisor

8.0 Additional Requirements

8.1 Resources

8.1.1 Army Furnished Resources

The Army will provide the following resources to the Contractor:

- Access to relevant Army-maintained records, reports, data, analyses, and information, in their current format (e.g., paper copy, electronic, tape, disks, CDs).

- Access to DoD and Army policy and guidance documents.
- If needed, all ROEs will be executed by a Government Real Property Officer.

8.1.2 Contractor Furnished Resources

The Contractor shall be responsible for the following:

- Coordination with the Army and MassDevelopment in order to gain access to available utilities (e.g., electric power), if required for execution of this PWS. No access to Fort Devens shall be expected or required.
- The contractor is responsible for disposal of all investigation derived waste generated under this contract including removal and disposal of munitions related debris.
- Any munitions debris or scrap found will be collected and managed for proper disposal in accordance with DoDI 4140.62 and recycled.
- Any other necessary resources needed to achieve the defined performance objectives of this PWS.

8.2 Contractor's Guarantee

For the purposes of this PWS, the following definitions apply. The "Project Price" identified in this PWS will be equal to the approved proposed price for completion of performance objectives, the payment of which will be tied to one or more project milestones. The Contractor guarantees to complete and meet all of the performance objectives outlined in this PWS at the Project Price.

8.3 Certification and Approval of Project Milestones and Deliverables

The COR will perform contract management, inspection, oversight, review, and approval activities. Certification and approval of project milestones by the COR is necessary before distribution of financing payments. Certification by the Army is also contingent upon the Contractor performing in accordance with the terms and conditions of the contract for this work, this PWS, and all amendments.

Representatives of the Army and the Contractor will have a conference with the COR in a manner and at a time agreed to by all parties after receipt of each status report to:

- Formally review the quantity and quality of services;
- Inspect work for compliance with this PWS, the associated Contractor's final proposal, and project documentation;
- Accept or reject milestones and deliverables completed since the previous review; and
- Modify the PMP and plan as required to identify those project planning changes, milestone payments, and project schedule.

8.4 Government Rights

The Army has unlimited rights to all documents/material produced under this contract. All documents and materials, to include the source codes of any software, produced under this contract shall be Army owned and are the property of the Army with all rights and privileges of ownership/copyright belonging exclusively to the Army. These documents and materials cannot be used or sold by the Contractor without written permission from the KO. All materials supplied to the Army shall be the sole property of the Army and cannot be used for any other purpose. This right does not abrogate any other Army rights under the applicable Data Rights clause(s).

8.5 Stop Work

Government personnel have the authority and responsibility to stop work immediately if the work is considered to be a serious threat to the safety or health of workers, other personnel, or to the environment. Authorized Government personnel include, but are not limited to, Government Ordnance Explosive Safety Specialists, safety officers, and command personnel with responsibility for overall operations. When work is stopped due to a hazard/threat to worker safety, health, or the environment, the situation and resolution must be documented and submitted to the KO. Work must be stopped whenever chemical and biological warfare agents or radiological materials are discovered. In addition, the KO has the authority to temporarily stop work on a project following a 24-hour (one working day) written notification to the Contractor. Stop work notices may be related to nonconformance to project specifications, lack of performance by the Contractor, financial considerations, funding considerations, and other circumstances outlined in the contract.

8.6 Environmental Responsibility Considerations

The Army will retain responsibility for any assessed natural resource damages that are attributed to historic releases of hazardous substances (prior to contract with the Contractor) and any injuries that are necessary and incidental to the reasonable implementation of a selected response or remedial action. The Contractor shall be responsible for any/all additional natural resource injuries and associated Natural Resource Damages claims brought as a result of its actions (e.g., release of hazardous substance or unreasonable disturbance of natural resources as a result of construction activities).

The Army will retain all responsibility for third party liability for Chemical Warfare Materiel (CWM) or radiological material that are either targeted for or may be discovered during the course of investigation. Response cost claims, property damage and personal injury claims brought due to contamination and hazardous substance releases that have occurred historically (prior to contract with the Contractor) and are not due to Contractor investigation activities are excluded from Contractor responsibility. The Contractor shall be responsible for and indemnify the Army for:

- Any response cost claims for any environmental investigation services which the Contractor has assumed responsibility for under this PWS;
- All costs associated with correction of a failure of any remedy implemented or operated and maintained by the Contractor to the extent such failure was caused by the willful or negligent acts or omissions of the Contractor in the course of performing the environmental services;
- All personal injury or property damage claims to the extent caused by the acts or omissions of the Contractor in the course of performing the environmental services;
- All natural resource damages pursuant to 42 U.S.C. Section 9607(a)(4)(C), to the extent that such damages were caused or contributed to by the actions of the Contractor or its successors in interest; and
- All costs associated with or arising from any negligent acts or omissions or willful misconduct of the Contractor in the course of performing the environmental services or implementing remedial actions.
- All costs associated with or arising from any negligent acts or omissions or willful misconduct of the Contractor in the course of performing the environmental services.

8.7 Inspections

The Army technical experts will independently review Contractor work to ensure compliance with all applicable requirements.

Any service or submittal performed that does not meet Task Order requirements shall be corrected or re-performed by the Contractor and at no additional cost to the Government. Corrective action must be certified and approved by the COR. If the contractor performs any task unsatisfactorily and all defects are not corrected, the Government reserves the right to terminate the Task Order for default. In addition, the Government reserves the rights under FAR clause 52.246-4, Inspection of Services – Fixed Price, for further remedies concerning a Contractor’s failure to perform in conformance with contract requirements.

8.8 Organizational Conflicts of Interest

8.8.1 Disclosure.

The Contractor shall provide a disclosure statement with its proposal, which concisely describes all relevant facts concerning any past or present organizational conflicts of interest relating to the work in each PWS. In the same statement, the Contractor shall provide the information required in the following paragraph to assure the Government that the conflicts of interest have been mitigated and/or neutralized to the maximum extent possible. If a conflict of interest is discovered after contract award, the KO will make a decision whether to terminate or rescind the PWS and/or contract at that time.

8.8.2 Potential Conflicts of Interest.

In order to avoid any organizational conflicts of interest, or even the appearance of any organizational conflicts of interest, the Contractor performing environmental and/or related munitions response services work under this PWS will need to avoid, neutralize and/or mitigate - prior to task order award - significant potential conflicts of interest that may prejudice effective competition. The KO has determined that at a minimum Contractors will ensure that all data pertaining to contamination shall be made available to all landowners in a timely fashion.

8.9 Anti-Terrorism / Operations Security (OPSEC) Requirements

No activities by contractor employees, to include sub-contractor employees, shall require access to Army installations, facilities, controlled access areas, or networks.

8.10 Travel

Travel to/from the site and to other CONUS locations (locations within the continental United States) for such purposes as to attend meetings, briefings and/or presentations may be required incidental to this investigation, the costs for which shall be included in the total price for the PWS.

8.11 Performance and Payment Bonds

In accordance with the base contract, the Contractor:
- ☒ is NOT required to furnish Performance and Payment Bonds on this PWS.
- ☐ is required to furnish Performance and Payment Bonds on this PWS in accordance with the following:

8.12 Warranty

In accordance with the base contract, the Contractor:
- ☒ is NOT required to provide a 5-year warranty for the site specified in this PWS.
- ☐ is required to provide a 5-year warranty for the site specified in this PWS.

9.0 Other Requirements

9.1 Vegetation Removal

No vegetation removal is expected for this investigation.

9.2 MEC, MPPEH, and Material Documented As Safe (MDAS)

The management and disposition of MEC/MPPEH will be performed in accordance with DODI 4140.62, DESR 6055.09, Edition 1, and EM 385-1-97.

10.0 Contracting Officer's Representative

The COR's contact information will be provided after award.

Attachment A: Reference Documents

The Army believes that this documentation provided with the solicitation represents the most recent and appropriate documentation available for the site identified in this Task Order. However, if there is a conflict between this information and other site documentation (the existing reports), the Contractor is solely responsible for reviewing all available information and forming their independent, professional conclusions/interpretation of site conditions and requirements to meet the objectives of this PWS. This information is not intended as a substitute for complete analysis of technical data available, nor is it intended to be a guide on how the Contractor should address achievement of the performance objectives/standards.

Specific documents may be made available following a request to the KO, if the documentation can be distributed in a timely manner. Electronic format is not guaranteed. The listing of documents will be provided with the data download available via DoD SAFE.

Available Reference Documents.

Title	**Author**	**Date**
FFA for Former Fort Devens	Army and USEPA	15-NOV-1991
Final RSE for DoD Military Munitions Nashua River Former Fort Devens, Devens, Massachusetts	Environmental and Munitions Design Center Baltimore District - USACE	17-MAY-2021
Formal Dispute Agreement	Army and USEPA	20-JAN-2022

Attachment B: List of Acronyms

AOPI	Area of Potential Interest
APP	Accident Prevention Plan
CAIS	Chemical Agent Identification Set
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COR	Contracting Officer's Representative
CSDGM	Content Standard for Digital Geospatial Metadata
CWM	Chemical Warfare Materiel
DDESB	Department of Defense Explosives Safety Board
DESR	Defense Explosive Safety Regulation
DGM	Digital Geophysical Mapping
DID	Data Item Description
DMM	Discarded Military Munitions
DoD	Department of Defense
DODI	Department of Defense Instruction
DoT	Department of Transportation
EM	Engineer Manual
EOD	Explosive Ordnance Disposal
ER	Engineer Regulation
ESP	Explosive Site Plans
FAR	Federal Acquisition Regulation
FFA	Federal Facility Agreement
FGDC	Federal Geographic Data Committee
GIS	Geographic Information System
KO	Contracting Officer
MC	Munitions Constituents
MDAS	Material Documented As Safe
MEC	Munitions and Explosives of Concern
mm	Millimeter(s)
MMRP	Military Munitions Response Program
MPPEH	Material Presenting a Potential Safety Hazard
MR-QAPP	Munitions Response Quality Assurance Project Plan
NAVD88	North American Vertical Datum of 1988
NCP	National Oil and Hazardous Substances Contingency Plan
NRWA	Nashua River Watershed Association
NSSDA	National Standard for Spatial Data Accuracy
NTP	Notice to Proceed
OSHA	Occupational Safety and Health Administration
PBA	Performance-Based Acquisition
PMP	Project Management Plan
POC	Point of Contact
PWS	Performance Work Statement
QA	Quality Assurance
QASP	Quality Assurance Surveillance Plan
QC	Quality Control
RAB	Restoration Advisory Board
RSE	Removal Site Evaluation
SARA	Superfund Amendments and Reauthorization Act
SDSFIE	Spatial Data Standards for Facilities, Infrastructure, and Environment
SSHP	Site Safety and Health Plan
SUXOS	Senior Unexploded Ordnance Supervisor
U.S.C.	United States Code
USACE	United States Army Corps of Engineers
USATCES	U.S. Army Technical Center for Explosives Safety

USEPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
UXO	Unexploded Ordnance
UXOSO	Unexploded Ordnance Safety Officer

Attachment C: Definitions

Activity-Based Schedule: Activities and milestones defined at the detail level and logically sequenced to support, and manage completion of the performance objectives.

Contractor's Project Costs: Costs incurred by the Contractor (including costs covered by insurance and the PMP) in executing the work required to achieve the performance objectives identified in the PWS for this contract/task order.

Chemical Warfare Materiel (CWM): An item configured as a munitions containing a chemical substance that is intended to kill, seriously injure, or incapacitate a person through its physiological effects. CWM also includes V- and G- services nerve agent, H-series blister agent, and lewisite in other than munitions configurations. Due to their hazards, prevalence, and military-unique application, Chemical Agent Identification Sets (CAIS) are also considered CWM. CWM does not include riot control agency, chemical herbicides, smoke and flame producing items, or soil, water, debris, or other media contaminated with chemical agent.

Deliverables: Documentation or data that support the completion of milestones or achievement of the performance objectives identified in this PWS.

Discarded Military Munitions (DMM) **–** Military munitions that have been abandoned without proper disposal or removed from storage in a military magazine or other storage area for the purpose of disposal. The term does not include unexploded ordnance, military munitions that are being held for future use or planned disposal, or military munitions that have been properly disposed of consistent with applicable environmental laws and regulations.

Explosive Ordnance Disposal (EOD) – The detection, identification, on-site evaluation, rendering safe, recovery, and final disposal of unexploded explosive ordnance. It may also include explosive ordnance that has become hazardous by damage or deterioration.

Milestones: Significant events or activities that occur in the course of the Contractor achieving the performance objectives identified in this PWS.

Military Munitions (MM) – All ammunition products and components produced or used by or for the DoD or the U.S. Armed Services for national defense and security, including MM under the control of the DoD, the U.S. Coast Guard, the U.S. Department of Energy, and National Guard personnel. The term military munitions includes: confined gaseous, liquid, and solid propellants, explosives, pyrotechnics, chemical and riot control agents, smokes, and incendiaries used by DoD components, including bulk explosives and chemical warfare agents, chemical munitions, rockets, guided and ballistic missiles, bombs, warheads, mortar rounds, artillery ammunition, small arms ammunition, grenades, mines, torpedoes, depth charges, cluster munitions and dispensers, demolition charges, and devices and components thereof. MM do not include wholly inert items, improvised explosive devices, and nuclear weapons, nuclear devices, and nuclear components thereof. However, the term does include non-nuclear

components of nuclear devices, managed under the Department of Energy's nuclear weapons program, after all required sanitization operations under the Atomic Energy Act of 1954, as amended, have been completed.
Munitions Constituents (MC): Any materials originating from UXO, DMM, or other military munitions, including explosive and non-explosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions.

Munitions Debris (MD) – Remnants of munitions (e.g., fragments, penetrators, projectiles, shell casings, links, fins) remaining after munitions use, demilitarization, or disposal.

Munitions and Explosives of Concern (MEC): This term, which distinguishes specific categories of military munitions that may pose unique explosives safety risks, means UXO, as defined in 10 .SC 101(e)(5)(A) through (C); DMM, as defined in 10 USC 2710(e)(2); or MC (e.g., TNT, RDX), as defined in 10 USC 2710(e)(3), present in high enough concentrations to pose an explosive hazard.

Munitions response – A response action, including investigation, removal actions, and remedial actions, to address the explosives safety, human health, and/or environmental risks presented by MEC and/or MC.

Material Potentially Posing an Explosive Hazard (MPPEH) - Material that, prior to determination of its explosives safety status, potentially contains explosives or munitions (e.g., munitions containers and packaging material; munitions debris remaining after munitions use, demilitarization, or disposal; and range-related debris); or potentially contains a high enough concentration of explosives such that the material presents an explosive hazard (e.g., equipment, drainage systems, holding tanks, piping, or ventilation ducts that were associated with munitions production, demilitarization or disposal operations). Excluded from MPPEH are munitions within the DoD established munitions management system and other hazardous items that may present explosion hazards (e.g., gasoline cans, compressed gas cylinders) that are not munitions and are not intended for use as munitions.

PMP Documents: The original PMP (including project schedule), revisions, and status reports.

Project Price: The approved proposed price for achieving completion of remediation services in accordance with the PWS, the payment of which will be tied to one or more project milestones. The Project Price does not include the cost of the PMP, insurance premiums or surplus line taxes, if applicable.

Project-related information: All previous environmental restoration documentation of a technical nature developed by the Army and previous Army contractors and subcontractors during their work at the sites specified in this PWS, and all the documentation developed by the Contractor in order to achieve the performance objectives specified in this PWS.

Unforeseen environmental issues: include unknown and/or varied concentrations of contaminants at cleanup sites, but not unknown sites (e.g., sites not identified in this PWS). For sites addressed under the MMRP, unknown contaminants will be limited to MC and those chemicals reasonable associated with the identified munitions and munitions related activities.

Unexploded ordnance (UXO): Military munitions that have been primed, fuzed, armed, or otherwise prepared for action; have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installations, personnel, or material; and remain unexploded either by malfunction, design, or any other cause.

APPENDIX E

Accident Prevention Plan/Site Safety and Health Plan

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FINAL ACCIDENT PREVENTION PLAN

FORMER FORT DEVENS ARMY INSTALLATION

DEVENS, MASSACHUSETTS

Prepared for:
USACE Baltimore District

Contract Number: W912DR-21-D-0002
Task Order: W912DR22F0121

Prepared by:

Tetra Tech, Inc.
4801 University Square
Suite 24
Huntsville, AL 35816

October 2022

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APPENDICES

LIST OF ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
°F	degrees Fahrenheit
AAF	Army Airfield
ACGIH	American Conference of Governmental Industrial Hygienists
AED	automatic external defibrillator
AHA	activity hazard analysis
APP	Accident Prevention Plan
bpm	beats per minute
CFR	Code of Federal Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIH	Certified Industrial Hygienist
COC	chemical of concern
COR	Contracting Officer’s Representative
CHMM	Certified Hazardous Materials Manager
CP	Competent Person
CPR	cardiopulmonary resuscitation
CSIR	Contractor’s Significant Incident Report
CSP	Certified Safety Professional
dB	decibels
DCN	document control number
DD	Decision Document
DDESB	U.S. Department of Defense Explosives Safety Board
DEET	diethyl-meta-toluamide
DFW	definable features of work
DoD	U.S. Department of Defense
EC	Emergency Coordinator
EM	Engineer Manual
ESP	Explosive Safety Plan
EZ	exclusion zone
FFA	Federal Facilities Agreement
FMP	Fatigue Management Plan
GDA	government-designated authority
GFCI	ground-fault circuit interrupter
HAZCOM	Hazard Communication
HE	high-explosive
HIV	human immunodeficiency virus
HSE	Health, Safety, and Environment
KO	Contracting Officer
LHE	load-handling equipment
LO/TO	lockout/tagout
MC	munitions constituents
MD	munitions debris
MDAS	material documented as safe

MEC	munitions and explosives of concern
MPPEH	material potentially presenting an explosive hazard
OSHA	U.S. Occupational Safety and Health Administration
PEL	permissible exposure limit
PM	Project Manager
PPE	personal protective equipment
QAPP	Quality Assurance Project Plan
QP	Qualified Person
RAC	Risk Assessment Code
RRD	range-related debris
SDS	Safety Data Sheet
SHM	Safety and Health Manager
SOP	standard operating procedure
SSHP	Site Safety and Health Plan
SUXOS/DS	Senior UXO Supervisor
SZ	support zone
TLV	threshold limit value
TO	Task Order
TP	Technical Paper
Tetra Tech	Tetra Tech Inc.
TOTAL	Tetra Tech Corporate Database
U.S.	United States
USACE	United States Army Corps of Engineers
UXO	unexploded ordnance
UXOSO	UXO Safety Officer
WBGT	wet-bulb globe temperature

1.0 SIGNATURE PAGE

DRAFT
ACCIDENT PREVENTION PLAN

FORMER FORT DEVENS ARMY INSTALLATION

DEVENS, MASSACHUSETTS

JULY 2022

CONTRACT NO. W912DR-21-D-0002

TASK ORDER NO. W912DR22F0121

Prepared by:

TETRA TECH

Prepared by: ______________________________

Jeffrey (Jim) Streib, CIH, CSP, CHMM, SMS, CQA
Tetra Tech Director, Environmental, Health and Safety
(240) 727-9240

Approved by: ______________________________

Jennifer Harlan, PMP
Project Manager
(406) 940-5040

2.0 BACKGROUND INFORMATION

2.1 CONTRACTOR

Contractor: Tetra Tech, Inc. (Tetra Tech)

2.2 CONTRACT NUMBER

Contract Number: W912DR-21-D-0002, Task Order (TO) Number: W912DR22F0121.

2.3 PROJECT NAME

Former Fort Devens Army Installation, Military Munitions Investigation for Nashua River
Former Fort Devens

2.4 DESCRIPTION AND SITE HISTORY

The Former Fort Devens was active from 1917 to 1996 and was placed on the National Priorities List in 1991. In May 2021, the Army and USEPA signed a Federal Facilities Agreement (FFA). The river is primarily used by recreational users (i.e., canoeing, kayaking, fishing), with trails along some of its banks used for hiking. Massachusetts Department of Transportation (MDoT) divers perform bridge inspections and associated maintenance along the Nashua River. The Nashua River is also known to have an infestation of water chestnut, a non-native, invasive aquatic plant. Active management of this invasive species has been performed by volunteers with the Nashua River Watershed Association since 2014.

Recently, military munitions have been recovered within the project area. Recovered military munitions includes:

- Summer 2020: During magnetic fishing, two MK-II hand grenades and an un-fuzed 60-millimeter (mm) mortar were found.
- March 2021: During a MDoT bridge inspection, three practice 2.36-inch M6A1 rockets, a practice 60mm mortar, and an expended M18 smoke grenade were discovered.

Based on the recovered munitions findings, under the FFA in place for Fort Devens, USEPA Region 1 initiated an Informal Dispute with the Army and a Removal Site Evaluation (RSE) was conducted. Based on the 2021 RSE, there is no evidence the Army used the banks of the Nashua River or the river itself for munitions-related operations. The most likely source of potential munitions in the Nashua River is due to discarded military munitions (DMM).

This Accident Prevention Plan (APP) and associated Site Safety and Health Plan (SSHP), included as Attachment 1 to this APP, have been prepared following requirements contained in the USACE Safety and Health Manual, Engineer Manual (EM) 385-1-1, dated 30 November 2014 (USACE 2014).

2.5 MAJOR PHASES OF WORK

The scope of work for this project are listed below. Based on the information known at present, the currently anticipated definable features of work (DFW) or major activities to be performed, each requiring an activity hazard analysis (AHA), are as follows:

- Mobilization, site setup, and demobilization
- Boating Operation

- Diving Operations and Underwater Intrusive Investigations
- Underwater Digital Geophysical Mapping (UDGM) Survey
- MPPEH through MDAS Management and Disposal

3.0 STATEMENT OF HEALTH AND SAFETY POLICY

TETRA TECH

Health and Safety Policy

Tetra Tech, Inc. is committed to providing and maintaining a healthy, safe, and secure work environment for our associates. Tetra Tech's program is designed to address the hazards associated with our business and to prevent injury and illness in the workplace. Tetra Tech intends to meet its responsibilities by committing to the following:

- Providing a safe, secure, and healthy environment in which to work and promote mental, physical, and social wellbeing initiatives
- Complying with applicable standards, laws, and regulations;
- Designating personnel accountable for implementing H&S programs;
- Communicating H&S programs and practices throughout the organization;
- Encouraging the participation of employees in the OHS program;
- Mitigating potential risks through hazard identification and assessment, employee training, and safe work practices;
- Reporting and investigating OHS events and share learnings across the business, and where appropriate, wider industry;
- Allocating sufficient resources to the program;
- Implementing enforcement and accountability measures; and
- Establishing OHS performance standards and continual improvement of the OHS Program.

Management is responsible for ensuring that Tetra Tech workplaces are safe, and that risks, hazards, and safety violations brought to their attention are investigated, and promptly corrected.

Tetra Tech associates are responsible for complying with Tetra Tech's OHS policy, programs, and standards, and conducting their work safely and without detriment to themselves, other employees, other individuals, or property.

Compliance with this policy is mandatory. Willful violation or negligent disregard of this policy will be considered cause for disciplinary action up to and including termination.

Dan Batrack
CHIEF EXECUTIVE OFFICER

JANUARY 2021

3.1 CONTRACTOR ACCIDENT EXPERIENCE

	Tetra Tech 2019	Tetra Tech 2020	Tetra Tech 2021
TRIR	0.45	0.23	0.22
LWDIR	0.11	0.07	0.05
DART	0.22	0.11	0.09
EMR	0.93	0.86	0.74

Abbreviations and Acronyms:
DART - Days Away/Restricted Duty/Transfer Rate
EMR - Experience Modification Rate
LWDIR- Lost Workday Recordable Rate
TRIR - Total Recordable Incident Rate

4.0 RESPONSIBILITIES AND LINES OF AUTHORITY

4.1 STATEMENT OF RESPONSIBILITY

Tetra Tech is responsible for implementing its Health, Safety, and Environmental (HSE) Program for Tetra Tech employees, subcontractors, and all others on the worksite. No person will be required or instructed to work in surroundings or under unsafe or dangerous conditions to their health. Each employee is responsible for complying with applicable safety and occupational health requirements, wearing prescribed safety and health equipment, reporting unsafe conditions/activities, preventing avoidable accidents, and working safely.

4.2 IDENTIFICATION AND ACCOUNTABILITY

No person may work in a manner that conflicts with the intent of, or the inherent safety and environmental precautions expressed in these procedures. After due warnings, Tetra Tech will dismiss from the site any person who violates safety procedures. Tetra Tech employees are subject to progressive discipline and may be terminated for continued violations. All on-site personnel will be trained in accordance with this document.

4.2.1 Project Management

Line management, managers, and supervisors will confirm the successful execution of project activities per Tetra Tech HSE programs, procedures, and applicable regulations. Line managers have primary HSE responsibility and have HSE personnel to support them in fulfilling this responsibility. Line managers have the responsibility to integrate loss control principles into operations and to:

- Preserve Tetra Tech's safety culture is preserved by demonstrating commitment and program involvement; safety remains a primary project goal, not subordinated to other demands.
- Develop project-specific continuous improvement goals and objectives based on HSE events and issues and communicate them to Tetra Tech employees and subcontractors.
- Implement projects in compliance with environmental, safety, and health laws and regulations, as well as HSE program requirements.
- Develop, approve, and implement the HSE plans following Tetra Tech requirements.
- Personnel understands the requirements of the project's HSE plan(s), and each individual understands his/her responsibility for plan implementation.
- Personnel has the required training and capabilities to perform the assigned tasks.
- Corporate professionals or external resources, such as private consultants, are available for project support as needed.
- Project staff members are aware of and have access to Tetra Tech's technical information, various HSE databases, and online regulatory subscription services.
- Provide providing additional HSE reference books and technical information to project staff upon request.
- Facilities and equipment meet Tetra Tech and government regulations.

- Enforce work rules.
- They are conducting inspections and incident investigations per HSE program requirements.
- Implement timely, practical corrective actions following inspections, audits, incident investigations, etc.
- Employees, including subcontractors, are encouraged and required to notify their supervisor(s) of any actual or potential health and safety hazards in the workplace and develop safe work methods and controls to be implemented in project AHAs.
- Assuring employees and subcontractors will be rewarded (not reprimanded) to report health and safety concerns.
- Notify clients of Tetra Tech incident reporting procedures.
- Appropriate disciplinary action is implemented by line supervision when necessary.

4.2.2 Project Manager

The Tetra Tech Project Manager (PM), Jennifer Harlan, is responsible for the following:

- Ensure implementation of this APP through coordination with the Unexploded Ordnance Safety Officer (UXOSO) and Safety and Health Manager (SHM).
- Ensuring conformance with corporate and other regulatory policies and procedures.
- Coordinating project with the USACE Project Manager (PM) and Contracting Officer's Representative (COR).
- Ensuring that the project personnel satisfy Tetra Tech, and regulatory, safety and health requirements.
- Providing management of all aspects of project work.
- Setting the tone for safety on the job site.
- Ensuring personnel have the equipment, training, and resources to perform the job safely.
- Confirm the APP is approved as required before conducting site work.
- Inform the SHM and UXOSO of project scope changes that need modifications of the APP.
- Assume overall project responsibility for health and safety.
- Provide adequate resources are provided to field staff to carry out their duties (as outlined in this APP/SSHP).

4.2.3 Corporate Safety and Health Manager

The SHM, Jeffrey Streib, will review and approve this APP and any amendments before their adoption. The SHM, a Certified Industrial Hygienist (CIH), Certified Safety Professional (CSP), and Certified Hazardous Materials Manager (CHMM), will help implement the APP and provide project support on health and safety issues. The SHM will advise the PM, SUXOS/DS and UXOSO regarding industrial hygiene concerns, interpretation and evaluation of analytical exposure data, and other safety-related issues, as needed. The SHM will review subcontractor HSE plans. It is also the SHM's responsibility to:

- Provide for the development and approval of the APP and SSHP.
- Serve as the primary contact to review any health and safety matters that arise.
- Approve revised or new safety protocols for field operations.
- Approve individuals who are assigned UXOSO responsibilities.
- Approve any revisions to this APP and its AHAs.
- Approve upgrading or downgrading of personal protective equipment (PPE).
- Assist in the investigation of incidents.
- Visit the project sites as needed to audit the effectiveness of the APP/SSHP.

4.2.4 Senior UXO Supervisor/Dive Supervisor

The SUXOS/DS, Don Schwalback, is qualified in this role, per the U.S. Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP) 18. He will implement on-site leadership for project-related activities about all aspects of military munitions/MPPEH management and accountability, including oversight of the munitions team and dive operations. The SUXOS/DS is responsible for confirming all munitions-related work is performed per the contract requirements safely and healthfully.

It is the SUXOS/DS' responsibility to:

- Direct all military munitions /MPPEH operations and supervise multiple project teams performing military munitions /MPPEH-related activities.
- Plan and direct all project diving operations ensuring all activities related to diving are conducted safely and in compliance with all relevant plans and SOPs.
- Implement and enforce all plans related to military munitions /MPPEH operations and this APP.
- Certify military munitions /MPPEH is ready to turn in for disposal per current policies and contract requirements.
- Coordinate with the UXOSO and SHM on matters regarding site safety and health.
- Maintain control of the work area and prevent any unauthorized persons from entering controlled work zones. If the unauthorized persons refuse to leave, the field crew personnel will cease operations and notify the local authorities to remove these individuals.
- Halt or modify any work conditions or remove personnel from the task site if conditions are unsafe.
- Ensure all task site personnel understand and comply with all safety requirements.
- Monitor the performance of team members, including issues about safety and quality control.

- Be responsible for the overall direction of on-site military munitions C/MPPEH activities.
- Conduct daily activities, such as:
  - Supervising munitions employees in daily operations.
  - Overseeing the implementation of specified levels of PPE.
  - Identifying potential problem areas and taking corrective action recommendations to the PM.
  - Implementing all corrective actions and maintaining a daily log of work activities, including noting any extraordinary occurrences.
- Conduct weekly safety inspections jointly with the UXOSO.
- Conduct incident investigations.
- Initiate corrective actions for observed safety violations.
- Conduct daily safety meetings.
- Ensure completion of the project on schedule and within budget, following the permits and project plans.
- Ensure that appropriate change management procedures are in place.
- Ensure compliance with all environmental, health, and safety requirements, including corporate policies, programs, and procedures; U.S. Occupational Safety and Health Administration (OSHA) construction management requirements; USACE EM 385-1-1 requirements; and any client-specific requirements included in this plan.
- Ensure all site UXO dive team meet training and certification requirements per DDESB TP 18.
- Adequate site security, appropriate for the activities, is maintained.
- Ensure that an adequate labor force is assigned to the project with the proper training, education, experience, skills, tools, equipment, and materials to complete the tasks and minimize potential impacts to the environment.
- Act as Emergency Coordinator (EC) for all military munitions /MPPEH and diving related emergencies.
- Prepare and submit (electronically) the Daily Contractor Production Report to the Tetra Tech PM.

4.2.5 UXOSO/Site Safety and Health Officer (SSHO)

The UXOSO/SSHO, Patrick Oberley, will have the same minimum qualifications as a UXO Technician III. The UXOSO/SSHO (hereafter referred to only as UXOSO) will also meet the requirements for SSHO, as specified in EM 385-1-1, will fulfill the duties and responsibilities as defined by corporate procedures. To be in the role of SSHO, the UXOSO will have completed the 30-hour OSHA construction safety class or equivalent. The UXOSO has five years of construction experience and has had 8 hours of formal health and safety training every year. The UXOSO reports to the SHM assists with the on-site implementation of relevant Tetra Tech HSE programs and procedures. The UXOSO observes operations according to the applicable client- and site-specific requirements and government regulations. The UXOSO is a full-time responsibility. The UXOSO will be present at the project site and located to have full mobility and reasonable access to all significant work operations. The UXOSO is also responsible for:

- Implement and enforce the approved military munitions/MPPEH, explosives safety program, APP, and SSHP in compliance with all Department of Defense (DoD), federal, and local statutes and codes.
- Verify field personnel have received required HSE regulatory and program training, medical surveillance, and respirator fit test requirements.
- Conduct daily informal inspections of site activities to identify safety and occupational health deficiencies and ensure corrective action is implemented.
- Assist SUXOS/DS with weekly health and safety inspections. Ensure corrective actions identified are being addressed and corrected.
- Update the Safety and Health Deficiency Log daily. Post the log as required by EM 385-1-1, Section 01.A.13.d.
- Conduct or assist with daily HSE briefings per corporate procedures.
- Exercise stop work authority when warranted by conditions, per the project plans.
- Support accident and incident investigations.
- Function as a technical resource for all environmental, safety, loss control, and industrial hygiene issues.
- Confirm completion of HSE personnel's specific responsibilities identified in the Tetra Tech HSE programs and the HSE plan(s).
- Perform on-site exposure monitoring to determine/adjust appropriate levels and use of PPE when required.
- Implement procedures and programs to eliminate risk to site personnel, including initiating changes to the plan.
- Act as Emergency Coordinator (EC) for all military munitions/MPPEH-related emergencies when SUXOS/DS is not immediately available to perform this role.

4.2.6 Field Crew Personnel

Field crew personnel include the other persons entering the worksite to assist in completing each project. Personnel includes, but is not limited to, subcontractor workers working under the SUXOS/DS direction, Tetra Tech management personnel, regulatory personnel, and site workers. It is the responsibility of the field crew to:

- Report any unsafe or potentially hazardous conditions or injury/accident/mishap immediately to their supervisor; the supervisor must report this to the SUXOS/DS and UXOSO unless already informed.
- Maintain knowledge of the information, instructions, and emergency actions contained in the MR-QAPP, including this APP.

- Comply with rules, regulations, and procedures outlined in this APP, Dive Operations Plan (DOP), and the attached SSHP, and any revisions made to these documents.
- Initiate the incident reporting chain by notifying the supervisor when involved in an incident/accident (if able to do so).
- Prevent admittance to work sites by unauthorized personnel (if the unauthorized persons refuse to leave, the field crew personnel will cease operations and notify the SUXOS/DS, who will notify the USACE for guidance).
- Perform daily inspections of tools and equipment, including PPE, before use.
- Participate as directed in the preparation of and modifications to the AHAs for work tasks.
- Assist the SUXOS/DS and UXOSO with the implementation of and compliance with the APP/SSHP.

4.2.7 Competent Persons (CPs) and Qualified Persons (QPs)

CPs for anticipated health and safety related issues are designated by the PM and identified, by name, in the AHA where a CP is specifically required (e.g., for excavation) for a task. Subcontractor personnel will provide CPs as required where their tasks require a CP. The subcontractor CPs will also be designated by name in the AHA when needed. For tasks that require a QP, the AHA will also define the QP by name. The names of QPs or CPs designated by Tetra Tech management (e.g., the SHM, or PM) in the AHAs will be provided to the USACE for review and acceptance before any work starting. No work will occur on-site unless a designated CP/UXOSO is present on the job site.

4.3 SUBCONTRACTORS AND SUPPLIERS/VENDORS

When utilizing subcontractors, Tetra Tech directs the subcontractor's supervisor regarding the performance of assigned tasks. Subcontractors are responsible for assigning specific tasks to their employees. Ensuring their employees are adequately trained and in compliance with applicable regulations; and allocating sufficient time, materials, and equipment to safely complete activities according to this APP and their own HSE plans. Subcontractors will attend Tetra Tech's daily health and safety meeting before starting fieldwork.

All subcontractors participating in field activities are required to participate in the Tetra Tech Subcontractor Health and Safety Prequalification Program prior to performing on-site or off-site work. Subcontractors are responsible for the development and enactment of their own site-specific Health and Safety Plan to cover their personnel and actions. Tetra Tech may provide this APP as a courtesy, but subcontractors are responsible for their own health and safety and for supplying their own PPE. Subcontractors will have General Site 24-hour or 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training and latest 8-Hr HAZWOPER Refresher training should they be required to perform on-site work. This will be verified by the UXOSO through initial training documentation review prior to permitting personnel to participate in any onsite activities. Subcontractors are required to have a first aid kit and a fire extinguisher in their vehicles. All personnel must meet the appropriate safety training requirements for the job being performed.

4.3.1 SAFETY RESPONSIBILITIES OF SUBCONTRACTORS AND SUPPLIERS/VENDORS

Individuals employed by subcontractors and suppliers/vendors will receive a site-specific briefing regarding the site-specific physical, chemical, or biological hazards present on the worksite, required safety activities, and their roles and responsibilities for safety practices. While on-site, all subcontractor supervisors will ensure their crews perform tasks that they are contracted to complete and follow, at a minimum, this APP and the task/activity AHAs. The SUXOS/DS will observe their performance and require that the contractor's supervisors ensure compliance.

Subcontractors are responsible for complying with this APP and all applicable federal, state, and local regulations. Subcontractor personnel must receive a briefing from the UXOSO before accessing the project work site. They must fulfill the APP requirements and must acknowledge receipt of the plan and the hazard communication briefing. On-site subcontractors are responsible for providing their personnel with appropriate PPE, as specified by the plan; however, it is the ultimate responsibility of the SUXOS/DS to ensure the APP is followed. Before the commencement or continuation of work, the subcontractor and third-party personnel have the authority to request a work area hazard assessment by the SUXOS/DS (UXOSO input as required). Any work party member observing an imminent safety hazard or potentially dangerous situation will immediately suspend field activities.

Hazards not listed in this APP but known by the subcontractor or known to be associated with a subcontractor's specialty must be identified and addressed before beginning work, both in the subcontractor's HSE plan and during the daily health and safety briefing. The contractor will inform the UXOSO of these hazards and assist in developing and/or revising AHAs.

4.4 LINES OF AUTHORITY

An organization chart depicting the lines of authority is included. Tetra Tech will require that the personnel and subcontractors follow the APP requirements and verify that they are met.

4.4.1 Policies Regarding Noncompliance

Tetra Tech has a discipline program discussed in all new employee orientations and is also written in the Tetra Tech Project Orientation, Rules and Safety Guidelines Handbook (Tetra Tech, 2019). This booklet is given to every company employee. Briefly, the rules implement a progressive disciplinary program. However, if there is a significant compromise of safety procedures at any time, the procedures allow immediate termination of an employee. The UXOSO will immediately report to the PM, and SHM observations of noncompliance in the performance of the subcontractor or workers.

4.4.2 Manager and Supervisor Accountability for Safety

Line Management, the Project Manager, and supervisors ensure all company activities are executed following Tetra Tech HSE programs, procedures, and applicable regulations. Line managers have primary HSE responsibility and have HSE personnel support to help them fulfill this responsibility.

5.0 TRAINING

The training requirements for this contract are specified in the following sections.

5.1 NEW HIRE SAFETY AND OCCUPATIONAL HEALTH TRAINING

All new hire employees will receive Tetra Tech's HSE orientation training at the time of initial hire.

5.2 ON-THE-JOB TRAINING

In addition to the required initial training, each employee will receive three days of directly supervised on-the-job training (i.e., close supervision during the first three days working in the field). This training will address the duties the employees are expected to perform.

5.3 PERIODIC SAFETY AND HEALTH TRAINING

To maintain competency, in addition to completing the 30-hour construction safety training, the UXOSO (for SSHO competency) will receive 8 hours of documented formal, online, or self-study safety- and health-related coursework every year. All project personnel will receive site orientation training at the start of work. This training will be repeated as necessary whenever work activities and site conditions change. Workers with specific training and qualifications will receive recurrent training as required by regulation or certification credential requirements.

5.4 HAZARDOUS WASTE OPERATIONS TRAINING AND REFRESHER

All site workers who work within an exclusion zone (EZ) and may be exposed to chemical-related hazards are required by 29 Code of Federal Regulations (CFR) 1910.120/1926.65 to have completed 40 hours of Hazardous Waste Operations and Emergency Response training. An 8-hour refresher course is also required on an annual basis. Supervisors such as the SUXOS/DS, UXOSO, and subcontractor supervisors must have completed 8 hours of additional relevant supervisory health and safety training.

5.5 HAZARD COMMUNICATION TRAINING

Per the OSHA Hazard Communication Standard (29 CFR 1910.1200 and 29 CFR 1926.59), copies of safety data sheets (SDSs) for hazardous chemical materials used during site operations or that may be present on-site will be available from the on-site UXOSO. The UXOSO will conduct hazard communication (HAZCOM) training per 29 CFR 1910.1200 and 29 CFR 1926.59, EM 385-1-1 (current version), and the HAZCOM program. Training will include, but will not be limited to, all-hazards or potential hazards associated with work activities and any hazardous chemical materials brought to or found on the site.

Tetra Tech will ensure field personnel has the required OSHA Global Harmonization System training; personnel who have not already had the training will receive it as part of the orientation process.

5.6 SITE-SPECIFIC TRAINING

Before the commencement of field activities, the UXOSO will provide site-specific orientation training on each element of this APP and SSHP to all personnel assigned to the site. Site-specific training will address the activities, procedures, monitoring, and equipment for work operations. Training will include site layout, hazards, evacuation route(s), emergency services at the site, and the HAZCOM program, highlighting all APP provisions. This training will also allow field workers to clarify anything they do not understand and reinforce each individual's responsibilities regarding health and safety for their particular activity. If additional training is required to complete field tasks during the site work, then the SHM or UXOSO will either conduct the training or manage site personnel to ensure that tasks are conducted by appropriately trained personnel.

Personnel will be trained in the site-specific emergency response plan, including the employee alarm system, evacuation procedures, routes, meeting places, and accountability; control of fuel sources; fire extinguisher education; minor spill control and cleanup procedures; reporting requirements; and rescue operations, as applicable. AHAs for each DFW or work task will also be reviewed by all employees involved in the task before starting that activity.

5.7 MEC/MPPEH TRAINING

All non-UXO-qualified personnel who will be involved in on-site operations will be given MEC Recognition Training. This training will be used to familiarize non-UXO-qualified personnel with the appearance and components associated with the MEC that may be found on-site. This training will include reviewing the U.S. Army 3Rs training (Recognize; Retreat; and Report).

All UXO technicians are qualified per DDESB TP 18 requirements. All UXO personnel will receive refresher training on the essential identification and safety precautions for anticipated incendiary, practice, and other assorted bombs to ensure safe operations.

5.8 DIVER QUALIFICATION

Diver qualifications are addressed in the Dive Operations Plan separately from this APP. All divers who perform intrusive operations related to munitions are qualified UXO technicians.

5.9 VESSEL OPERATOR

Persons who operate vessels (dive boat and support boat) will have appropriate United States Coast Guard (USCG) licensing for the specific type and classification of vessels they operate. At a minimum, survey and support boat operators who do not have USCG licenses must have completed a boating safety course meeting the criteria of the USCG Auxiliary, National Association of Safe Boating Law Administrators or equivalent, and motorboat handling training, based on the type of boats they will operate and must be designated as boat operators by their company’s authorized representative.

5.10 HEAT STRESS PREVENTION TRAINING

Personnel (including newly hired employees) will receive heat illness prevention training before working outdoors. This training will review the signs and symptoms of heat illness, detail the concept and importance of acclimatization, and Tetra Tech’s responsibility to provide water, shade, cool-down rests, and first aid access.

5.11 FIRST AID AND CARDIOPULMONARY RESUSCITATION (CPR)

The UXOSO will identify individuals with current first aid and cardiopulmonary resuscitation (CPR) training. At a minimum, two people on-site will have current CPR/first aid certification. The SUXOS/DS and UXOSO have current first aid/CPR training. The names of all CPR/first aid-qualified workers will be posted. An automatic external defibrillator (AED) will be available on-site.

5.12 BLOODBORNE PATHOGENS TRAINING

Individuals on-site who have first aid and CPR certification and who may provide first aid and CPR will have completed training per the Tetra Tech Bloodborne Pathogens Program, and the annual OSHA Bloodborne Pathogen Standard found in 29 CFR 1910.1030.

5.13 USE OF PORTABLE FIRE EXTINGUISHERS

Project personnel will receive OSHA-compliant fire extinguisher education (29 CFR 1910.157[g]) to use portable fire extinguishers to respond to incipient-stage fires. Typically provided during site orientation.

5.14 HEARING PROTECTION

Users of personal hearing protection will receive an OSHA hearing conservation program and hearing protector use training (29 CFR 1910.95[i],[k]). Typically provided during site orientation.

5.15 ON-SITE HEALTH AND SAFETY BRIEFINGS AND AHA REVIEW

Project personnel and visitors will participate in daily on-site health and safety briefings conducted by the SUXOS/DS, UXOSO, or designee (e.g., subcontractor supervisor) to assist site personnel in safely conducting their work activities. The briefings will include information on new operations, changes in work practices, or changes in the site's environmental conditions, including AHAs if modified. The briefings will also provide a forum to facilitate conformance with safety requirements, identify performance deficiencies related to safety during daily activities or as a result of safety inspections, and review any events (near misses, injuries, material releases, etc.). Work will stop, and a safety briefing will be conducted following any event that could compromise personnel or the environment's safety.

Weekly, one project employee will be assigned as the Safety Observer. This person will observe the activities for that week and note potential issues of particular concern. Before the daily safety briefing at the beginning of the following work week, this individual will present his/her findings. The intent of this process is not for the development of a lengthy brief but to involve our personnel in the hazard assessment process required to keep our employees safe.

Once per week (usually Monday), a weekly safety briefing will be presented in addition to the daily safety briefing. This briefing will consist of information about site hazards or general safety/health issues relevant to the site personnel and presented by the UXOSO or a speaker selected by the UXOSO. All site personnel will attend the training, and the UXOSO will document this training within the log.

5.16 TRAINING CERTIFICATES

Copies of the required training certificates and licenses (as applicable) will be maintained on-site and made available for government inspection upon request. If utilized, subcontractors will provide Tetra Tech with copies upon request, and these will be held on-site by the UXOSO.

5.17 APP/SSHP ACCEPTANCE FORM

The APP/SSHP Acceptance Form, shown below, will be signed by all workers entering the project site to document site-specific training. Each AHA has a signature page as well.

TETRA TECH, Inc.	**APP/SSHP ACCEPTANCE FORM**	
I have read and understand the policies and procedures listed in the Accident Prevention Plan, Site Safety and Health Plan, and AHAs. I will comply with the provisions therein.		
Print Name	**Signature**	**Date**

6.0 SAFETY AND HEALTH INSPECTIONS

Documented vehicle inspections will be performed daily by the operator. The UXOSO and SUXOS/DS will complete weekly site inspections. Subcontractors and craft personnel may participate in these assessments. The UXOSO will perform daily inspections on the day(s) of scheduled field activities. Included in Appendix D are blank field inspections. During the inspections, any identified deficiencies will be noted on a deficiencies log, as required per EM 385-1-1, Section 01.A.13.d. Defects to safety devices or equipment will be corrected before use or removed from service until repaired.

Tetra Tech will track inspections for follow-up action on each of the respective forms. After the quarterly SHM inspections (if required), the inspection reports are reviewed, and action items are followed up. The SHM, or his designee, may conduct an unannounced inspection of the project.

6.1 SPECIFIC ASSIGNMENT OF RESPONSIBILITY FOR A MINIMUM DAILY JOB SITE SAFETY AND HEALTH INSPECTION DURING PERIODS OF WORK ACTIVITY

The UXOSO will conduct daily HSE inspections during this field effort to ensure work areas are safe and in compliance with the APP/SSHP, AHAs, OSHA regulations, and EM 385-1-1 requirements.

6.2 PROOF OF INSPECTOR'S TRAINING/QUALIFICATIONS

The UXOSO (for SSHO designation) will have completed the 30-hour OSHA Construction Safety Training. They will also have five years of continuous construction industry safety experience in supervising/managing general construction projects (managing safety programs or processes or conducting hazard analyses and developing controls). The UXOSO maintains competency by having taken 8 hours of documented formal, online, or self-study safety- and health-related coursework every year to meet EM 385 1-1 Section's requirements 01.A.17 in the role of SSHO.

6.2.1 Documentation Procedures

The UXOSO will record any deficiencies in the on-site field logbook or a daily safety report submitted along with the Contractor Production and Contractor Quality Control reports to the USACE representative. Additionally, deficiencies will be logged and tracked to closure on the site Deficiency Log.

6.2.2 Deficiency Tracking System

Deficiencies will be logged as required in EM 385-1-1, Section 01.A.13d, and tracked to closure. Responsibility for resolving each item noted during these audits will be assigned and tracked through resolution. Results from field audits are also regularly communicated within Tetra Tech through training and electronic means as a method of continuous program improvement.

6.2.3 External Inspections

External inspections may be conducted by the USACE and Area of Operation commanders, with jurisdiction over the work they may elect to perform inspections.

6.2.4 Competent/Qualified Safety Inspection Personnel

- UXOSO: Patrick Oberley (30-hour Construction Safety Certificate)
- SHM: Jeffrey Streib, CIH, CSP, CHMM

Qualifications are located within Appendix G.

7.0 MISHAP REPORTING AND INVESTIGATION

A mishap is any unplanned, undesired event that occurs during work being performed. The term "mishap" includes accidents, incidents, and near misses. All accidents and near misses shall be investigated by the Contractor. All mishaps as described in in EM 385-1-1 Section 01.D to include property damage accidents in which the property damage exceeds $5,000.00 (excludes on-the-road vehicle accidents) shall be verbally reported to USACE within 24 hours of the incident and then documented on the Initial Notification Form. ENG Form 3394 shall be completed and submitted to USACE Project Manager within five working days of the incident. When a mishap occurs, the employee will notify his/her supervisor immediately. The supervisor will inform the UXOSO and SUXOS/DS. The SUXOS/DS will inform the PM, and the UXOSO will notify the SHM. If the mishap is an emergency, Tetra Tech will notify emergency services, respond as discussed in the Emergency Plans, and then follow up with internal reporting and an investigation. Recordable mishaps will be reported as soon as possible, but not more than 24 hours afterward to the KO/COR by the PM.

7.1 EXPOSURE DATA

The UXOSO will calculate exposure data weekly. Labor hours worked are obtained from hours charged to a project for payroll purposes. The UXOSO also collects the number of subcontractor labor hours performed by reviewing daily project production reports and recording those reports. The UXOSO will forward the labor hours and the Weekly Safety Report to the SHM, and compile the monthly total (field staff only). The PM will submit exposure man-hours for work under this contract to the USACE Project Manager and COR in the monthly report. This will include the total number of exposure hours worked onsite for the prime contractor and any subcontractors .

7.2 IMMEDIATE NOTIFICATION OF MAJOR ACCIDENTS

Tetra Tech requires immediate reporting of incidents. Also, if any accident has, or appears to have, any of the consequences listed below. In that case, Tetra Tech management will immediately (as soon as possible, but not more than 2 hours after the event) report the accident to the USACE. The USACE representative will be notified and will follow up with an official accident report.

Immediate reporting of accidents include:

- An injury or illness that:
  - Involves exposure to a hazardous substance above the permissible exposure limit (PEL)
  - Meets the OSHA recordable criteria
  - Results in permanent total or partial disability
  - Results in one or more worker hospitalizations
  - Results in a worker fatality
  - Involves one or more individuals becoming ill or having a medical condition that is suspected to be related to a site condition, or a hazardous or toxic agent on the site
  - Results in the amputation of any body part or loss of an eye
- An injury or unexpected chemical exposure to a client or member of the public

- Any material or weight-handling incident or near miss, including an overturned crane, collapsed boom, dropped load, or damage to crane or adjacent property
- Any property damage greater than $5,000
- A fire, explosion, or arc flash
- Safety-related events reported by an enforcing authority or client
- External regulatory inspections that result in findings or citations
- A spill or release resulting from Tetra Tech activities
- A permit exceedance
- Any event that could result in adverse public media interest

In addition to the above, any mishap occurring in any of the following high-hazard areas will be immediately reported to the USACE representative. These mishaps will be investigated in-depth to identify all causes and to recommend hazard control measures. The USACE representative will subsequently follow up with official reports as prescribed by regulation. The USACE representative must also be notified immediately (within 2 hours) and provided follow-up investigative findings within ten days of occurrences involving the following hazards:

a. Electrical – including arc flash, electrical shock, etc.
b. Uncontrolled release of hazardous energy (electrical and non-electrical)
c. Load-handling equipment (LHE) or rigging
d. Fall from height (any level other than the same surface)
e. Underwater diving

7.3 PROCESS FOR IMMEDIATE REPORTING TO USACE

Described below is the process for reporting mishaps to the USACE:

1. The scene of any fatality, injury involving hospitalization, weight-handling incident, fire/explosion/flash, or property damage exceeding $5,000 will be secured from disturbance pending investigation and further instructions from the USACE and Tetra Tech SHM.
2. Tetra Tech will make a verbal report to the USACE representative as soon as possible, or within 2 hours, with as much information as available.
3. The Contractor will complete the Contractor's Significant Incident Report (CSIR). The CSIR will be sent via email to the USACE representative for a review of the minimum requirements. Tetra Tech will update the CSIR as information becomes available. Included in Appendix D of this APP is a copy of the CSIR.
4. The USACE representative will review the CSIR for minimum notification content and resolve any issues or concerns.
5. For property damage exceeding $5,000 and any injuries requiring more than first aid, Tetra Tech will complete and submit a USACE Accident Investigation Report (ENG Form 3394).

7.4 ADDITIONAL REPORTING REQUIREMENTS

In addition to the reporting requirements listed above, the employer is required to report:

- Property damage exceeding $5,000
- Days-away injuries
- Days-away illnesses
- Restricted/transferred injuries

If a fatal injury occurs, in-patient hospitalization is needed, or a single occurrence involving amputation, or loss of an eye involving one or more persons happens, the following additional steps will be followed:

- The work activities on the project will be stopped for 24 hours for a fatality
- Personnel will assist the SHM as directed

7.5 TETRA TECH ACCIDENT INVESTIGATIONS, REPORTS, AND LOGS

Except for rescue and emergency measures, the mishap scene will not be disturbed until the investigating official has released it. After the oral reporting has been performed, as noted above, the UXOSO must complete a written event report form for the designated Tetra Tech corporate representative within 24 hours. This form can be prepared manually using the Tetra Tech Corporate Reference Library form or electronically using the corporate database (TOTAL). Within 72 hours, a completed investigation report must be submitted. The investigation report is part of the initial written report form. These forms can be completed by persons involved in the incident, but the investigation must be completed by a supervisor and/or the UXOSO. All reports are reviewed by the PM and the SHM upon submission. Within the reporting system, corrective actions and persons responsible for those corrective actions are identified. The system requires to follow up to ensure completion of corrective actions. All recordable injuries, near-miss incidents, high-loss-potential incidents, property damage incidents, first aid cases, and environmental spills (greater than reportable quantity) will be entered on the Tetra Tech program incident safety database. This database summarizes the program's accident/incident history from the start of the contract and on a year-to-date basis.

8.0 PLANS (PROGRAMS, PROCEDURES) REQUIRED IN EM 385-1-1, THE SAFETY MANUAL (AS APPLICABLE)

Tetra Tech has established written requirements for complying with regulations and implementing Tetra Tech policies to prevent accidents and injuries. This section describes how some of these programs are implemented specifically for this contract.

8.1 FATIGUE MANAGEMENT PLAN

A fatigue management plan (FMP) is completed as part of the APP whenever work hours:

(1) Exceed 10 hours a day for more than four consecutive days

(2) Exceed 50 hours in a 7-day work week

(3) Exceed 12 hours a day for more than three consecutive days

(4) Exceed 58 hours a week for sedentary [including office] work

For this project, field teams will work up to five 10-hour days. The UXO team performing military munitions/MPPEH handling operations, however, will perform these activities for no more than 9 hours per day (not to exceed 45 hours per week). The remaining hour per day will be spent performing non-munitions-related fieldwork (surveying, scrap handling, equipment cleanup, etc.). Due to the hours worked by field staff on this project, an FMP is required and is included below.

8.1.1 Affected Workers

Motor Vehicle Operators

Operators of motor vehicles, while on duty, will not operate vehicles for a continuous period of more than 10 hours in any 24-hour period. In addition, no employee, while on duty, may operate a motor vehicle after being in a duty status for more than 12 hours during any 24-hour period. A minimum of 8 consecutive hours will be provided for rest in each 24-hour period.

8.1.2 Management Responsibility

Tt managers and subcontractor managers, as applicable, will assign the proper number of employees to each shift to complete the work safely and prevent fatigue. Tt and subcontractors will have adequate numbers of personnel available to enable workers to take breaks, eat, relax, and sleep. The PM should establish work-rest schedules based on the level of exertion of the tasks, the PPE utilized, the environmental conditions (e.g., excessive heat), and other contributing factors. The PM is responsible for:

- Ensuring that workers assigned to projects where a formal FMP has been implemented receive initial and annual refresher training on fatigue management
- Scheduling project work in a way that controls worker fatigue
- Utilizing ergonomically friendly equipment on projects when applicable and feasible
- Taking appropriate actions when workers on the project report concerns with tiredness/fatigue

Tt's SUXOS/DS or UXOSO will conduct fatigue management training for workers during site orientation that will cover the topics discussed in Section 8.1.3, below. The UXOSO is responsible for:

- Enforcing work/rest schedules set by the PM
- Ensuring the work/rest cycle minimizes the risk of fatigue throughout the project by performing periodic hazard assessments
- Monitoring workloads, work patterns, and shift arrangements to ensure employees are not placed at risk from fatigue
- Providing instruction about the risks of fatigue to employees through documented safety tailgate meetings

Each individual worker is responsible for:

- Participating in fatigue management awareness training and employing the techniques to manage individual fatigue

- Reporting issues of tiredness or fatigue to the PM and UXOSO, and working together to find the appropriate means to address the situation
- Ensuring that personal use of over-the-counter medication, prescription drugs, and any other products does not affect the ability of the employee to safely perform the assigned work

8.1.3 Training

This type of project and project location can also present unique circumstances that can increase the potential for fatigue. In addition to the possibility of requiring travel on top of the work on site during a particular shift, these types of projects may have the added fatigue potential associated with:

- Heavy physical activity
- Environmental factors, including excessive noise, sun exposure, temperature extremes, direct sunlight, etc.
- Large amount of activity and distractions on the site
- Use of machinery and repetitive motions

Symptoms of Fatigue

Fatigue is a feeling of tiredness or exhaustion and indicates a need to rest because of lack of energy or strength. Fatigue may result due to overworking, poor quality of or lack of sleep, worry, boredom, anxiety, depression, personal medical conditions, use of over-the-counter medications, or lack of exercise. In addition, the following symptoms may indicate that a person is fatigued (the symptoms may vary among individuals):

- Tired eyes and having trouble keeping eyes open or blurry vision
- Tired legs or whole body tiredness
- Stiff shoulders
- Trouble concentrating
- Weakness or malaise
- Boredom or lack of motivation
- Bad mood
- Lack of energy
- Fixed gaze
- Itchy or watery eyes
- Being forgetful
- Difficulty starting or finishing tasks
- Poor decision-making
- Decreased hand-eye coordination

- Decreased attention to the surroundings or poor vigilance
- Decreased reaction time in responding to unsafe conditions
- Dizziness or vertigo, rapid heartbeat, or fainting (in some people, which may indicate if other underlying causes are contributing to the fatigue)

Adequate Sleep

Adequate sleep will help in preventing fatigue by ensuring adequate sleep opportunities, proper sleep-period timing, and appropriate accommodations. Strive to prevent fatigue from occurring in the first place. The primary culprit for feeling fatigued is sleep loss. The first strategy for minimizing sleep loss is to establish a routine approach to obtaining sleep, one that allows enough time to obtain sufficient sleep, and ensures an appropriate sleeping environment. This means going to bed at the same time every night and waking up at the same time every day, allowing for at least 8 hours of rest. Additional sleeping methods/considerations are described below.

- **Napping –** Using napping as a fatigue countermeasure involves sleeping for brief periods during awake periods. Napping should not be used as a substitute for getting enough sleep during your regular sleep period. Additionally, naps should be limited to a time and duration that will not interfere with regular sleep periods. Napping too close to bedtime will produce a boost in alertness that may make it difficult to fall asleep during the regular sleep period.
- **Anchor Sleep –** A regular sleep period of at least 4 hours duration obtained at the same time each day. The anchor sleep period is supplemented by an additional sleep period taken when the schedule allows. This should be used as a coping mechanism for situations where you cannot get a full 8 hours of sleep, but not as a routine. While split sleep periods may give you a sufficient amount on a short-term basis, getting your full sleep allotment in a single episode is preferred.
- **Good Sleeping Environment –** To ensure that sleep is restorative, sleeping environments must be quiet, dark and comfortable. Remove any noise sources, especially those that are unpredictable. Use of earplugs to reduce traffic noise or other external sounds helps many people, as well as the use of a constant low-level noise source such as a fan. Light can be reduced by using black-out shades or eyeshades. The bed and pillows should be appropriate for personal comfort and the temperature not too warm or too cold. Orient the clock face away from you so as not to worry about the time of day, especially when having trouble falling asleep.

Recognizing Fatigue in Coworkers

The recommendations provided below should be followed to assist in recognizing fatigue in coworkers performing shift work; however, these signs also apply to work performed on most construction/field sites. It is important for workers to be able to recognize the signs and symptoms of fatigue and for managers and coworkers to know what to look for in others. Fatigue affects hand-eye skills, judgment, decision making, responsiveness, and more. Fatigued workers take greater risks and make more errors.

The following are some warning signs to watch out for:

- Degraded performance while driving, monitoring equipment, operating and maintaining machinery, etc. This translates into degraded vigilance and decision making and the margin for error, or safety margin, is decreased.
- Poor memory (forgetful), poor decisions, apathetic, lethargic, bad mood, and nodding off.
- Decreased hand-eye coordination, and poor communication and information processing.
- Poor decision making – fixation on certain aspects of a situation to the neglect of other information.
- Poorer performance despite increased effort. People are poor judges of our own performance levels, so it is important for coworkers to watch for this.
- Slowed reaction time – taking longer to react to unsafe conditions, and to shut down equipment in time and to avoid obstructions when operating equipment.
- Reduced vigilance and lower alertness levels.
- Lapses in attention – inability to concentrate and keep a visual scan of instruments and gauges.
- "I just want to get finished" attitude. We tend to press the envelope of safety more because we are too tired to realize how badly the fatigue is affecting our performance, or we just want to be finished. We also accept lower standards.

When you see these signs in yourself or others, it is important to implement appropriate fatigue countermeasures, for the health and safety of the worker and the safe and smooth running of the operation.

8.1.4 Avoiding and Controlling Fatigue

The following will help with avoiding fatigue:

- Work within normal daylight hours (roughly 7 a.m. to 6 p.m.) whenever possible.
- Avoid rotating work hours around the clock by changing work times from day to evening, day to night, etc. (rotating shift work).
- Get sufficient sleep every night (minimum of 8 hours when possible).
- Try to make the sleep environment quiet, dark, comfortable, and temperature controlled.
- Schedule work tasks to allow for doing the most heavy or demanding work at times when workers are most likely to be alert and deliver peak performance, such as at the very start of the shift.
- Break up tasks that are labor intensive or repetitive amongst various workers to avoid overloading any one person. Utilize mechanical equipment versus hand methods for heavy lifting or repetitious tasks whenever possible.
- Eat a well-balanced healthy diet and a get regular exercise. Avoid skipping meals.
- Balance coffee and caffeine laden beverage intake – know how your body reacts to caffeine and generally avoid intake in the late afternoon or evening.

- Minimizing work environment conditions that add to fatigue, such as high temperatures or high noise levels.
- Train workers on how to recognize the signs and symptoms of fatigue.
- Be aware that driving between 1 a.m. and 6 a.m. is during the "fatigue high crash risk period."
- Organize social or recreational activities like games and contests to break up long shifts and give workers a chance to unwind.
- Reduce heat or cold stress in the work environment through engineering controls or administrative controls as appropriate.
- If experiencing chronic (long term fatigue) or prolonged periods of poor sleep, schedule an appointment with your doctor to determine and treat or manage possible underlying causes.

Workers who drive long distances to and from work (when applicable) may consider possible ridesharing with other coworkers if a possibility so as to rotate driving tasks during the week (alternating drivers). Workers who drive vehicles during work shifts may have a higher potential for fatigue when getting behind the wheel for the drive home from work, and, if the commute is long, may not have sufficient time for rest between shifts. The PM should be made aware of this extended "work shift" due to travel and evaluate the way work is organized, managed, and performed to minimize this occurrence.

Management will perform adequate scheduling to afford sufficient opportunity for worker rest. If night shifts are required (not currently anticipated), Tt will limit the number of consecutive night shifts performed by the same workers. Tt supervisors will rotate jobs to prevent repetitive work, and will provide breaks at critical times in the work cycle. Tt management will evaluate and control environmental factors (e.g., excessive heat, excessive cold, and PPE use), will use the buddy system for working in isolated locations, and will evaluate alternate transportation for long commutes.

8.2 EMERGENCY PLANS

The UXOSO will perform pre-emergency planning before starting field activities and during the mobilization and site-specific training phase of the project and will coordinate emergency response with police/fire/rescue personnel and the nearest hospital. Pre-emergency planning meetings will be used to inform local authorities of the nature of site activities that will be performed under the PWS and the potential hazards that activities may pose to site workers, the environment, and the public.

8.2.1 Pre-Emergency Planning and Test

Based on the nature of the planned activities, emergencies resulting from physical or chemical hazards, such as personnel exposures, fires, explosions, injuries, or medical emergencies, could result. It is the responsibility of the SUXOS/DS and UXOSO with participation by subcontractor and craft personnel to minimize or eliminate the potential for these emergencies; pre-emergency planning activities will include the following:

- Coordinating with the local emergency response personnel and local hospitals (before the commencement of work to ensure that Tetra Tech emergency action activities, including rescue and escape capabilities, are compatible with existing Tetra Tech, subcontractor, and local emergency response agency procedures.

- Establishing and maintaining information and equipment at the project staging areas (Support Zones [SZs]) for easy access in an emergency.
- Training all workers on the requirements of emergency plans and the locations of emergency equipment and evacuation routes.
- Evaluating emergency procedures via drills and updating plans as required when procedures are ineffective, or situations change.
- Creating and maintaining documents on-site that can be important in the event of an emergency.

At the beginning of the fieldwork, the EC will hold an emergency evacuation drill. The drills will require evacuations of the site to the designated evacuation area. The UXOSO will, after the drill, conduct a written debrief meeting with all participants. The UXOSO will prepare a short report with recommendations for improving the evacuation plan when necessary, and, if required, the emergency evacuation plans will be updated accordingly. During a drill, it will be important to indicate to the team through all communications that “this is a drill.” Emergency drills will be conducted such that adjacent operations will not be affected by the drill, and emergency service agencies will not be contacted.

The UXOSO will drive each hospital route using only the text directions from the figure. If a route map is not accurate, it will be updated accordingly.

8.2.2 Posting of Emergency Telephone Numbers

The list of emergency telephone numbers in Table 8-2 will be maintained in all site vehicles and boats.

8.2.3 Spill Emergency Plan

Tetra Tech will conduct cleanup operations in the event of a spill of hazardous materials. The UXOSO will manage the collection of spilled material with the appropriate absorbent materials (e.g., sorbent pads, sorbent socks, chemical protective gloves, and bags) into a DOT approved container for disposal. A complete spill kit will be maintained on site when spills are a potential hazard. Chemicals brought to the site will be in small quantity containers in order to limit the amount of material spilled, should a spill occur. As part of mobilization training all personnel will be trained in the procedures for cleanup of small spills.

In the event of a spill or leak of any potentially harmful material, onsite personnel will:

- Notify the SUXOS/DS and UXOSO immediately
- The SUXOS/DS or UXOSO will notify the PM and SHM of the spill/leak with relative information (time, chemical identity, quantity, location, hazards listed on the SDS), and any corrective actions/measures taken
- Locate the source and stop the spill/leak if it can be done safely
- Begin containment and recovery of spilled material using appropriate PPE and spill cleanup equipment and materials

- Determine if quantities meet or exceed the reporting requirements for spills.
- Once notified, the PM will notify USACE representative.
- Tetra Tech will assist the USACE representative as directed with any required notification to regulatory agencies if the spill is reportable.
- In no case will Tetra Tech report a spill to a regulatory agency without the USACE representative and/or KO concurrence.
- An investigation and incident report will be prepared and corrective actions identified.
- Waste from the spill will be evaluated and managed for proper disposal in accordance with federal and local laws and regulations and base requirements.

8.2.4 Fire Emergency Plan

Workers will not fight any fires other than incipient-stage fires (small fires that have recently occurred and can be reasonably extinguished immediately). There will be at least one fire extinguisher (refer to Table 8-1) at each active work location. Fire extinguishers will also be located in each boat and in the crew pickup trucks. The fire extinguishers are intended to fight only incipient-stage fires. In no case will workers attempt to fight any fire that cannot be reasonably extinguished within 30 seconds to 1 minute.

If a fire breaks out, call or designate someone to call the local fire department before attempting to put out the fire (incipient stage only) and only if fighting the fire does not put anyone at further risk. Ensure a means of egress is available in the event the fire cannot be extinguished. The local Fire Department will respond.

To use the fire extinguisher, remember the word P.A.S.S. – pull the pin, aim the nozzle at the base of the fire, squeeze the lever, and sweep side to side at the base of the fire. Workers will be given fire extinguisher training during project orientation.

Fire extinguishers will be inspected by the UXOSO initially and then every month (at a minimum). Additionally, all fire extinguishers will be inspected and serviced annually by a qualified professional. Any defective or partially used fire extinguisher will be red-tagged and taken out of service until such time that it can be serviced. Fire extinguishers will be secured or supported when transported and in storage. During project demobilization, all fire extinguishers and other hazardous material will be properly dispositioned for further use at other Tetra Tech projects or for use by others at the base, if suitable.

In the event of a fire or explosion, contact the appropriate emergency authorities by calling emergency services. Any fire must also be reported to the appropriate client point of contact and the SHM.

8.2.5 Inclement Weather

The potential for severe weather is possible, as storms can occasionally be severe. The UXOSO will monitor the weather forecast a minimum of two times per day and more frequently as required (e.g., when a storm is forecast in the area). If particularly ominous weather conditions are predicted (e.g., approaching thunderstorm cell), the UXOSO will regularly monitor radio broadcasts or host nation weather service reports. Management will evaluate the situation and take appropriate action in advance of the storm to maintain worker safety, including travel to and from work, and evaluate whether to shut down the site, secure equipment, and/or perform specific tasks as necessary before the storm arrives.

In preparation for an approaching storm, the SUXOS/DS and UXOSO will determine the appropriate length of time that it will take to safely halt operations and secure equipment and operations in advance of the storm so that work can be halted with enough advance time for the safety of crew and equipment. Equipment will be secured and all doors and windows of the equipment (e.g., equipment cabs) will be closed. Tools and supplies will be stored in a designated secure location.

Nearby thunderstorms, if present, could have lightning associated with them. When a storm arises, the UXOSO will determine if lightning is within 10 miles of the site. Once lightning is seen, count the number of seconds until you hear the thunder. Divide the number of seconds by 5 to get the distance the lightning is away from you. If lightning is 10 miles away or less, work shall stop until 30 minutes after the last audible thunder or visible flash of lightning. A lightning meter may be used, as well, if available on-site. If lightning is observed, all work will stop until no lightning activity is observed for a minimum of 30 minutes, and all outdoor workers will seek shelter in a fully enclosed vehicle cab or other fully enclosed structure.

The SUXOS/DS and UXOSO will assess what work procedures can be safely performed when wind conditions exceed 20 miles per hour (mph) for any activities that can be affected by wind; lesser wind speeds may require consideration of work suspension depending on conditions. The SUXOS/DS and UXOSO will also consider fugitive dusts, the safety of equipment in high winds, and the protection of workers from flying debris.

8.3 SITE SANITATION/HOUSEKEEPING PLAN

Sanitation facilities will be provided and maintained on-site as required in Section 2 of EM 385-1-1. Tetra Tech will provide portable toilet and handwashing (soap and water) facilities at each project worksite, unless workers have transportation to readily available toilet and/or handwashing facilities. Where it is not practical to provide running water, hand sanitizers containing at least 60 percent ethyl alcohol may be provided, and workers trained in the proper use of the sanitizer. Sanitation facilities will be ventilated and serviced on an as-needed basis, but not to exceed a weekly basis, maintained in sanitary condition, and located in an area accessible to work activities. Individual disposable paper towels or warm air blowers designed for hand drying will be available. The minimum number of toilet facilities will be provided in accordance with Table 2-1 (other than construction-sites) in EM 385-1-1.

Potable water will be provided for washing the hands and face and for drinking water. During hot weather, cool drinking water will be provided. Drinking water will be from a local municipal water supply or will be store-purchased bottled water whenever possible. Potable drinking water containers with lids will be marked “drinking water” and will not be used for any other purposes. Disposable cups will be provided for drinking water, or Tetra Tech will provide bottled drinking water purchased from a vendor.

Any outlets or containers that dispense non-potable water will be labeled as “Caution – water unsafe for drinking, washing, or cooking.” There will be no cross-connection, open or potential, between a potable water system and a system furnishing non-potable water.

Workers will discard all food debris and other detritus generated on-site in a designated refuse container with a closing lid regularly serviced. Used disposable PPE and other project wastes will be managed as detailed in the MR-QAPP in a manner that does not allow for the spread of contamination by rain, wind, or spills/releases.

Good housekeeping procedures will be maintained throughout the duration of work, and regular cleaning will be performed to maintain safe and sanitary conditions in the workplace. Workroom floors will be kept as dry as possible, with appropriate drainage if wet processes are used. Floors and working surfaces will be kept free of protruding objects, splinters, loose boards, clutter, and unnecessary holes and/or openings.

8.4 MEDICAL SUPPORT AGREEMENT

Tetra Tech and subcontractor crews will have working cellular telephones and handheld radios to allow team members to communicate with one another and dial local emergency services if required. Tetra Tech and subcontractors will use work trucks to transport workers to the evacuation area in an emergency. The UXOSO vehicle will be designated as emergency evacuation safety vehicle. All communication devices will be regularly tested in the work areas to ensure functionality.

Table 8-2 includes the telephone numbers of hospitals, or ambulances for emergency medical support, along with project personnel emergency contact names and numbers. This table will be conspicuously posted in the SZ and present in each site vehicle/boat.

During or before mobilization, as required, personnel working at medical facilities will be used to treat injured employees. The UXOSO will confirm the nature of the work to be performed and the injuries/illnesses prevalent on such job sites.

A copy of the map showing the best route to hospital will be posted in the SZ and present in the office and each supervisor’s site vehicle.

The project site will have a first aid kit (one for every 25 or fewer employees) that complies with the criteria in American National Standards Institute standard Z308.1 and EM 385-1-1, Table 3-1. In addition to the basic fill requirements, each kit will be supplied with optional fill contents commensurate with the hazards found in the work environment, as recommended by a local health care professional. Additional supplies, such as an AED, fire blankets, burn gel, and trauma kit, will also be available at the SZ during field activities.

A minimum of two first aid-/CPR-qualified persons will be on-site for each shift. UXOSO will have first aid/CPR training. Names of all first aid-/ CPR-qualified persons will be posted on the office bulletin board or SZ for field crews.

8.5 BLOODBORNE PATHOGEN PROGRAM

Bloodborne pathogens enter the human body and blood circulation system through punctures, cuts, or abrasions of the skin or mucous membranes. Transmission of bloodborne pathogens does not occur through ingestion (swallowing), through the lungs (breathing), or by contact with whole, healthy skin. However, under the principle of universal precautions, all blood should be considered infectious, and all skin and mucous membranes should be deemed possible entry points for pathogens. Two primary bloodborne pathogens include Hepatitis B and human immunodeficiency virus (HIV)/Acquired Immune Deficiency Syndrome.

Potential bloodborne pathogen exposures include:

- Contact with contaminated medical equipment or medical waste or Sharps

- Medical emergency response operations, such as administering first aid or CPR

To reduce the risk of contracting a bloodborne pathogen, take the following precautions:

- Avoid contact with blood and other bodily fluids.
- Use protective equipment when giving first aid/CPR, such as disposable gloves and breathing barriers (Found within first aid kits).
- Thoroughly wash your hands with soap and water immediately after giving care.

When cleaning up blood or other bodily fluids:

- Clean up the spill immediately or soon as possible after the spill occurs.
- Use disposable gloves and other PPE when cleaning spills.
- Wipe up the spill with paper towels or other absorbent materials.
- After wiping up the area, flood the area with a solution of one-quarter cup of liquid chlorine bleach to 1 gallon of fresh water and allow it to stand for at least 20 minutes.
- Dispose of the contaminated material used to clean up the spill in a labeled biohazard container.

Notify the UXOSO of any potential contact with blood or bodily fluids resulting from first aid or CPR administered on the job. The UXOSO will notify the SHM. Before work activities, occurring site persons are training on bloodborne pathogens.

8.6 EXPOSURE CONTROL PLAN

If exposure to potential bloodborne pathogens occurs, the SHM will direct the post-exposure activities. An exposure control plan will be prepared to include a requirement for immediate medical evaluation of exposed individual(s) per current recommendations of the Centers for Disease Control for HIV, Hepatitis B virus, and Hepatitis C virus.

Before starting work outside the employee’s normal geographical area, Tetra Tech will inform employees of parasitic, bacterial, viral, and environmental diseases endemic to the geographical work location. This information and preventative measures and actions to take upon exposure from potential carriers of these diseases relevant to this project location (e.g., mouse or bird droppings, bites from mosquitos, ticks, etc.) are contained in Section 8.12.4 of this APP.

8.7 AUTOMATIC EXTERNAL DEFIBRILLATOR PROGRAM

An AED will be available on-site. First responders who have current first aid/CPR training and may be called upon to use the AED in a medical emergency will be trained in the proper use of the AED model supplied at the site, including a hands-on training component.

8.8 SITE LAYOUT PLAN

Approval to stage materials and equipment and set up work areas and laydown areas and access to the site and employee parking for the clearance and logistical activities will be coordinated and approved before starting field activities.

The approved laydown area(s), including a location for temporary field facilities, such as break areas, portable sanitary facilities, and an area for staging supplies and materials and equipment storage, will be established during mobilization.

A Traffic Plan is not necessary for this project. Construction areas and EZs will be delineated with high-visibility fencing, barriers, and/or signage.

Tetra Tech personnel and subcontractors will become familiar with and obey the local requirements and security procedures required at all times. Tetra Tech and subcontractor personnel will keep within the established work area limits and avenues of ingress and egress. It will not enter any buildings or areas unless specifically authorized in advance by the USACE representative for such entry. Tetra Tech will conspicuously mark any equipment and materials in possession for identification purposes.

8.9 ACCESS/HAUL ROAD PLAN

An Access and Haul Road Plan, as required by EM 385-1-1, is not applicable.

8.10 HEARING CONSERVATION PROGRAM

The UXOSO will evaluate the workplace for noise hazards initially and regularly during work. The UXOSO will conduct noise monitoring whenever it is difficult to communicate at distances greater than 2 feet, upon worker complaint of excessive noise, or whenever hazardous noise levels are suspected, including when new equipment is placed into service or new areas.

The assessment of noise hazards will comply with the instrumentation requirements of Section 05.C.03 of EM 385-1-1, the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) continuous noise exposure standards outlined in Table 5-4 of EM 385-1-1, and the assessment/evaluation will be documented.

- For impact (impulse) noise, personnel exposures may not exceed 140 decibels (dB) (unweighted) without effective hearing protection devices.
- For continuous (steady-state) noise, personnel exposures may not equal or exceed 85 dB without effective hearing protection devices.

During this contract, noise hazards are known or expected during the following tasks:

- Operation of power tools
- Operation of refilling air tanks

Adjacent operations not under the control of Tetra Tech may also present a source of the noise.

The SUXOS/DS and UXOSO will consider and implement practical engineering or administrative controls when personnel are exposed to continuous (steady-state) sound pressure levels exceeding the above levels. Engineering controls may include lubrication, isolation, damping, baffles, or other methods suitable for the situation.

As an administrative control, the SUXOS/DS and UXOSO will post hazardous noise areas (areas where the noise values exceed the above thresholds) and the requirement for hearing protection in these areas. Equipment identified as noise hazardous will be labeled as a noise hazard requiring the use of hearing protection. If the equipment's noise hazards may affect adjacent workers, the workers will be notified of the noise values and offered hearing protection. If noise exposure to employees cannot be reduced to below the required standard, operating time limits may be imposed.

Hearing protection devices will be provided to affected employees to attenuate noise to acceptable levels (less than 85 dB for continuous [steady-state] noise). Ear insert devices, including disposable, pre-formed, or custom-molded earplugs, will be fitted to the exposed individual by an individual trained in fitting and recognizing the difference between a good and poor fit.

Workers who work in noise hazardous environments more than 30 days per year on the job will undergo pre-employment and end-of-employment hearing testing.

8.11 RESPIRATORY PROTECTION PLAN

Respiratory protection is not anticipated at the site. Any modifications to this plan that dictate the need for additional respiratory protection measures will be added to this plan by Field Change Request and approved by the SHM.

8.12 HEALTH HAZARD CONTROL PLAN

The primary physical health hazards associated with this contract include:

- Ergonomic hazards associated with movement and placement of heavy and awkward materials or equipment which can also fall or shift and injure or crush a worker if workers are placed in proximity to these activities.
- Trip and fall hazards due to debris and materials on the job site, slippery surfaces such as the vessel deck, or uneven surfaces.
- Diving related hazards (addressed in the Dive Operations Plan, Attachment 2).
- Working onboard vessels and on the water. Falls into water from vessel are also possible which can lead to drowning and/or hypothermia or could lead to being struck by another vessel.
- Working with and handling MPPEH, including UXO, and using donor explosives to perform underwater and/or land-based disposal operations. There is the potential for unanticipated explosions to occur if items are not handled properly.

This project will also use fuel, such as diesel and gasoline, and other hazardous materials, such as grease and oil, equipment maintenance, and spray paint for marking utilities and site features. Use of hazardous materials will occur per manufacturer's use instructions, in an outdoor and well-ventilated area, using the proper PPE as per the pertinent SDS, per the Hazard Communication Standard. Tetra Tech will provide HAZCOM training to all employees that may be exposed to a substance.

Biological hazards may be present on-site from biting/stinging insects, venomous snakes, and bloodborne pathogens (e.g., if first aid or CPR are required).

Chemical hazards and mitigation measures to reduce those hazards, including the monitoring strategy for this contract, are described in Section 8.12.1 below. Section 8.12.2 addresses biological hazards.

Munitions-related hazards and mitigation measures to reduce hazards related to unexpected explosions or fires during military munitions/MPPEH operations are addressed through standard operating procedures (SOPs) and industry-standard requirements included in the QAPP and Explosive Safety Plan (ESP) by qualified UXO technicians under the direct supervision of the SUXOS/DS.

Tetra Tech will create systems and processes to prevent and control physical, chemical, and biological hazards identified through the risk/hazard analysis. The hierarchy of controls is engineering, administrative, work practice, and PPE. Such controls, in conjunction with PPE, will help reduce the hazard or exposure to the lowest practical level. The basic formula for controlling workplace hazards, in order of preference, includes:

- Eliminating the hazard from the method, material, or the facility
- Abating the hazard by limiting exposure or controlling it at its source
- Training personnel to be aware of the hazard and to follow safe work procedures to avoid it
- Prescribing PPE (for protecting employees against the hazard and ensuring they not only use it, but they know how to use it correctly

8.12.1 Chemical Hazards and Controls

Chemicals of concern (COCs) related to military munitions/MPPEH (e.g., if items are broken open and contain explosive filler) and hazardous materials to be used will be identified before the initiation of field activities. The implementation of site control zones, proper decontamination, and handwashing procedures will help control potential dermal, inhalation, or ingestion exposures and transfer of contaminants, which could be ingested, inhaled, or contacted by others, to adjacent areas. When these engineering controls are not enough, PPE will be designated to help control potential exposures.

A variety of controls will be implemented during the work tasks to keep worker exposures below the PEL and TLV and to minimize the potential for the spread of contaminants, as follows:

- Workers will have access to and will be informed of the requirement to use hand washing stations to wash hands before taking breaks, eating, drinking, or smoking.
- Workers will doff and stow any soiled PPE in a designated location at the direction of the UXOSO and will not wear or bring dirty clothing or soiled work boots into break areas, office areas, or cab of site vehicles.
- Control zones will be established around the work areas where chemicals are present as specified in this APP.
- Appropriate level of decontamination for equipment and personnel will be specified by the UXOSO and will be performed when leaving contaminated areas to ensure contaminants are not tracked out to adjacent areas.

8.12.2 Biological Hazards

Biological hazards that may be found on-site include plants; insects, such as bees, wasps, and mosquitoes; spiders; and snakes. Employee awareness and the safe work practices outlined in the following paragraphs should reduce the risk associated with these hazards to acceptable levels.

8.12.2.1 **Human Biological Exposure Prevention**

No human biological exposure hazards are anticipated during this contract. The human biological exposure of blood from the occasional first aid treatment is addressed in HSE 1-06, Bloodborne Pathogen Program.

8.12.2.2 **Rabies and Animal Exposure Prevention**

Rabies is a deadly disease caused by a virus. The rabies virus is found in the saliva and brain tissue of infected (rabid) animals. The rabies virus does not live in the blood of animals. Rabies can be spread from animal to animal or from animal to human. Rabies is spread when the saliva or brain tissue of an infected (rabid) animal gets in the mouth, the eyes, or an open cut. Rabies is most often spread to animals and humans through a bite from an infected animal.

Animal to Human Transition

Mainly wild animals, such as raccoons, skunks, foxes, and bats, carry rabies. Humans, dogs, and cats can also get rabies. Squirrels, hamsters, guinea pigs, gerbils, chipmunks, rats, mice, and rabbits usually do not get rabies. If a rabid animal bites or scratches or its saliva or brain tissue makes contact with the mouth, eyes, or an open cut, it can transmit rabies. Rabies can be prevented in humans if medical treatment is begun soon after contact with the rabies virus. If left untreated, rabies is always deadly.

Identification of Rabid Animals

Rabid animals may act tame. They may also display strange or unusual behavior. They may act aggressive, avoid food and water, foam at the mouth, or have trouble moving. Stay away from any unknown animals, especially wildlife. Report any dog or animal acting unusually to the UXOSO.

Prevention

Stay away from wild, sick, hurt, or dead animals. Do not pick up or move sick or hurt animals. If you find a wild, sick, or hurt animal, contact the UXOSO. Do not leave garbage or food outside. Food left out may attract wild or stray animals.

Treatment

Wash the bite area with warm, soapy water. Notify the UXOSO immediately. Treatment consists of six shots given over the course of one month. The shots are no more painful than any other shot. They are usually given near the area of the bite or in the arm or the buttocks.

8.12.2.3 **Domestic Animals**

The work on this contract may present a possible exposure to wild dogs. Guidelines for dealing with wild dogs include the following:

- Do not approach an unfamiliar dog
- Do not run from a dog and scream
- Remain motionless when approached by an unfamiliar dog
- If knocked over by a dog, roll into a ball and lie still
- Do not play with an unfamiliar dog

- Immediately report stray dogs or dogs displaying unusual behavior
- Avoid direct eye contact with a dog
- Do not disturb a dog that is sleeping, eating, or caring for puppies
- Do not pet a dog without allowing it to see and sniff you first
- If bitten, immediately report the bite to the UXOSO

8.12.2.4 **Bees, Wasps, Hornets, and Yellow Jackets**

Most people stung by an insect will have redness, itching, swelling, and some pain around the sting site. Some people are allergic to insect stings. They may experience hives, rash, itching palms and feet, headache, dizziness, nausea, vomiting, and trouble breathing. If stung, employees should contact the UXOSO immediately. If any of these symptoms develop, it may be necessary to go to the nearest hospital or doctor right away for treatment.

Prevention

Stinging insects are found around flowers, plants, garbage cans, picnic grounds, and other places where food is kept. Avoiding these locations is the best way to avoid being stung. While walking in grassy areas, employees should wear long pants, long sleeves, hats, gloves, and shoes.

Treatment

The following actions should be taken if stung by an insect:

- If a stinger is present, remove it by scraping a card across the wound. Do not touch or squeeze the stinger. This will force venom (poison) into the skin.
- Wash the sting site with soapy water.
- Put a paste of meat tenderizer and water on the sting site. This may help stop some pain and swelling. Ice packs can also help to stop the pain and swelling.

Protective Measures

With these things in mind, and with the high probability of contact with stinging insects, all site personnel will comply with the following safe work practices:

- If a worker knows that he is hypersensitive to bee, wasp, or hornet stings, he must inform the UXOSO of this condition before participation in site activities. The worker should have prescription medication such as Epi-Pen available if prescribed by their doctor.
- All site personnel will be watchful for stinging insects and their nests and will advise the UXOSO that a stinging insect nest or the presence of a swarm of bees is located or suspected in the area.
- Any nests located onsite will be flagged and site personnel will be notified of its presence.
- If stung, site personnel will immediately report to the UXOSO to obtain treatment and to allow for the observance of the individual for signs of an allergic reaction.

8.12.2.5 **Ticks**

Ticks are small, ranging from the size of a comma up to about one-quarter inch. Ticks feed by inserting their mouths into the skin of a host and slowly take in blood. They are sometimes difficult to see. The tick season typically extends from spring through summer. When embedded in the skin, they may look like a freckle.

Preventive Measures

Ticks often hide in shady, moist ground litter, but the adults can often be found above the ground clinging to tall grass, brush, and shrubs. No natural vegetated area can be considered completely free of ticks. Ticks cannot jump or fly and do not drop from above onto a passing animal or person. Only by direct contact do you encounter ticks. The tick climbs upward until it reaches a protected or creased area, often the back of the knee, groin, navel, armpit, ears, or nape of the neck. It then begins the process of inserting its mouthpiece into the skin until it reaches the blood supply. Standard field gear (i.e., work boots, socks, light-colored clothing, long-sleeved shirts, and long pants) provide good protection against tick bites. Light-colored clothes make it easier to see ticks; however, even when wearing field gear, the following precautions should be taken when working in areas that might be infested with ticks:

- When in the field, check yourself often for ticks, particularly your lower legs and areas covered with hair.
- Spray outer clothing and skin, particularly your pant legs and socks, with an insect repellent that contains at least 33% diethyl-meta-toluamide (DEET).
- When walking in wooded areas, avoid contact with bushes, tall grass, or brush as much as possible.
- If you find a tick, remove it by pulling on it gently with pointed tweezers.
- Do not use matches, a lit cigarette, nail polish, or any other type of chemical to "coax" the tick out.
- Be sure to remove all parts of the tick's body and disinfect the area with alcohol or a similar antiseptic after removal.

8.12.2.6 **Venomous Snakes**

Of the 14 types of snakes generally located in Massachusetts only two of them are venous. They are the Northern Copperhead (shown below) and the Timber Rattlesnake.

Treatment

If bitten, immediately get medical help from medical professionals. The most appropriate treatment for a significant snake envenomation is geographic and species-specific antivenin administered by trained medical personnel.

Prevention

Never approach a snake. The best snakebite treatment is to avoid being bitten. The following suggestions will help in this process:

- Learn to identify venomous snakes. This will be reviewed during site-specific safety training.
- Watch where you sit and where you place your hands and feet.
- Avoid rock piles, crevices, and brushy areas. If movement is necessary, use a remote means to initially relocate the material before entering an area--look and listen carefully.
- Do not place hands into holes, crevices, debris, or anywhere that may hide a snake.
- Never handle "dead" snakes; they may not be completely dead.
- Do not attempt to capture or kill ***ANY*** snakes.

8.12.2.7 **Plants (Poisonous and Irritants) Causing Skin Reactions**

A number and variety of hazardous plants may be encountered. The ailments associated with these plants range from mild hay fever to contact dermatitis to carcinogenic effects. The plants that present the greatest degree of risk to site personnel (i.e., potential for contact versus effect produced) are those that produce skin reactions and skin and tissue injury.

8.12.2.8 **Plants Causing Skin and Tissue Injury**

Contact with sharp leaves, nettles, and thorns are of special concern to site personnel. This concern stems from the fact that punctures, cuts, and even minor scrapes caused by accidental contact may result in non-infectious skin lesions and the introduction of fungi or bacteria through the skin or eye. This is especially important because the warm, moist environment created inside protective clothing is ideal for propagating fungal and bacterial infections. Personnel receiving any of the injuries listed above, even minor scrapes, will report it immediately to the UXOSO for initial and continued observation and care of the injury. Keeping the skin covered as much as possible (i.e., long pants and long-sleeved shirts) in areas where these plants are known to exist will limit much of the potential exposure. If the rash is scratched, secondary infections can occur. The rash usually disappears in 1 to 2 weeks, in mild exposure cases, and up to 3 weeks when exposure is severe.

Preventative Measures

The hazardous plants of greatest concern are those varieties found in the project area having the ability to cause redness, blisters, swelling, and intense burning and itching due to punctures, scrapes, or lacerations. Improper treatment of an injury can cause secondary infections to occur. Preventive measures that can prove effective for most site personnel are:

- Avoid contact with any hazardous plants on-site.
- Remove gloves before touching the face, neck, or other exposed areas of the body.
- Wash hands, face, or other exposed areas at the beginning of each break period and the end of each workday.

- Keep the skin covered as much as possible (i.e., long pants and long-sleeved shirts) in areas where these plants are known to exist, limiting some of the potential exposure.

8.13 HAZARD COMMUNICATION PROGRAM

At the time of the preparation of this APP and SSHP, specific hazardous materials or chemicals that will be brought onto the project site or used on the project site are not fully known; however, small quantities of gasoline, diesel, and motor oil, as well as lead-acid or lithium-ion batteries for powering equipment. When any material or chemical is brought onto the site, an SDS must be provided to the UXOSO. The hazardous materials inventory in Appendix F, including actual SDSs, will be finalized before mobilization and will include the locations where hazardous materials are stored.

The UXOSO will file the SDSs in a notebook available in the UXOSO's vehicle. The UXOSO will review the SDSs with the workers, and this training will be documented on the daily safety meeting form. All workers will have general HAZCOM training that explains how the program is managed at the site. It specifically requires them to notify the UXOSO when any new material is brought onto the site.

All containers will be labeled specifying the content and hazards of the material in the container. An inventory will be maintained, citing the location and quantities held. Products will be maintained in the original product manufacture's containers whenever possible. Gasoline and diesel fuel will be contained in UL-listed metal safety containers. Any products transferred to an alternate container will be appropriately labeled with the product identification and hazard warnings.

8.14 PROCESS SAFETY MANAGEMENT PROGRAM

Not applicable. No highly hazardous chemicals will be used during work activities in thresholds requiring this program to be in place.

8.15 LEAD COMPLIANCE PLAN

Not applicable. This contract does not include handling or abatement of lead.

8.16 ASBESTOS ABATEMENT PLAN

Not applicable. This contract does not include handling or abatement of asbestos.

8.17 RADIATION SAFETY PROGRAM

Not applicable. This contract does not include handling or working with or around radiation sources.

8.18 ABRASIVE BLASTING PROCEDURES

Not applicable. This contract has no abrasive blasting activities.

8.19 HEAT STRESS MONITORING PLAN

Procedure SWP 5-15, located in Appendix C, provides the appropriate control measures for managing thermal stress concerns along with monitoring ambient temperature in the work area, tracking thermal workloads, and determining the need for personal protective and administrative controls. The UXOSO will be responsible for monitoring workers during work and rest regimens for heat stress.

8.20 COLD STRESS

Procedure SWP 5-16, located in Appendix C, provides the appropriate control measures for managing cold stress concerns along with monitoring ambient temperature in the work area, tracking thermal workloads, and determining the need for personal protective and administrative controls. The UXOSO will be responsible for monitoring workers during work and rest regimens for cold stress.

8.21 INDOOR AIR QUALITY MANAGEMENT

Not applicable. The designated smoking area will be at least 25 feet from any building entrance, and local ordinances will be reviewed to determine if more stringent requirements apply. Use of tobacco (cigarettes and cigars or pipes) and smokeless (vapor) devices are prohibited in Tetra Tech and DoD vehicles and work buildings.

8.22 MOLD REMEDIATION PLAN

Not applicable. This contract does not include mold remediation.

8.23 CHROMIUM (VI) EXPOSURE EVALUATION

Not applicable. Chromium (VI) is not a contaminant at the project sites.

8.24 CRYSTALLINE SILICA EVALUATION

Not applicable. Tasks performed during this project will not present sources of crystalline silica exposure.

8.25 LIGHTING PLAN FOR NIGHT OPERATIONS

Work will be performed during daylight hours only. However, if, throughout the fieldwork, if necessary temporary on-task lighting is adequate to illuminate the working areas while not interfering with the operator's vision (i.e., 55 Lux or 5 foot-candles) will be provided for all outdoor work areas.

8.26 TRAFFIC CONTROL PLAN

Not applicable.

8.27 FIRE PREVENTION PLAN

Fire prevention and protection measures require preplanning. Shown in Table 8-1 are fire extinguisher types, capacities, and locations. The UXOSO will inspect fire extinguishers monthly, and a qualified service provider will perform servicing on an annual basis.

Employees will follow safe work practices, including proper storage of flammable and combustible liquids, and the following rules:

- Smoking is permitted only in those areas explicitly designated by the SUXOS/DS, or UXOSO (verify local requirements as well) that is free of combustible materials, including vegetation and never within 50 feet of fuel-related handling operations or contaminated EZs. All cigarettes must be extinguished by placement into a receptacle that contains water when the person is done smoking.

- Perform refueling of equipment only in a designated area that is free of dry surface vegetation with a 60: BC fire extinguisher present and over secondary containment (e.g., kiddie pool).

- Perform refueling only in a designated area that is free of dry surface vegetation. The area must have spill control materials available nearby.
- Refueling must occur with the equipment turned off (except under particular circumstances required by an operator's manual). Allow the equipment to cool down before refueling.
- No refueling will be performed unattended.
- Tetra Tech will not park vehicles or drive over dry vegetation or grass.
- When portable gasoline powered equipment is used onsite, it will be equipped with a spark arrester.
- Latching on fueling hoses is prohibited. In areas where refueling is occurring, smoking is not permitted.
- Compressed gases, if present, will be secured only in an upright position. Flammable gases will be stored separately from oxygen gas cylinders. Any flammable cylinder storage areas (if any) will be posted as "FLAMMABLE, NO SMOKING."
- All sources of ignition will be prohibited within 50 feet of operations with a potential fire hazard. The area will be conspicuously and legibly posted "NO SMOKING, MATCHES, or OPEN FLAME."
- Store flammable liquids only in an approved storage cabinet in UL-listed metal containers or National Fire Protection Association-rated fuel tank, hoses, and nozzles.
- Transfer of fuel from containers (if performed) will be performed with proper grounding and bonding techniques in place.
- Fuel tanks will have a means of preventing overfilling (visual or other indicators of fuel level).
- Non-sparking and explosion-proof equipment and tools will be used whenever the potential for ignition of flammable or explosive gases, vapors, or liquids exists.
- Monitoring will be performed in fuel-contaminated work areas to ensure that the lower explosive limit is below and remains less than 10 percent. Strict controls of potential spark-producing tasks or equipment will be applied in any work area where there is a potential for vapors.
- Good housekeeping will be maintained such that debris and materials do not accumulate in work areas and pose a fire hazard.
- Self-closing, UL-labeled, or metal containers will be used to collect waste that is saturated with flammable or combustible liquids (e.g., oily rags).

During this work, we will carefully evaluate the potential for severe weather including lightning (including dry lightning), wind (speed and direction), and consider any Red Flag Warnings related to conducting operations where fuel powered equipment is being used.

Prior to starting any field operations, Tetra Tech will review the AHA and the team will conduct an on-site safety meeting to include a discussion of predicted weather patterns, escape routes, and safety zones with potential wildland fire hazards in mind. Tetra Tech will also notify local fire response agencies and ensure they are advised about the explosive operations that will be conducted and the location of the operations. If a Red Flag Warning is in effect, Tetra Tech will carefully evaluate whether the treatment operations can be safely conducted relative to the weather conditions and wildland fire potential and will suspend operations as appropriate until the danger has decreased.

8.28 WILDLAND FIRE MANAGEMENT PLAN

Not applicable. Tetra Tech is not tasked with or qualified to provide wildland fire management as specified in EM 385-1-1.

8.29 ARC FLASH HAZARD ANALYSIS

Not applicable. No live electrical work is required for this project.

8.30 ASSURED EQUIPMENT GROUNDING CONTROL PROGRAM

At present, it is anticipated that all work can be performed using ground-fault circuit interrupter (GFCI) protection (GFCI is only used for 110- to 120-volt circuits).

8.31 HAZARDOUS ENERGY CONTROL PROGRAM AND PROCEDURES

Not currently applicable. Hazardous energy will be controlled using lockout/tagout (LO/TO) procedures if such tasks, activities, or equipment use presents potential exposure of workers to hazardous energy.

While LO/TO procedures are not typically needed for military munitions/MPPEH operations, maintenance operations on equipment may, in some cases, require the control of energized systems. Energized systems are defined as those containing residual or stored energy or connected to an energy source. Site operations involving the construction, installation, setup, adjustment, modification, inspection, maintenance, or servicing of machines or equipment may require the use of LO/TO procedures to ensure the protection of site personnel. These activities may include the lubrication, cleaning, or un-jamming of machines or equipment, making adjustments where site personnel is exposed to the unexpected energization or startup of the equipment or the release of hazardous energy. All unserviceable machinery will be red-tagged per the Logistics Manager Work Instructions to prevent personnel from operating damaged or unserviceable equipment.

Should LO/TO be required, a Hazardous Energy Control Plan, including specific procedures to be used, will be prepared. All LO/TO will be per Procedure DCN 02-16 Control of Hazardous Energy Program to control hazardous energy and manufacturer’s instruction. The specific means and method of LO/TO for the equipment will be included in the AHA for the task.

8.32 STANDARD PRELIFT PLAN - LOAD-HANDLING EQUIPMENT

Not applicable. No lifts are planned.

8.32.1 General Requirements for Hoisting

Not applicable. No hoisting operations will be performed.

8.32.2 Hoisting by Mechanical Equipment

Not applicable. No hoisting by mechanical equipment is planned.

8.33 CRITICAL LIFT PLAN – LOAD-HANDLING EQUIPMENT

Not applicable. No critical lifts are planned.

8.34 NAVAL ARCHITECTURAL ANALYSIS – LOAD-HANDLING EQUIPMENT (FLOATING)

Not applicable. No floating platform load handling will be performed.

8.35 FLOATING PLANT INSPECTION AND CERTIFICATION

Float plant inspections will be performed using the inspection located in Appendix D.

8.36 SEVERE WEATHER PLAN FOR MARINE ACTIVITIES

Is located in the Dive Safe Practices Manual within Appendix C.

8.37 EMERGENCY PLAN FOR MARINE ACTIVITIES

Is located in the Dive Safe Practices Manual within Appendix C.

8.38 MAN OVERBOARD/ABANDON SHIP PROCEDURES

In the event of a man overboard, the following will occur:

- The person who observes the man overboard shall shout out “man overboard” and the side of the boat (port or starboard) the incident occurred.
- The person who went overboard should shout out to those on the boat if his or her going overboard was unnoticed and should use the whistle on the PFD if present.
- Throw a life ring over the side as near as possible to the person in the water.
- Notify the boat operator as quickly as possible and keep track of the person in the water so they do not become lost.
- Direct the boat operator to the direction of the person so that a rescue can be performed.

Abandon Ship Procedure

In the event an abandon ship order is issued, the following will occur:

- Follow the direction of the boat operator, who will direct personnel to the appropriate station onboard the vessel.
- Ensure PFD is securely fastened.
- Note the location of and distance to the nearest land and remain with your group until instructed to abandon ship.
- Deploy rescue raft (if equipped) on windward side of the boat and await orders to board.
- The boat captain or designated person will activate the ship’s emergency communication devices (marine distress call via radio, air horn, marine flares, etc.) as capable based on the nature of the emergency and will retrieve the survival kit as applicable.
- Enter the water by the safest means. Use ladder, if present, to enter the water before jumping overboard.
- If the boat is on fire or there is risk of explosion, stay at least 200 yards from the boat.
- If raft is equipped, stay in raft, attempt to flag down a rescue boat, and paddle toward shore. If the current takes you away from shore, try to paddle perpendicular to the current, toward areas where more land is visible or where more boaters may be present.

- As a group, or if personnel are separated and in the water, remain calm. To conserve energy and reduce risk of hypothermia, float on your back with your knees bent toward your chest. If together as a group, huddle together.

8.39 FLOAT PLAN FOR LAUNCHES, MOTORBOATS, AND SKIFFS

Not applicable for this project.

8.40 FALL PROTECTION AND PREVENTION PLAN

Not applicable. The need for fall protection planning is not currently anticipated. Should the need arise for fall protection, a plan must be prepared and approved by the Tetra Tech SHM.

8.41 DEMOLITION/RENOVATION PLAN (INCLUDING ENGINEERING SURVEY)

Not applicable. This contract does not have demolition/renovation tasks.

8.42 ROPE ACCESS WORK PLAN

Not applicable. No required rope access for this contract.

8.43 EXCAVATION/TRENCHING PLAN

Not applicable. No excavation/trenching is involved in this contract.

8.44 FIRE PREVENTION AND PROTECTION PLAN FOR UNDERGROUND CONSTRUCTION

Not applicable. This contract does not involve underground construction.

8.45 COMPRESSED AIR WORK PLAN FOR UNDERGROUND CONSTRUCTION

Not applicable. This contract does not involve underground construction.

8.46 ERECTION AND REMOVAL PLAN FOR FORMWORK AND SHORING

Not applicable. This contract does not involve formwork or shoring.

8.47 PRECAST CONCRETE PLAN

Not applicable. This contract does not involve precast concrete work.

8.48 LIFT-SLAB PLANS

Not applicable. This contract does not involve lift-slab work.

8.49 MASONRY BRACING PLAN

Not applicable. This contract does not involve masonry bracing.

8.50 STEEL ERECTION PLAN

Not applicable. This contract does not involve steel erection.

8.51 EXPLOSIVES SAFETY SITE PLAN

All relevant requirements for military munitions/MPPEH and explosive safety hazards are contained in the MR-QAPP and ESP for this project. Qualified UXO technicians will perform all work.

8.52 BLASTING PLAN

This contract does not involve blasting. All relevant requirements for military munitions/MPPEH and explosive safety hazards for the currently scoped tasks are contained in the MR-QAPP and ESP for this project. Qualified UXO technicians will perform all work.

8.53 DIVE OPERATIONS PLAN

Dive Operation Plan is located as Attachment 2.

8.54 SAFE PRACTICES MANUAL FOR DIVING ACTIVITIES

Diving Safe Practices Manual is located within Appendix C.

8.55 EMERGENCY MANAGEMENT PLAN FOR DIVING

Is located within Attachment 4 of Diving Safe Practices Manual in Appendix C.

8.56 TREE FELLING AND MAINTENANCE PROGRAM

Not applicable. This contract does not involve tree felling or maintenance.

8.57 AIRCRAFT/AIRFIELD CONSTRUCTION SAFETY AND PHASING PLAN

Not applicable. No aircraft or airfield construction will be performed.

8.58 AIRCRAFT/AIRFIELD SAFETY PLAN COMPLIANCE DOCUMENT

Not applicable. No aircraft or airfield construction will be performed.

8.59 SITE SAFETY AND HEALTH PLAN FOR HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

An SSHP is included as Attachment 1 to this APP. Many elements required in EM 385-1-1 for hazardous/toxic waste work are already included in this APP. In such cases, the SSHP refers the reader to the appropriate section of the APP where the information is contained so that information is not duplicated.

8.60 CONFINED SPACE ENTRY PROCEDURES

Not applicable. At present, there is no identified need to enter any confined space for this project, and this APP authorizes no confined space entry.

8.61 CONFINED SPACE PROGRAM

If confined spaces are identified in the work area and are not posted, the UXOSO will post the area as confined spaces per EM 385-1-1 and inform site personnel entry is prohibited.

Work areas will be classified as a confined space if they meet the three following requirements:

- The space is large enough and configured such that an employee can bodily enter the space and perform assigned tasks
- The space has limited or restricted means for entry or exit (e.g., tanks, vessels, silos, storage bins, vaults, and pits)
- The space is not designed for continuous human occupancy

9.0 RISK MANAGEMENT PROCESSES

This plan requires the preparation of an AHA for each task, activity, or DFW. This plan also requires AHAs to be reviewed with all workers and that workers acknowledge their review of safety and health requirements for each task. A detailed AHA will be prepared, which will provide a thorough analysis of the hazards for each task involved in the fieldwork and the procedures to eliminate or minimize those hazards. Hazards and mitigation methods will be identified for each component of a particular task.

Tetra Tech's initial AHAs for the DFWs are including in Appendix A. Before starting work activities, these initial AHAs will be further refined by those who will perform the work and will be revised if needed. As new activities or tasks are identified or the work environment of the task changes, they will revise or prepare new AHAs. New AHAs will be submitted to the SHM and USACE representative for review before the start of the operation, and any revisions to existing AHAs will be submitted to the SHM and the USACE representative for review only if the RAC increases from that of the original AHA (e.g., a medium becomes a high or a low becomes a medium RAC).

Workers performing tasks described in AHAs must receive training on the AHA and be allowed to make comments and suggestions regarding the AHA to ensure that all hazards are properly identified and that control measures are in place to mitigate these hazards. Retraining will occur if/when AHAs are modified.

TABLES

Table 8-1. Types and Locations of Emergency Equipment

Equipment	Location
Industrial first aid kit with bloodborne pathogens kit	SZ for active work locations
Fire extinguisher, one 10-A-60: BC	SZ for active work locations
Fire extinguisher, one 1A-10: BC	Site vehicles and boats
Fire extinguisher, one 60:BC	Refueling areas
Portable eyewash (15-minute/0 to 4 gallons per minute)	SZ for active work locations
Air horn (if not equipped with vehicle horn)	SZ for active work locations
Spill kit (appropriately stocked with sorbent pads, gloves, and bags)	SZ for active work locations and refueling areas
Pickup trucks (emergency evacuation and transport)	UXOSO pickup
Cellular telephones & handheld radios.	Minimum of UXOSO and each field supervisor (others as required for safety and communication purposes)

Abbreviations and Acronyms:
SZ – Support Zone
UXOSO – Unexploded Ordnance Safety Officer

Table 8-2. Emergency Contact List

Emergencies- Ambulance/Fire/Police	**911**
Emergency Hospital UMass Memorial Health Hospital 60 Hospital Rd, Leominster, MA 01453	(978) 466-2000
Hyperbaric Chamber Hospital Norma Knight Hyperbaric Medicine Center Massachusetts Eye and Ear Hospital 243 Charles Street Boston, MA 02114	(617) 573-4411 (emergency services)
Clinic Fallon Clinic 165 Mill Street Leominster, MA 1453	(978) 466-3301 (non-emergencies)
CORE Injury Case Management	1 855-683-9006
Poison Control	1 800-222-1222
COR, Mr. Timothy Peck	(410) 962-3416
USACE PM, (New England District) Penelope Reddy	(978) 318-8160
USACE PM, (Baltimore District) Peter Philips	(410) 962-2714 (office) (443) 613-3607 (cell)
USACE OESS, Marty Holmes	(410) 962-2258 (office) (410) 982-9724 (cell)
USACE DDC, David Holland	
Tetra Tech PM, Jennifer Harlan	(406) 940-5040
Tetra Tech SHM, Jeffrey Streib, CIH, CSP, CHMM	(240) 727-9240
Tetra Tech Dive Safety Scot Wilson	(360) 626-3193
Tetra Tech SUXOS/DS, Don Schwalback	(360) 941-0912
Tetra Tech UXOSO, Patrick Oberley	(865) 364-5437

Abbreviations and Acronyms:
CIH- Certified Industrial Hygienist
CSP – Certified Safety Professional
CHMM- Certified Hazardous Materials Manager
COR- Contracting Officer Representative
PM – Project Manager
SHM – Safety and Health Manager
UXO – unexploded ordnance
UXOSO – Unexploded Ordnance Safety Officer

FIGURES

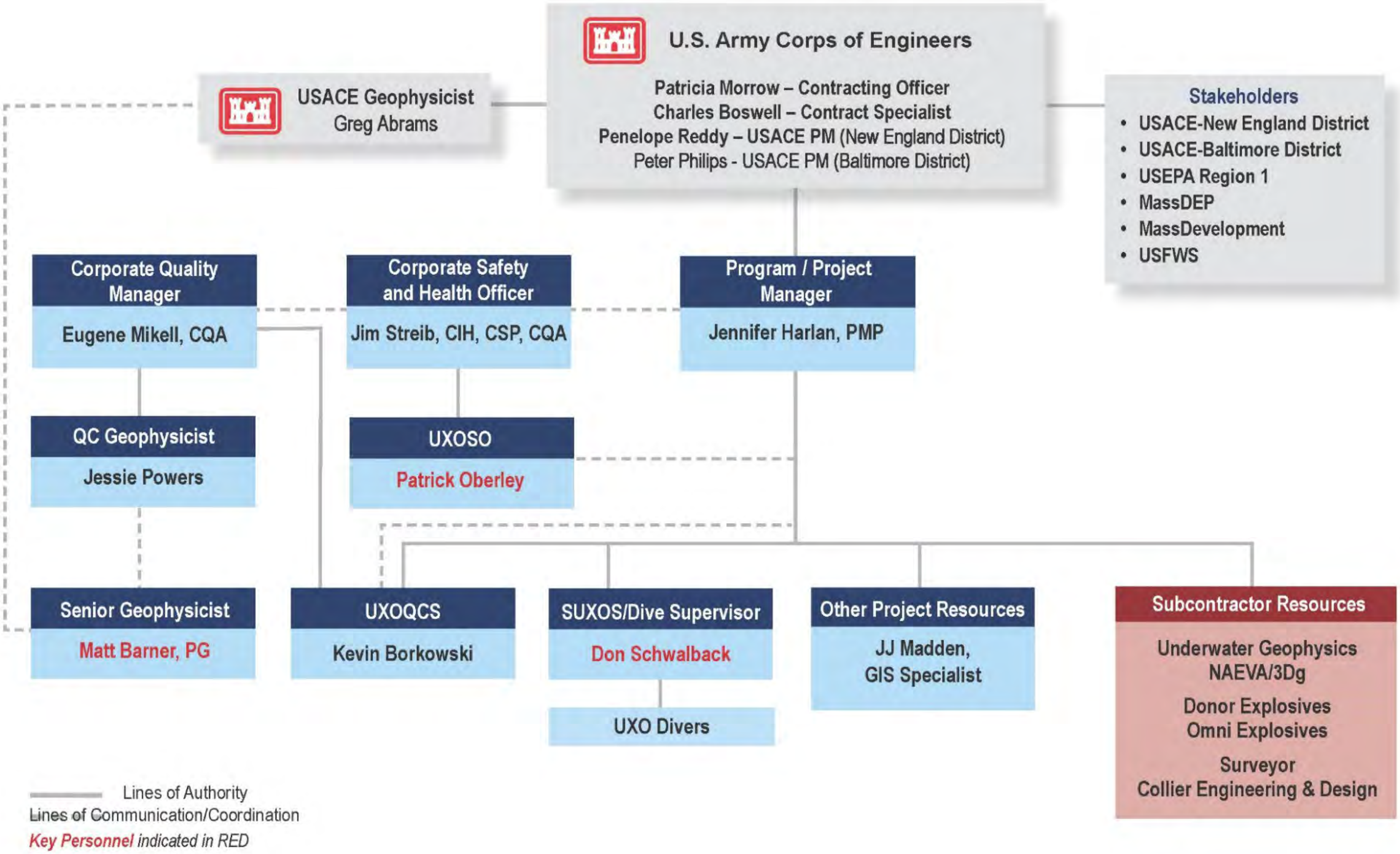

Figure 1 - Organization Chart

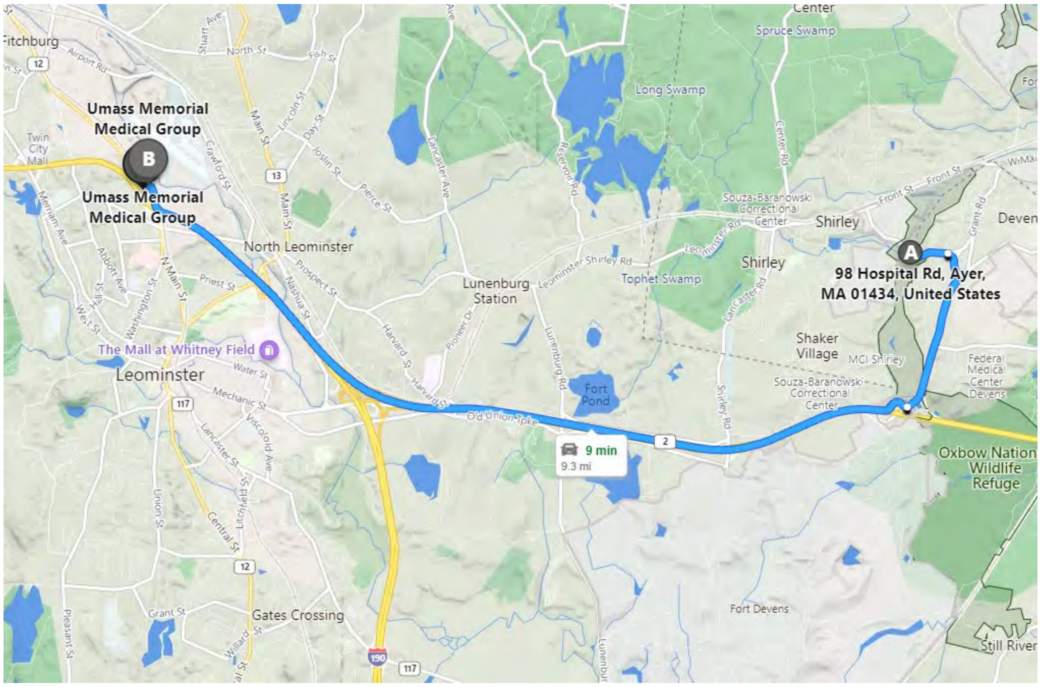

Figure 2 - Emergency Route to Hospital

Hospital Contact and Route Information:

Hospital:	UMass Memorial Health Hospital 60 Hospital Rd, Leominster, MA 01453
	• Head Southeast on Hospital Rd • Right on Givry St. • Turn right on Jackson Rd. • Ramp on right for MA-2 West • At Exit 99B, head right on the ramp for MA-12 North toward Fitchburg

TETRA TECH PERSONNEL MUST HAVE A COPY OF THE MAP TO THE HOSPITAL AND EMERGENCY CONTACT INFORMATION AVAILABLE IN THEIR VEHICLE.

TETRA TECH PERSONNEL ARE REQUIRED TO HAVE A PARTNER ON THE SITE AT ALL TIMES

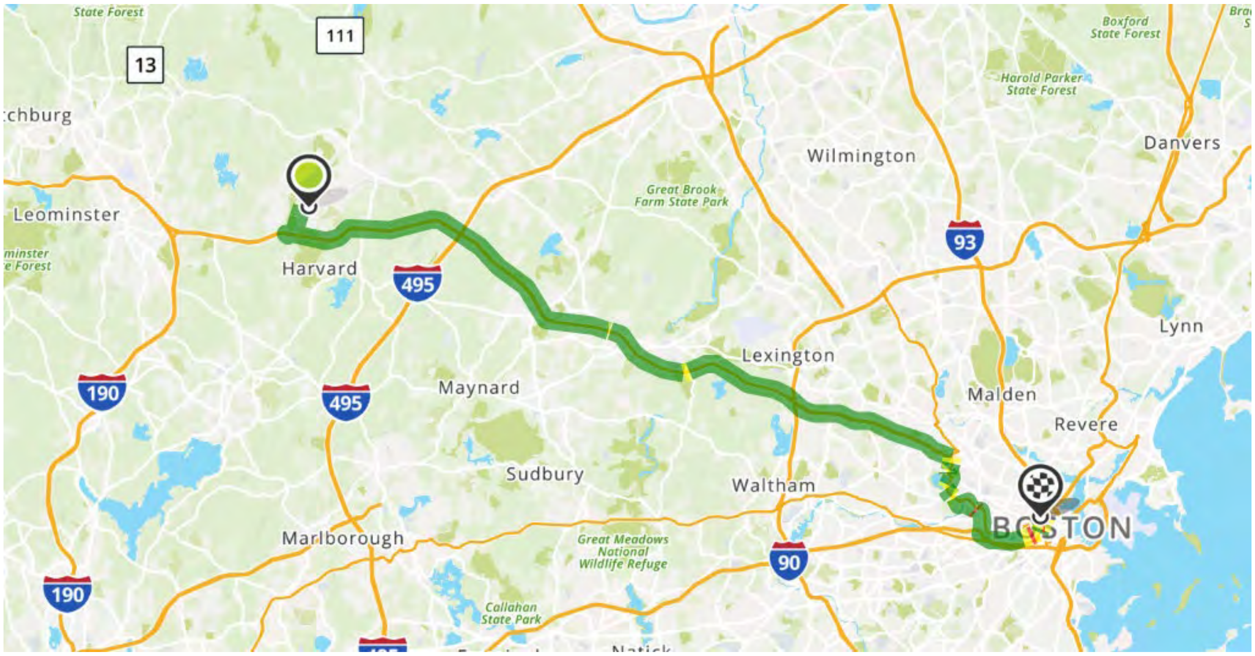

Figure 3 - Emergency Route to Ft. Norma Knight Hyperbaric Medicine Center

Hospital:	Ft. Norma Knight Hyperbaric Medicine Center 243 Charles Street Boston, MA 02114
	• Head Southeast on Hospital Rd • Right on Givry St. • Take 1st left on Jackson Rd. • Stay straight to go onto MA-2 E. Pass through 1 roundabout. • Enter next roundabout and take the 2nd exit onto Concord Ave/US-3 S/MA-16/MA-2. • Enter next roundabout and take the 1st exit onto UX-3 S/MA-2. • Turn slight right onto Gerrys Landing Rd. • Take the ramp toward Gov’t Ctr. • Stay straight to go onto David G Mugar Way. • Turn left onto Charles St. • Turn right onto Charles Cir/MA-3. • Hospital is on the right.

APPENDIX A

PRELIMINARY ACTIVITY HAZARD ANALYSES

Activity Hazard Analysis (AHA) #1

A draft AHA for this task is included below. This AHA will be reviewed by the SHM and the USACE as part of planning during development and finalization of the APP. The draft AHA will be finalized prior to initiation of this phase of field work by the staff performing the work and will be submitted for final approval by the SHM and the USACE prior to the preparatory phase inspection. Any modifications to the approved AHA that results in a higher RAC than the approved AHA will also be reviewed by the USACE and SHM. The AHA will be maintained by the staff performing the work, under SUXOS/DS and UXOSO oversight to keep it current to the work being performed and the hazards presented by the work as a living document.

<table>
<tr><td>Activity/Work Task: Mobilization/ Site Setup and Demobilization</td><td colspan="6">Overall Risk Assessment Code (RAC) (Use highest code)</td><td>L</td></tr>
<tr><td>Project Location: Military Munitions Investigation Nashua River Former Ft. Devens</td><td colspan="7">Risk Assessment Code (RAC) Matrix</td></tr>
<tr><td>Contract Number: W912DR-21-D-0002, Task Order W912DR22F0121</td><td rowspan="2">Severity</td><td colspan="6">Probability</td></tr>
<tr><td>Date Prepared: July 2022</td><td>Frequent</td><td>Likely</td><td>Occasional</td><td>Seldom</td><td colspan="2">Unlikely</td></tr>
<tr><td rowspan="2">Prepared by: Jennifer Harlan, PMP</td><td>Catastrophic</td><td>E</td><td>E</td><td>H</td><td>H</td><td colspan="2">M</td></tr>
<tr><td>Critical</td><td>E</td><td>H</td><td>H</td><td>M</td><td colspan="2">L</td></tr>
<tr><td rowspan="2">Reviewed by: Jeffrey (Jim) Streib, CIH, CSP, CHMM, CQA
Director, Health, Safety and Environmental</td><td>Marginal</td><td>H</td><td>M</td><td>M</td><td>L</td><td colspan="2">L</td></tr>
<tr><td>Negligible</td><td>M</td><td>L</td><td>L</td><td>L</td><td colspan="2">L</td></tr>
<tr><td rowspan="6">Notes: (Field Notes, Review Comments, etc.)
In addition to the information listed in this AHA, all field personnel must review and be familiar with all provisions of the approved APP/SSHP. EM 385-1-1 will also be available on site for personnel to review specific materials and mitigation measures associated with this project. PPE for this AHA will consist of a hard hat (when overhead safety hazards exist), leather safety-toed boots, safety glasses with side shields, a standard work uniform (long pants, tee shirt), hearing protection (as required), work gloves worn when indicated, a Class 2 high-visibility safety vest, and other PPE described in this AHA.

First Aid-/CPR-Qualified Persons:
SUXOS/DS- Don Schwalback
UXOSO- Patrick Oberley</td><td colspan="7">Step 1: Review each “Hazard” with identified safety “Controls” and determine RAC (see above).</td></tr>
<tr><td colspan="4">“Probability” is the likelihood to cause an incident, near miss, or accident and is identified as Frequent, Likely, Occasional, Seldom, or Unlikely.</td><td colspan="3">RAC Chart</td></tr>
<tr><td colspan="4" rowspan="2">“Severity” is the outcome/degree if an incident, near miss, or accident did occur and is identified as Catastrophic, Critical, Marginal, or Negligible.</td><td colspan="3">E = Extremely High Risk</td></tr>
<tr><td colspan="3">H = High Risk</td></tr>
<tr><td colspan="4" rowspan="2">Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each “Hazard” on the AHA. Annotate the overall highest RAC at the top of the AHA.</td><td colspan="3">M = Moderate Risk</td></tr>
<tr><td colspan="3">L = Low Risk</td></tr>
</table>

AHA #1 – Mobilization/ Site Setup and Demobilization

Job Steps	Hazards	Controls	RAC
Unloading and initial staging of materials and equipment and demobilization of materials, laydown areas.	Vehicle operations or unloading tasks could cause injury to personnel or others on site.	• Workers operating rental vehicles will have a valid state issued driver's license and will be authorized by Tt to operate rental vehicles per corporate procedures. • Any Commercial Driver's License truck and trailers will be operated by CDL qualified drivers who are vetted and authorized vendors. • Operate at safe speeds and obey traffic speeds and rules as instructed. • Wear seat belt at all times when vehicle is in operation. • Use parking brake when parked. Use chocks when parked on inclines. Use dedicated spotter and standard hand signals for backing operations.	L
	Ergonomic hazards such as sprains, strains, or back injury could occur from lifting or repetitive actions.	• Use mechanical lifting equipment or team lift when possible rather than by hand and tool methods. • Do not bend at the waist, bend at the knees. • Do not twist at the waist and turn while lifting. Keep the load centered and close to body. • Do not lift more than 50 pounds (may be lesser for some workers) alone. • Rotate tasks and take breaks when performing repetitive tasks and try to find the best position possible to perform the task.	L
	Slips, trips, and falls could lead to injuries.	• Keep work areas free of debris and equipment in work paths. • Follow good housekeeping in work areas. • Correct hazards when seen, such as holes or other trip hazards. • If they cannot be removed, they must be covered or marked.	L
	Handling sharp objects or using hand tools or knives could cause cuts, punctures, or scrapes.	• Wear leather work gloves when handling materials that may be sharp or have sharp edges. • Be familiar with the proper use and limitations of hand tools. • Report even minor injuries to your supervisor for evaluation. • Have a first aid kit available and have a minimum of 2 persons with first aid and CPR training onsite. • Never carry a knife in one's pocket. • Ensure knives have retractable blades. • Cut away from the body.	L
	Workers could be exposed to heat or to cold stress.	• UXOSO will monitor for heat or cold stress in accordance with SWP 5-15, Heat Illness prevention and SWP 5-16 General Safe work practices for cold stress.	L

AHA #1 – Mobilization/ Site Setup and Demobilization

Job Steps	Hazards	Controls	RAC
		• All workers will be trained in heat (and cold) stress signs and symptoms and proper prevention measures and will employ the buddy system to watch for signs and symptoms in co-workers. • Provide fluids, rest breaks (in shade and/or airconditioned environment; (e.g., work trucks) will be taken during warm weather. • Dress appropriately for the outdoor conditions and be prepared for changes that can occur throughout the day. • Provide a steady controlled work pace. • New workers not used to working in high heat environment may require more acclimatization to site conditions and may be more susceptible to heat stress.	
	Contracting or spreading coronavirus.	• Monitor yourself for coronavirus symptoms. • Maintain social distance. • Wear a face covering, when CDC community exposure is high and social distancing can't be maintained. • Wash hands regularly.	L
	Noise from operations	• Hearing protection is required when sound levels exceed 84 dBA continuously. • This rule applies to personnel working near or any other sources of loud noise. • Generators, if used will be quiet in operation or will be shielded to minimize noise generation in common work areas so that hearing protection is not required to work in the area • The UXOSO will monitor and post hearing protection required areas and activities.	L
	Fall hazards (falls from heights of 6 feet or greater)	• No person will climb upon any equipment, where there is exposure to a fall of 6 feet or greater unless proper guarding and rails is in place.	L
	Potential trips or falls	• Survey the site for any slip, trip, or fall hazards. • Either eliminate the hazard or mark the hazard so it can be avoided. • Use caution when walking around the site and wear sturdy leather work boots. • Maintain a clean and orderly work site and keep travel pathways free of obstacles.	L
	Contact with biting or stinging insects could occur; including bees, wasps, hornets, ticks, scorpions and spiders.	• Workers will apply DEET to work clothing following manufacturer's instructions as a preventative measure for biting insects as required. • Workers with allergies will let the UXOSO know using the medical data sheet and will carry their own prescription medication as applicable. • First aid and medical attention as required.	L

AHA #1 – Mobilization/ Site Setup and Demobilization			
Job Steps	**Hazards**	**Controls**	**RAC**
		• Report all bites, stings, and rashes to UXOSO. • Avoid reaching blindly into areas, depressions, debris, etc.	
	Failure of proper backing can cause struck by and pinch point injuries or property damage.	• Use spotters for all backing operations. Ensure spotter stands in line of sight of the person backing the vehicle. • All personnel who back a trailer are trained and qualified to do so and are designated by the PM for such activities. • Use boat checklist in APP prior to launching boat. • Verify understanding of hand signals used for backing, going forward, stopping, and turning left or right. • Use parking brake and ensure operator is not moving vehicle before unhitching boat from trailer. • Ground personnel involved in backing operations will wear class 2 high visibility vest.	L
	Electrical hazards could be present during tool use or during setup of and breakdown of equipment.	• Ensure that power cords are inspected and in good condition for use, that GFCIs are used properly, and portable generators are not overloaded. • Ensure any power tools used are in good working condition and have third prong on cord or are double insulated.	L

AHA #1 – Mobilization/ Site Setup and Demobilization		
Equipment to be Used	**Training Requirements/Competent or Qualified Personnel Name(s)**	**Inspection Requirements**
Site vehicles	Drivers must have driver's license. Drivers of Tt's rental vehicles must be authorized to drive the rental vehicle in accordance with Tt's procedures.	Receipt inspection by Equipment Supervisor (SUXOS/DS). Vehicle inspection by drivers. Operator's manual for each vehicle must be located with the vehicle.
Boats	Qualified Operators will have USCG approved boater safety qualifications identified in the APP and experience in use of the boats on the project.	• Inspect daily, and before use. • Use the boating checklist form.
Hand and power tools	Training in use of hand and power tools by the UXOSO or designee and review of operating manual. Use proper hand tools.	Daily inspection by users/operators. Inspect tools and power cords to ensure they are listed by a NRTL. Inspect for damage to tool and to cords.
First aid kit, fire extinguisher, eye wash station	Use of emergency equipment including first aid kits, fire extinguishers and eye wash must be done by personnel familiar with this plan; use and inspection criteria of the equipment, and what the equipment is used for, are by or under direction of the UXOSO.	Fire Extinguisher • Initially and at least monthly thereafter by UXOSO First Aid Kit • Weekly and after use for restocking by UXOSO Eye Wash Station • Weekly by UXOSO • Potable water changed weekly unless a preservative solution is used
PPE	Users must be trained in the proper use of, limitations of, inspection of, donning and doffing of, and replacement of PPE.	Daily by user

Abbreviations and Acronyms:
APP – Accident Prevention Plan
CSP- Certified Safety Professional
CIH- Certified Industrial Hygienist
DEET – 33% diethyl-meta- toluamide
EHS – Environmental, Health, and Safety
GFCI – Ground-fault circuit interrupter
NRTL – Nationally recognized testing laboratory
OSHA – Occupational Safety and Health Administration
UXOSO – UXO Safety Officer
PPE – Personal protective equipment
SSHP – Site Safety and Health Plan
SUXOS/DS – Senior UXO Supervisor
UL – Underwriters Laboratory
USACE – U.S. Army Corps of Engineers
UXO – Unexploded ordnance

AHA Signature Sheet #1

I have reviewed the above AHA and acknowledge the hazards involved with this work task and the controls that will help to minimize illness or injury during the tasks.

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Activity Hazard Analysis (AHA) #2

A draft AHA for this task is included below. This AHA will be reviewed by the SHM and the USACE as part of planning during development and finalization of the APP. The draft AHA will be finalized prior to initiation of this phase of field work by the staff performing the work and will be submitted for final approval by the SHM and the USACE prior to the preparatory phase inspection. Any modifications to the approved AHA that results in a higher RAC than the approved AHA will also be reviewed by the USACE and SHM. The AHA will be maintained by the staff performing the work, under SUXOS/DS and UXOSO oversight to keep it current to the work being performed and the hazards presented by the work as a living document.

Activity/Work Task: Boat Operations	**Overall Risk Assessment Code (RAC) (Use highest code)**	**M**

Project Location: Military Munitions Investigation Nashua River Former Ft. Devens

Contract Number: W912DR-21-D-0002, Task Order W912DR22F0121

Date Prepared: July 2022

Prepared by: Jennifer Harlan, PMP

Reviewed by: Jeffrey (Jim) Streib, CIH, CSP, CHMM, CQA
Director, Health, Safety and Environmental

Risk Assessment Code (RAC) Matrix

Severity	**Probability**				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	**E**	**E**	**H**	**H**	**M**
Critical	**E**	**H**	**H**	**M**	**L**
Marginal	**H**	**M**	**M**	**L**	**L**
Negligible	**M**	**L**	**L**	**L**	**L**

Notes: (Field Notes, Review Comments, etc.)
In addition to the information listed in this AHA, all field personnel must review and be familiar with all provisions of the approved APP/SSHP. EM 385-1-1 will also be available on site for personnel to review specific materials and mitigation measures associated with this project. PPE for this AHA will consist of a PFD, appropriate footwear, safety glasses with side shields, a standard work uniform (long pants, tee shirt), hearing protection (as required), work gloves worn when indicated, , and other PPE described in this AHA.

First Aid-/CPR-Qualified Persons:
SUXOS/DS- Don Schwalback
UXOSO- Patrick Oberley

Step 1: Review each **"Hazard"** with identified safety **"Controls"** and determine RAC (see above).

	RAC Chart
"Probability" is the likelihood to cause an incident, near miss, or accident and is identified as Frequent, Likely, Occasional, Seldom, or Unlikely.	
"Severity" is the outcome/degree if an incident, near miss, or accident did occur and is identified as Catastrophic, Critical, Marginal, or Negligible.	**E = Extremely High Risk** **H = High Risk**
Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on the AHA. Annotate the overall highest RAC at the top of the AHA.	**M = Moderate Risk** **L = Low Risk**

AHA#2 - Boat Operations			
Job Steps	**Hazards**	**Controls**	**RAC**
1. Boating	Boats & Skiffs could cause injury or death.	• Follow the requirements of EM 385-1-1 and using the inspection checklist provided in the dive safety procedure manual (DSPM). • All boat operators are qualified and trained in boat use and procedures. • Boat will be equipped with rescue equipment to handle a man overboard situation (such as life ring with rope, or similar equipment), and personnel trained in its use. • Ensure boat passengers have been briefed on the location, use, and inspection of emergency equipment onboard and the procedures to follow in the event of a shipboard emergency. • Practice drills will be done prior to or during first deployment for situations such as man overboard, fires and explosions, and abandon ship.	M
	Fueling of boat – potential for fire, environmental release. Run out of fuel when operating.	• No smoking or other sources of ignition when fueling. • Engine must be off. • There must be a fire extinguisher available. • Refuel in a manner to prevent any spills, especially spills into the water. If there is any sheen in the water the spill must be reported. • Check for fuel leaks in the boat, if fuel lines are in the boat. • Ensure there is enough fuel supply for the trip and the return to dock plus 1/3 in reserve.	M
	Boat could malfunction and drift into open water if engine does not work.	• Have anchor and enough line to deploy in the event of motor/engine malfunction. Ensure that a Float Plan is filed in accordance with the APP using the example Coast Guard Float Plan in the APP. • File this plan daily with the PM or designee before leaving the dock and notify them of your return. • Perform military munitions avoidance by avoiding operating the boat in shallow waters in which the boats hull, outdrives or jet-drives impact the sea floor. • Boat Operator will ensure that boat is well maintained and in good condition prior to taking on passengers. • Emergency radios will be in operating condition prior to leaving the wharf. There will be a primary and alternate means of communication, and extra batteries will be available. • Directions for contacting the Coast Guard and hospital will be posted with each radio and cell phone.	M
	Grounding	• Use caution in the shallow areas. • Use depth meter and spotting to avoid striking the bottom or grounding.	M
	Slip, trips, and falls	• Personnel should use appropriate footwear (sturdy leather deck shoes) to ensure that there is enough tread on the soles to minimize slipping. • Identify and remove trip hazards.	L

AHA#2 - Boat Operations			
Job Steps	**Hazards**	**Controls**	**RAC**
		• Those hazards that cannot be removed must be marked. When climbing up or down or on and off boats, always ensure three points of contact. • Good housekeeping standards will be enforced. Cargo will be properly staged on the boat to prevent tripping hazards. • Personnel will remain seated while boat is in motion and keep all extremities inside the boat.	
	Contracting or spreading coronavirus.	• Monitor yourself for coronavirus symptoms. • Wash hands regularly.	M
	Worker exposure to extreme temperatures and sunburn.	• Properly dress for the weather. Such as a full brim hat. • UXOSO to monitor weather and implement heat stress and cold stress controls as specified in the APP. • Provide breaks for personnel to get either into cool (heat stress) or warm (cold stress) environment. • Encourage a steady work pace. • Ensure adequate potable drinking water is available. • Know the signs and symptoms of exposure and keep an eye on your partner. • Boat occupants will be prepared with raingear and a change of clothing in the event they get wet and chilled. • SSHO to implement SWP 05-15 Heat Illness Prevention and Monitoring or SWP 05-16 Cold Stress.	L
	Severe weather can cause dangerous seas and hazardous boating conditions.	• Monitor the local and national weather service broadcasts prior to mobilization by boat and during the day. • Local weather will be monitored, and boat operations will be terminated during an approaching storm or should sea conditions make it unsafe to continue. • Monitor actual water conditions for dangerous wave or ground swell action. • Follow provisions in the APP for severe weather. • All personnel will wear personal flotation devices while boat is in transit and during inclement weather. At all other times, a personal flotation device should be readily available and accessible.	M
	Boat could be struck by other boats in area.	• Boat operator oversees situational awareness while on the water. • Boat operator will not be doing other tasks while boat is being moved. • Monitor Channel 16 and U.S. Coast Guard rules for lighting and other vessel operations. • Use air horn in the event of a boat coming close.	M

AHA#2 - Boat Operations		
Equipment to be Used	**Training Requirements/Competent or Qualified Personnel Name(s)**	**Inspection Requirements**
PPE: • Footwear with rubber soles to prevent slipping. Safety toe footwear required near heavy diving equipment (SCUBA cylinders) • Type II or better PFD to be worn in transit • Back braces (optional) • Appropriate clothing and PPE (to include personal flotation device, puncture resistant or leather work gloves, safety sunglasses and cap). Hearing protection will be required if noise from boat engine reaches hazardous levels. • Chemical-resistant gloves for use when handling MPPEH/military munitions and in fueling operation	PPE requirements training	• PPE inspected daily prior to use by user with additional random inspections by UXOSO.
Boat/s: • Shark Marine Underwater Navigation (SM) system • HERO Underwater camera • Fuel spill kit • Boat tool kit • Fuel container	• Site specific military munitions training will be presented to all site personnel • Equipment familiarity training • Site-specific training, slip/fall hazards • Site-specific training/lifting and carrying techniques • Current HAZWOPER training • Site-specific training in use of equipment and tools	• UXOSO will ensure that all controls are being followed, all equipment is being correctly utilized, and all personnel have received appropriate training. • Equipment inspected daily prior to use by user and UXOSO. • Daily serviceability check of magnetometers by user and UXOQCS. • UXOQCS to check SM and RTK each day prior to operations.
Emergency Gear: • Communications equipment • First Aid Kit • Fire extinguishers • Vessel rescue equipment (hook, rope, life ring) • WBGT monitor	• Emergency response procedures • Heat stress symptoms/first aid • Site-specific biological hazards to include first aid • Equipment familiarity training	• Communications equipment checked daily prior to use by UXOSO. • First Aid Kits checked daily and inspected weekly by the UXSO. • Fire extinguishers checked daily and inspected weekly by the UXOSO. • Equipment inspected daily prior to use by user and UXOSO.

Abbreviations and Acronyms:
APP – Accident Prevention Plan
CSP- Certified Safety Professional
CIH- Certified Industrial Hygienist
CHMM- Certified Hazardous Materials Manager
DEET – 33% diethyl-meta- toluamide
HSE – Health Safety, and Environmental
GFCI – Ground-fault circuit interrupter
OSHA – Occupational Safety and Health Administration
UXOSO – UXO Safety Officer
PPE – Personal protective equipment
PFD- Personal flotation device
SSHP – Site Safety and Health Plan
SUXOS/DS – Senior UXO Supervisor
USACE – U.S. Army Corps of Engineers
UXO – Unexploded ordnance

AHA Signature Sheet **AHA#2 - Boat Operations**

I have reviewed the above AHA and acknowledge the hazards involved with this work task and the controls that will help to minimize illness or injury during the tasks.

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Activity Hazard Analysis (AHA) #3

A draft AHA for this task is included below. This AHA will be reviewed by the SHM and the USACE as part of planning during development and finalization of the APP. The draft AHA will be finalized prior to initiation of this phase of field work by the staff performing the work and will be submitted for final approval by the SHM and the USACE prior to the preparatory phase inspection. Any modifications to the approved AHA that results in a higher RAC than the approved AHA will also be reviewed by the USACE and SHM. The AHA will be maintained by the staff performing the work, under SUXOS/DS and UXOSO oversight to keep it current to the work being performed and the hazards presented by the work as a living document.

Activity/Work Task: Diving Operations and Intrusive Investigation	**Overall Risk Assessment Code (RAC) (Use highest code)** — **M**
Project Location: Military Munitions Investigation Nashua River Former Ft. Devens	**Risk Assessment Code (RAC) Matrix**
Contract Number: W912DR-21-D-0002, Task Order W912DR22F0121	
Date Prepared: July 2022	
Prepared by: Jennifer Harlan, PMP	
Reviewed by: Jeffrey (Jim) Streib, CIH, CSP, CHMM, CQA Director, Health, Safety and Environmental	

Severity	**Probability**				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	**E**	**E**	**H**	**H**	**M**
Critical	**E**	**H**	**H**	**M**	**L**
Marginal	**H**	**M**	**M**	**L**	**L**
Negligible	**M**	**L**	**L**	**L**	**L**

Notes: (Field Notes, Review Comments, etc.)
In addition to the information listed in this AHA, all field personnel must review and be familiar with all provisions of the approved APP/SSHP. EM 385-1-1 will also be available on site for personnel to review specific materials and mitigation measures associated with this project. PPE for this AHA will consist of a PFD, appropriate footwear, safety glasses with side shields, a standard work uniform (long pants, tee shirt), hearing protection (as required), work gloves worn when indicated, , and other PPE described in this AHA.

First Aid-/CPR-Qualified Persons:
SUXOS/DS- Don Schwalback
UXOSO- Patrick Oberley

Step 1: Review each **"Hazard"** with identified safety **"Controls"** and determine RAC (see above).

"Probability" is the likelihood to cause an incident, near miss, or accident and is identified as Frequent, Likely, Occasional, Seldom, or Unlikely.	**RAC Chart**
"Severity" is the outcome/degree if an incident, near miss, or accident did occur and is identified as Catastrophic, Critical, Marginal, or Negligible.	**E = Extremely High Risk** **H = High Risk**
Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on the AHA. Annotate the overall highest RAC at the top of the AHA.	**M = Moderate Risk** **L = Low Risk**

AHA # 3 - Diving Operations & Intrusive investigation			
Job Steps	**Hazards**	**Controls**	**RAC**
1.Pre-Dive Safety Brief 2. Dress out divers and conduct surface and in water equipment checks Deploy and recover divers to/from water. 3. Deploy and recover divers to/from water. Deploy underwater waypoints, transects and grids 4.Diver(s) navigate to targets and perform underwater intrusive investigation. survey 5.Diver(s) excavate targets anomalies 6.Diver(s) identify and photograph MEC/MPPEH. Diver consults with SUXOS/DV and receives acceptable to move determination. 7. Diver recovers MEC/MPPEH and transfers MEC/MPPEH to the surface team. and process MEC/ MPPEH 8..Diver(s) are recovered and observed on the surface for 10 min. and dive team extraction 9.Dive Team and equipment transit to staging area. 10.Equipment transit and maintenance	Vessel Traffic	• Display Commercial Dive Alpha Flag • Display Recreational Dive Flag Topside Personnel Aware of Boat Traffic	L
	Slip, trips, & Falls	• Personnel should use appropriate footwear (sturdy leather deck shoes) to ensure that there is enough tread on the soles to minimize slipping. • Identify and remove trip hazards. • Those hazards that cannot be removed must be marked. When climbing up or down or on and off boats, always ensure three points of contact. • Good housekeeping standards will be enforced. Cargo will be properly staged on the boat to prevent tripping hazards.	L
	Fall from ladder	• Verify water depth prior to entry • Proper entrance ladder or walk-in entry only • Ladder extends minimum of 3 feet below water surface • Maintain three points of contact to ladder. • Sweep for submerged objects	L
	Contracting or spreading coronavirus.	• Monitor yourself for coronavirus symptoms. • Wash hands regularly.	M
	Primary Air Supply Failure/ Loss of Air	• Failure of the primary air supply - Diver switch over to the emergency air source. • If breathing resistance occurs on the bottom, surface immediately, using controlled ascent. • If out of air completely, go onto emergency air from bail-out bottle. • Divers will surface when primary air reaches 500 PSIG. • Alternative method is to "Buddy Breath" with dive partner. • Adhere to No D tables to prevent decompression sickness. • Dive operations will be terminated.	L
	Loss of Communications	• Initiate diver locator system- lost diver buoy • Attempt to establish visual contact • Initiate diver recall system • Topside actions for lost diver: Initiate emergency recall. Identify GPS coordinates of the last known location of the diver. Mark last known location with anchor and buoy. • Dive team surface	L

AHA # 3 - Diving Operations & Intrusive investigation			
Job Steps	**Hazards**	**Controls**	**RAC**
	Fouled or entrapped Diver	• Diver must always be aware of his surroundings and avoid any hazardous situations if identified. • All hazardous situations will be communicated to the dive supervisor or team leader immediately. • Request Stand-by Diver to assist if any problems	L
	Hazardous Marine Life	• Wear Protective Outer-Garments (wet/ skin suits or coveralls) • Determine types of hazardous aquatic life found in this location from local marine or harbor police or lifeguard headquarters. Training in biological hazards avoidance. • Wear protective gloves • Avoid hazards • Terminate dive operations on any imminent threats	L
	Biological hazards – hazardous sea life, bees, wasps, centipedes, mosquitoes, spiders, and rodents	• Training in biological hazards avoidance • Workers will apply DEET to work clothing following manufacturer's instructions as a preventative measure for biting insects as required. • Tuck in pant legs to socks and tuck in shirt to pants. • Wear long sleeves.	L
	Line entanglement	• Diver will assess the situation and attempt self-extraction by removing or cutting the line. • Standby diver will be at the ready when diver(s) are in the water and will be deployed to assist if directed by the Diving Supervisor.	M
	MEC hazards	• On-site MEC Training • Perform MEC operations using approved methods and techniques. • Divers will not investigate targets unless there is suitable visibility. • Dive team to maintain neutral buoyancy as much as possible to remain above riverbed/seabed. • Divers plan to approach target from down-current side to prevent unintended contact. • Target will be investigated using hand tools, without moving the MEC until it can be identified and inspected • MEC operations will cease if unauthorized watercraft/personnel enter the area. Personnel will be informed of the site hazards and of the fact that they are not authorized to be near the site operations and will be asked to leave.	M
	Pinch points	• No divers between boats or objects and boats • Do not place hands, feet or legs in between boats or boats and docks	L

Abbreviations and Acronyms:

APP – Accident Prevention Plan
CSP- Certified Safety Professional
CIH- Certified Industrial Hygienist
CHMM- Certified Hazardous Materials Manager
DEET – 33% diethyl-meta- toluamide
HSE – Health Safety, and Environmental
GFCI – Ground-fault circuit interrupter
MEC – Munitions and Explosives of Concern
OSHA – Occupational Safety and Health Administration
UXOSO – UXO Safety Officer
PPE – Personal protective equipment
PFD- Personal flotation device
SSHP – Site Safety and Health Plan
SUXOS/DS – Senior UXO Supervisor
USACE – U.S. Army Corps of Engineers
UXO – Unexploded ordnance

AHA Signature Sheet **AHA # 3 - Diving Operations & Intrusive Investigation**

I have reviewed the above AHA and acknowledge the hazards involved with this work task and the controls that will help to minimize illness or injury during the tasks.

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Activity Hazard Analysis (AHA) #4

A draft AHA for this task is included below. This AHA will be reviewed by the SHM and the USACE as part of planning during development and finalization of the APP. The draft AHA will be finalized prior to initiation of this phase of field work by the staff performing the work and will be submitted for final approval by the SHM and the USACE prior to the preparatory phase inspection. Any modifications to the approved AHA that results in a higher RAC than the approved AHA will also be reviewed by the USACE and SHM. The AHA will be maintained by the staff performing the work, under SUXOS/DS and UXOSO oversight to keep it current to the work being performed and the hazards presented by the work as a living document.

Date: July 8, 2022	Task Risk Assessment Code (RAC): **L**
Project: Areas of Potential Interest (AOPIs) along a stretch of the Nashua River near Former Fort Devens, Devens, Massachusetts	L = Low
Site Supervisor: Karen Lemley, Brian Herridge, Erik Kitt	E = Extremely High Risk
Site Safety Coordinator: Pat Oberley	H = High Risk
Boat Operator: Brian Herridge	
HSM Review/Approval: Jim Streib, CIH, CSP, CHMM	M = Moderate Risk
Job/Activity: Geophysical surveying within the Nashua River near Former Fort Devens, Devens, Massachusetts **Description of the work**: Underwater Digital Geophysical mapping will employ towed array instruments on transects to identify anomalies that may be indicative of Munitions and Explosives of Concern (MEC) and Material Potentially Presenting an Explosive Hazard (MPPEH).	

		Probability				
		Frequent	**Likely**	**Occasional**	**Seldom**	**Unlikely**
Severity	**Catastrophic**	E	E	H	H	M
	Critical	E	H	H	M	L
	Marginal	H	M	M	L	L
	Negligible	M	L	L	L	L

TYPES OF POTENTIAL ENERGY:									
1	2	3	4	5	6	7	8	9	10
BIOLOGICAL	CHEMICAL	ELECTRICAL	GRAVITY	MECHANICAL	MOTION	PRESSURE	RADIATION	SOUND	TEMPERATURE

Work Task Sequence (List steps you need to take to complete the activity.)	**Potential Health and Safety Hazards** (How can you be harmed? Cut, struck, exposed…)	**Potential Energy(ies) Associated with Task**	**Hazard Controls** (List the **specific controls** for each potential hazard. Refer to EN&N Market HSSE Handbook for required controls)	**RAC**
General Safety Guidelines	Inadequate Supervision		• A competent person must be present during all boating operations. The competent person shall have the appropriate knowledge and training to identify existing and predictable hazards associated with working on the water and operating the boats. The competent person shall have the authority to take prompt and immediate actions to correct or eliminate the hazards. • During Boat Operations the minimum team requirements are for two experienced personnel with operating experience on the boat. The "Buddy System" will be employed for all operations on the water: o Master Boat Operator (competent person) o "First Mate" also knowledgeable of boat operations, docking, undocking, launching, etc. • During digital geophysical mapping operations, the additional team requirements are: o DGM System Operator—knowledgeable of system operations • During small boat operations the "First Mate" and the DGM System Operator may be the same person	L
	Improper Procedures		• All personnel will receive a site safety briefing prior to the start of onsite operations • All field personnel will receive a daily field safety briefing prior to the start of work activities. All personnel will be informed of the operations that will be conducted and the expected duties for the day.	L
Mobilization	Preparedness		• Review conditions of documents applicable to the assigned work. • Check field vehicle for necessary vehicle equipment (i.e. ice scrapers) and road safety kit. Also check field vehicle tire conditions and lights prior to mobilization. • Verify that EMS services are available and can respond in a prompt manner prior to the start of work. • Local Emergency medical Service and Fire Dispatch numbers programmed into cellular phones. Have hospital route maps readily available. • Buddy System maintained for all phases of work.	L

Work Task Sequence (List steps you need to take to complete the activity.)	**Potential Health and Safety Hazards** (How can you be harmed? Cut, struck, exposed…)	**Potential Energy(ies) Associated with Task**	**Hazard Controls** (List the **specific controls** for each potential hazard. Refer to EN&N Market HSSE Handbook for required controls)	**RAC**
			• Report all unsafe conditions and acts, injury/illness or property damage to supervisors immediately. • Emergency Medical Services contact information: • Contact Tetra Tech immediately for any work-related incidents and near misses. • All employees have the right and responsibility to stop work for any unsafe conditions that cannot be immediately corrected. Contact Tetra Tech upon stoppage work.	
	Driving	5,6	• Always using a seat belt while driving. Always observe posted speed limits, traffic signs and signals. Never use a cell phone or two-way radios while driving. • Precautions will be taken to avoid driving in inclement weather, however if conditions worsen while already on the road, safe inclement driving practices will be followed; such as slowing down, driving with hazards on and if need be stopping for the night. • Personnel mobilizing to the site will be well rested and no personnel will drive if tired.	L
Trailering and Hitching Operations	Hooking Up	5,6	• One person: Align Hitch to bumper then back slowly. • Two or more persons: Watch Only One Back up Guide. • Attach safety chains securely to vehicle. • Don't get between trailer and truck hitch or bumper while truck is moving. • Don't stand behind trailer. • Don't let trailer fall or be pushed off jack.	L
	Pulling Trailer to Truck	5,6	• Don't Overexert, Get Help, Move Slowly, Keep Proper Balance. • Don't let the trailer push you	
	Pulling	6	• Pull trailer with vehicle properly equipped for towing (licensed operators only). • Be Aware to changing conditions. • Adjust speed downward. • No passengers on trailer. • Tie down all loads or secure with suitable strapping.	

Work Task Sequence (List steps you need to take to complete the activity.)	**Potential Health and Safety Hazards** (How can you be harmed? Cut, struck, exposed…)	**Potential Energy(ies) Associated with Task**	**Hazard Controls** (List the **specific controls** for each potential hazard. Refer to EN&N Market HSSE Handbook for required controls)	**RAC**
			• Plan for extreme vibrations while securing loads and check strapping our tie downs frequently.	
	Turning (Area Too Small)	6	• Know the turning radius required for each type of trailer. Turn slowly. • Know turning width taken up by truck and specific trailer. • Avoid roads that do not provide turning areas for maneuvering the trailer. • Avoid going down steep roads unless there is another way out. Use 4WD, if necessary.	
	Spare Tire		• Ensure that spare tire is available and fully inflated prior to each trailer use.	
Small Boat Operations: Pre-Launch Briefings	Preparedness		• Prior to the start of work activities or task specific operations boat personnel shall meet with on site management and site personnel to discuss: o Hazards of boat operations, site hazards and site-specific safety considerations, including PFD requirements when underway o Boat safety support procedures, including communications with onsite personnel o Responsibilities and lines of authority for safe boat operations o Emergency Response procedures, including man overboard recovery, abandon ship requirements • A Site Supervisor will remain on land and within communication with the survey team after the boat is launched	L
Small Boat Operations	Navigation Hazards		• Review current navigation charts prior to project startup (if applicable) • Consult local authorities or knowledgeable parties about local site conditions and history	L
Small Boat Operations	Boat Operations		• While underway safe operating speeds will not be exceeded • Outboard motor will be equipped with a “kill switch” • Boat capacity (weight/passengers) will not be exceeded • Proper tools onboard for cutting line and unfouling propellers	L

Work Task Sequence (List steps you need to take to complete the activity.)	**Potential Health and Safety Hazards** (How can you be harmed? Cut, struck, exposed…)	**Potential Energy(ies) Associated with Task**	**Hazard Controls** (List the **specific controls** for each potential hazard. Refer to EN&N Market HSSE Handbook for required controls)	**RAC**
			• Boat equipped with at least 1 secondary propulsion source • Boat equipped with push-poles and/or oars to facilitate travel in extreme shallow water environments	
Small Boat Operations	Launching	4, 5, 6	• Ensure launch and recovery area is clear of items presenting a hazard • Do not engage boat propulsion until directed by the Master Boat Operator/Competent Person • Be aware of boat launch area existing hazards (holes, debris, slippery surfaces) • Use a backer/spotter when launching or recovering the boat • Never stand or pass behind the boat/trailer during launch or recovery • Perform pre-launch inspection and remove all towing safety equipment securing the boat to the trailer prior to backing boat and trailer down the dock • Ensure someone is behind the wheel of the vehicle with brake engaged or that the vehicle is in park and the emergency brake is engaged before leaving the vehicle to launch the vessel.	L
Small Boat Operations: Emergency Rescue	Falling Overboard	10	• Each passenger will wear a life preserver or buoyancy compensator (Coast Guard approved Type III PFD) while underway • All passengers will be briefed on emergency recovery man overboard (MOB) procedures: o Primary actions: Shout MOB; Turn into MOB direction to clear propeller; Throw ring buoy as marker; Point o Secondary actions: Assess situation, Transmit distress call (if necessary); Initiate turn for rescue; Approach; Use situationally appropriate recovery method • All passengers will be briefed on use of a throwable ring buoy and lifeline for overboard passenger retrieval	L
Geophysical Survey	Severe Weather Conditions	3, 10	• Prior to launch, Master Boat Operator will obtain weather forecast.	L

Work Task Sequence (List steps you need to take to complete the activity.)	**Potential Health and Safety Hazards** (How can you be harmed? Cut, struck, exposed…)	**Potential Energy(ies) Associated with Task**	**Hazard Controls** (List the **specific controls** for each potential hazard. Refer to EN&N Market HSSE Handbook for required controls)	**RAC**
			• All boat personnel will be briefed on weather conditions, and signs of inclement weather • Boat operations will be suspended if inclement weather is encountered or reasonably anticipated. Boats will be returned to safe harbor. • Frequently observe the skyline for rain squalls and thunderstorm systems that may be developing. • Bring clothing suitable for anticipated daily weather conditions. • Shut down operations during heavy rain/lightning events or high wind conditions. For storms producing lightning, seek safe haven in a grounded structure or rubber tire vehicle. Implement 30 – 30 rule (take shelter if thunder is heard within 30 seconds of a lightning flash and wait 30 minutes after the last thunder clap.). Do not use telephones during electrical storms, except in the case of emergency	
Geophysical Survey	Equipment and IVS set up hazards (heavy lifting, bending, pinch points, use of PPE, etc.)	4,5,6	• When lifting objects, lift using knees not back. For repetitive lifting tasks, the use of lifting braces/supports may be considered. Use heavy equipment to transfer heavy or awkward loads wherever possible. Have someone assist with the lift— especially for heavy (> 40lbs.) or awkward loads. Do not attempt to manually lift objects that should otherwise be lifted with heavy equipment. • Plan storage and staging to minimize lifting or carrying distances. Make sure the path of travel is clear prior to the lift. Avoid carrying heavy objects above shoulder level. • Wear leather or other abrasion resistant gloves when handling rough/sharp/splinter producing items. • All boat personnel will be aware of DGM equipment deployment procedures • Do not stand inline with winch lines • Keep hands away from operating winches and rigging pivot points / hinges • Do not stand underneath DGM equipment rigging during on land deployment	L

Work Task Sequence (List steps you need to take to complete the activity.)	**Potential Health and Safety Hazards** (How can you be harmed? Cut, struck, exposed…)	**Potential Energy(ies) Associated with Task**	**Hazard Controls** (List the **specific controls** for each potential hazard. Refer to EN&N Market HSSE Handbook for required controls)	**RAC**
Geophysical Survey	Slips, Trips, Falls/ housekeeping	4	• Be aware of poor footing, potential slipping/tripping hazards in the work area, such as wet surfaces, and where unprotected holes exist. Observe, mark and avoid any identified potential slip, trip and fall hazards. • Avoid leaning, lifting and reaching or passing objects over open water • Use protective footwear appropriate for the work and environment • Institute and maintain good housekeeping practices. Clean Work Areas as activities proceed. Remove and store materials from pathways and commonly traveled areas as soon as possible. • Three points of contact when enter/exiting equipment.	L
Geophysical Survey	Visible Lighting		• Tasks will be performed in daylight hours only.	L
Geophysical Survey	Cold stress (If necessary)	10	• All employees are trained in prevention of cold stress and the signs/symptoms. • Use a buddy System • Adjust your work schedule accordingly • Layer clothing • Wear appropriated PPE • Eat and Drink Hot liquids if needed	L
Geophysical Survey	Heat Stress (If necessary)	10	• In hot weather take regular breaks in a cool shady area, regular consumption of water to remain hydrated, use of sunglasses and sunscreen. • Standard Level D PPE	L
Geophysical Survey	Improper use Improper Maintenance Equipment failure		• Only properly trained and qualified personnel shall operate DGM equipment • Perform inspections of DGM equipment prior to each activity; • Document daily inspections of all equipment for operations as required	L
Geophysical Survey	Burns		• Avoid touching hot surfaces with bare skin such as hot metal laying in the sun, parts of operating boat motors • Wear sun protective lotions with an SPF rating of SPF30 or higher and reapply as necessary	L

Work Task Sequence (List steps you need to take to complete the activity.)	**Potential Health and Safety Hazards** (How can you be harmed? Cut, struck, exposed…)	**Potential Energy(ies) Associated with Task**	**Hazard Controls** (List the **specific controls** for each potential hazard. Refer to EN&N Market HSSE Handbook for required controls)	**RAC**
			• Keep skin covered to avoid over exposure from the sun • Notify your supervisor or UXOSO of injury or illness. • Whenever possible, avoid medications that make skin sun sensitive	
Geophysical Survey	Fire	2, 3, 10	• Clean up all fuel spills immediately. Dispose of rags ashore. • Ensure fire extinguishers are operational and placed for immediate use during all operations • Establish a fire watch during refueling operations • No smoking or open flames near flammable/combustible materials • During refueling operations an approved fire extinguisher must be on-site and readily available • Allow engines temperatures to cool before refueling • Use only approved safety fuel cans for storing and dispensing fuel; ensure proper labeling and storage • Ensure all combustible materials are removed from spark or flame • Smoking will only be allowed in designated areas. No smoking will be allowed while aboard water vessel. • If a fire starts on the boat initiate “F.I.R.E” fighting procedures: o F: find source o I: inform personnel o R: restrict the fire / fuel source o E: extinguish fire	L
Geophysical Survey	Explosions – Unexploded Ordnance		• UXO Avoidance support must be performed prior to/during the execution of this task. • In the event a potential MPPEH/MEC related discovery where to occur on-site by non-UXO qualified personnel, all work would cease and any operating heavy equipment will be shut-down and secured and the flowing procedures shall be executed: 1. **Immediately Stop Work (RECOGNIZE):** Do not disturb or move a suspect MEC/MPPEH hazard. Only trained UXO Technicians are authorized to investigate potential MEC/MPPEH hazards. Make sure that cell	L

Work Task Sequence (List steps you need to take to complete the activity.)	**Potential Health and Safety Hazards** (How can you be harmed? Cut, struck, exposed…)	**Potential Energy(ies) Associated with Task**	**Hazard Controls** (List the **specific controls** for each potential hazard. Refer to EN&N Market HSSE Handbook for required controls)	**RAC**
			phones/two way radios or other electro-magnetic sources are not engaged in the area of the suspect item. 2. **Secure area/location where the UXO/MPPEH/MEC item is discovered (RETREAT):** Stop and secure any operating equipment to the extent possible. Mark the general area/location of the UXO/MPPEH/MEC hazard with tape, colored cloth, or colored ribbon. Avoid using markers that penetrate the ground surface. 3. **Immediately make notification to CH2M HILL (REPORT):** Once area has been evacuated, appropriate notifications shall be made immediately to the site SUXOS, UXOSO/QCS, supervisor, project manager. Provide as much information as possible, including location, approximate size, shape, color, and any other distinguishing features. • Operations can not resume until such safeguards and approvals are in place to safely continue the assigned work.	

Equipment to be used (List equipment to be used in the work activity)	**Inspection Requirements** (List inspection requirements for the work activity)	**Training Requirements** (List training requirements including hazard communication)
Geonics EM61 Flex3	Visual inspection to be followed by instrument calibration.	Operator will have previous experience and training in the use of the EM61-Flex3.
GPS survey equipment	All components will be inspected visually. Reception of satellites and radio signal will attest to proper operation.	Operator will have previous experience and training in the use of GPS equipment.
Boat	Visual inspection of the boat and array platform before use. Safety inspection of the boat daily and routine maintenance.	Operator training: A boating safety course meeting the criteria of the USCG Auxiliary, National Association of Safe Boating Law Administrators (NASBLA), or equivalent
Communications Equipment • Cellular phones • Portable radios	Operational test prior to boat launch	Competent person to perform the operational test

Equipment to be used (List equipment to be used in the work activity)	**Inspection Requirements** (List inspection requirements for the work activity)	**Training Requirements** (List training requirements including hazard communication)
Marine Safety Equipment • Air Horn / Whistle • Signal flare • Fire Extinguisher (1x) • First Aid Kit • PFDs (1x person) • Throwable Ring Buoy • Anchors & Line • Oars / Push-poles	Visual inspection prior to boat launch	Competent person to perform the visual inspection

AHA Signature Sheet **AHA # 4 – Underwater Digital Geophysical Mapping (UDGM) Survey**

I have reviewed the above AHA and acknowledge the hazards involved with this work task and the controls that will help to minimize illness or injury during the tasks.

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Activity Hazard Analysis (AHA) #5

A draft AHA for this task is included below. This AHA will be reviewed by the SHM and the USACE as part of planning during development and finalization of the APP. The draft AHA will be finalized prior to initiation of this phase of field work by the staff performing the work and will be submitted for final approval by the SHM and the USACE prior to the preparatory phase inspection. Any modifications to the approved AHA that results in a higher RAC than the approved AHA will also be reviewed by the USACE and SHM. The AHA will be maintained by the staff performing the work, under SUXOS/DS and UXOSO oversight to keep it current to the work being performed and the hazards presented by the work as a living document.

Activity/Work Task: MPPEH through MDAS Management and Disposal	**Overall Risk Assessment Code (RAC) (Use highest code)**	**M**
Project Location: Military Munitions Investigation Nashua River Former Ft. Devens	**Risk Assessment Code (RAC) Matrix**	
Contract Number: W912DR-21-D-0002, Task Order W912DR22F0121 **Date Prepared**: July 2022		
Prepared by: Jennifer Harlan, PMP		
Reviewed by: Jeffrey (Jim) Streib, CIH, CSP, CHMM, CQA Director, Health, Safety and Environmental		

Severity	**Probability**				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	**E**	**E**	**H**	**H**	**M**
Critical	**E**	**H**	**H**	**M**	**L**
Marginal	**H**	**M**	**M**	**L**	**L**
Negligible	**M**	**L**	**L**	**L**	**L**

Notes: (Field Notes, Review Comments, etc.)
In addition to the information listed in this AHA, all field personnel must review and be familiar with all provisions of the approved APP/SSHP. EM 385-1-1 will also be available on site for personnel to review specific materials and mitigation measures associated with this project. PPE for this AHA will consist of a hard hat (when overhead safety hazards exist), leather safety-toed boots, safety glasses with side shields, a standard work uniform (long pants, tee shirt), hearing protection (as required), work gloves worn when indicated, a Class 2 high-visibility safety vest, and other PPE described in this AHA.

First Aid-/CPR-Qualified Persons:
SUXOS/DS- Don Schwalback
UXOSO- Patrick Oberley

Step 1: Review each **"Hazard"** with identified safety **"Controls"** and determine RAC (see above).

"Probability" is the likelihood to cause an incident, near miss, or accident and is identified as Frequent, Likely, Occasional, Seldom, or Unlikely.	**RAC Chart**
"Severity" is the outcome/degree if an incident, near miss, or accident did occur and is identified as Catastrophic, Critical, Marginal, or Negligible.	**E = Extremely High Risk** **H = High Risk**
Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on the AHA. Annotate the overall highest RAC at the top of the AHA.	**M = Moderate Risk** **L = Low Risk**

AHA # 5 – MPPEH through MDAS Management and Disposal

Job Steps	Hazards	Controls	RAC
MPPEH Processing (includes initial processing (e.g. intrusive investigation), demolition and final inspection/processing for transport and disposal or recycling	MPPEH classification failure Certification and Verification material as explosives free can be inaccurate and potentially explosive material can be sent off site improperly. Exposure to MEC (explosive hazards)	• Install and enforce exclusion zone (EZ) as outlined in MR-QAPP and ESP. • Evacuate all non-essential personnel from EZ before processing MPPEH. • Ensure the SUXOS/DS or designated UXO Tech III is present. • MPPEH processing will be performed by an UXO Tech III and SUXOS with-qualified personnel only. • Under no circumstances will personnel work alone. • Positively identify all munitions and ensure all non-munitions are verified by inspection as explosives free. • Keep all spark- and flame-producing materials away from energetic materials. • Do not handle ammunition and explosives roughly or carelessly. Extra care should be taken because in most cases the hazards of the ammunition and/or explosives increase with age, deterioration, or damage. • All MPPEH and debris management will be performed in accordance with procedures in the QAPP, including accountability requirements.	**M**
	Adverse weather conditions such as wind, thunder and lightning, rain	• Review weather forecast prior to work and travel (NOAA) (Weather Channel). • Reschedule field activities if forecasted weather is severe. • If lightning is within a 10 second count, from previous sound of thunder, suspend all general field and outdoor operations.	**L**
	Exposure to MEC by workers and/or the public prior to or during treatment if items are not attended at all times prior to treatment or MEC. Donor explosives and MEC can explode if handled improperly. Treatment of MEC requires enforcement of EZ.	• Follow the procedures detailed in the ESP for ensuring and maintaining watch over MEC/MPPEH until treatment has been achieved. • Only UXO qualified personnel will assess and handle MEC/MPPEH. All MEC must be evaluated and identified prior to handling. Items must be inspected and verified by the SUXOS as safe to move prior to moving. • Items that are deemed “safe to move” may be relocated for consolidated treatment. Items that are not “safe to move” will be treated using blow-in-place procedures. • UXO personnel will not handle or move MEC/UXO until a positive identification can be made. • UXO personnel will not move MEC or UXO potentially containing all-ways-acting fuzes. • Ensure all workers and any bystanders are outside of the EZ prior to initiating detonation. Ensure “all clear” and accountability of personnel. • Ensure the safety observer is located in the safe area maintains visual contact with the team down range • Ensure site radios are working	**M**

AHA # 5 – MPPEH through MDAS Management and Disposal

Job Steps	Hazards	Controls	RAC
		• Provide a specific brief with an operation overview • Ensure all required materials are present in the SZ • Ensure the EZ has been put in place • Review emergency procedures • Review explosives handling procedures • Ensure required notifications have been made • Ensure all nonessential personnel are outside the EZ and man the barricades (if used) • Ensure the 5 minute and 1 minute warning horns are sounded • Ensure misfire wait times are enforced before re-entry into EZ.	
	Initiating Explosives	• Segregation - Strict adherence will be practiced with regard to the segregation of initiating devices (cord and detonators) from the donor explosives during transportation and handling. • Non-essential personnel will be restricted from operating area	**M**
	If MEC is found broken open, filler could be exposed and present an explosive hazard or chemical hazard to workers who touch filler or contaminated soil around the item.	• Notify the UXOSO and SUXOS/DS if a MEC items is broken open and filler is exposed. • Do not handle without leather work gloves and nitrile gloves underneath. • Work upwind from any contamination when possible. • Control the generation of dusts during earth disturbing activities.	**M**
	Contracting or spreading coronavirus.	• Monitor yourself for coronavirus symptoms. • Maintain social distance. • Wear a face covering, when CDC community exposure is high and social distancing can’t be maintained. • Wash hands regularly.	L
	Uneven, wet, muddy walking surfaces	• Wear composite toe boots with 6-inch ankle support. Ensure footwear soles are in good condition and provide skid-resistance while walking on slippery surfaces • Walk, do not run. Minimize distractions when walking (i.e., looking back, talking on cell phones). • Be aware of walking surface. Rock and debris can cause tripping hazards along with holes and pockets. • Due to weather conditions, wet and icy walking surfaces along with steep slopes must be risk assessed and mitigated on a case by case basis. • Avoid walking on saturated, un-vegetated soils. • When possible, travel in pairs on slopes to ensure communication in case of incident. • Use walking implements on slopes when necessary to assist in climbing steep hills.	**L**

AHA # 5 – MPPEH through MDAS Management and Disposal

Job Steps	Hazards	Controls	RAC
	Exposure to sun light may result in sunburn or ultraviolet (UV) light exposure	• Use sunscreen (with a recommended SPF of 15 or greater, and both UVA and UVB protection) on exposed skin, as needed. (Note: Remember to apply on the back of the neck and ears.) • Wearing a hat with a large brim. A dark underside color brim is recommended to protect from reflective glare. • UV protection factor (UPF) clothing and headgear of 25 or higher provides very good protection from UVA and UVB. • Tetra Tech Safe Work Practice 5-15 requires access to shade to protect personnel from direct sunlight when working in ambient temperatures exceeding 80oF or higher. The shading will provide field personnel a place to recover and rest to adequately cool down to mitigate the risk to the heat-related disorders noted below.	**L**
	Exposure to heat-related disorders due to elevated ambient temperatures and high relative humidity	• If ambient temperature is forecasted to reach up to 85°F or higher, Drink adequate amounts of water as and replenish lost electrolytes. **Only water bottles shall be used to provide water to workforce. A water cooler is NOT ALLOWED due to COVID-19.** • Recognizing the signs and symptoms of heat-related disorders and preventive measures helps reduce the severity of these disorders. In addition, team members will know how to provide first aid care if required. • Frequent rest breaks shall be taken as needed to ensure proper hydration during elevated ambient temperatures and high relative humidity (greater than 60%).	**L**
	Eye injuries could occur from dust or debris.	• Wear safety glasses with side shields at all times when working. . • Set up portable eye wash for flushing of eye to try to remove object. • Use the eye wash for the full 15-minutes, regardless if you feel that the object has been removed. • Notify supervisor so eye can be monitored. • If object still irritates or stays in the eye, call CORE as soon as possible. • To keep dust down, travel at slower speeds on unpaved roads	**L**
	Irritating plants, wildlife and insects	• Wear light-colored long-sleeved shirts, long pants, socks, and hats when possible. • General knowledge and stay clear of any wildlife encountered. Self-inspect clothing and skin for ticks, if working in high grass or well vegetated areas. Attempt to become knowledgeable of any poisonous plants that you may encounter (seasonal), be able to identify them. SWP 05-17, Biohazard Exposures to Outdoor Workers	**L**

Equipment to be Used	Training Requirements/Competent or Qualified Personnel Name(s)	Inspection Requirements
Site vehicles	Drivers must have driver's license. Drivers of Tt's rental vehicles must be authorized to drive the rental vehicle in accordance with Tt's procedures.	Receipt inspection by Equipment Supervisor (SUXOS/DS). Vehicle inspection by drivers. Operator's manual for each vehicle must be located with the vehicle.
Boats	Qualified Operators will have USCG approved boater safety qualifications identified in the APP and experience in use of the boats on the project.	• Inspect daily, and before use. • Use the boating checklist form.
Hand and power tools	Training in use of hand and power tools by the UXOSO or designee and review of operating manual. Use proper hand tools.	Daily inspection by users/operators. Inspect tools and power cords to ensure they are listed by a NRTL. Inspect for damage to tool and to cords.
First aid kit, fire extinguisher, eye wash station	Use of emergency equipment including first aid kits, fire extinguishers and eye wash must be done by personnel familiar with this plan; use and inspection criteria of the equipment, and what the equipment is used for, are by or under direction of the UXOSO.	Fire Extinguisher • Initially and at least monthly thereafter by UXOSO First Aid Kit • Weekly and after use for restocking by UXOSO Eye Wash Station • Weekly by UXOSO • Potable water changed weekly unless a preservative solution is used
PPE	Users must be trained in the proper use of, limitations of, inspection of, donning and doffing of, and replacement of PPE.	Daily by user

AHA Signature Sheet **AHA #5 – MPPEH through MDAS Management and Disposal**

I have reviewed the above AHA and acknowledge the hazards involved with this work task and the controls that will help to minimize illness or injury during the tasks.

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APPENDIX B

OSHA 300A

OSHA's Form 300A (Rev. 01/2004)
Summary of Work-Related Injuries and Illnesses

Year 2021

U.S. Department of Labor
Occupational Safety and Health Administration

Form approved OMB no. 1218-0176

All establishments covered by Part 1904 must complete this Summary page, even if no injuries or illnesses occurred during the year. Remember to review the Log to verify that the entries are complete

Using the Log, count the individual entries you made for each category. Then write the totals below, making sure you've added the entries from every page of the log. If you had no cases write "0."

Employees former employees, and their representatives have the right to review the OSHA Form 300 in its entirety. They also have limited access to the OSHA Form 301 or its equivalent. See 29 CFR 1904.35, in OSHA's Recordkeeping rule, for further details on the access provisions for these forms.

Number of Cases

Total number of deaths	Total number of cases with days away from work	Total number of cases with job transfer or restriction	Total number of other recordable cases
0	0	0	0
(G)	(H)	(I)	(J)

Number of Days

Total number of days away from work	Total number of days of job transfer or restriction
0	0
(K)	(L)

Injury and Illness Types

Total number of...
(M)

(1) Injury	0	(4) Poisoning	0
(2) Skin Disorder	0	(5) Hearing Loss	0
(3) Respiratory Condition	0	(6) All Other Illnesses	0

Post this Summary page from February 1 to April 30 of the year following the year covered by the form

Public reporting burden for this collection of information is estimated to average 58 minutes per response, including time to review the instruction, search and gather the data needed, and complete and review the collection of information. Persons are not required to respond to the collection of information unless it displays a currently valid OMB control number. If you have any comments about these estimates or any aspects of this data collection, contact: US Department of Labor, OSHA Office of Statistics, Room N-3644, 200 Constitution Ave, NW, Washington, DC 20210. Do not send the completed forms to this office.

Establishment information

Your establishment name: Tetra Tech TMR

Street: 1320 N. Courthouse Rd.

City: Arlington State: VA Zip: 22201

Industry description (e.g., Manufacture of motor truck trailers): Remediation Services

Standard Industrial Classification (SIC), if known (e.g., SIC 3715): ___ ___ ___ ___

OR North American Industrial Classification (NAICS), if known (e.g., 336212): 5 6 2 9 1 0

Employment information

Annual average number of employees: 102

Total hours worked by all employees last year: 208,328

Sign here

Knowingly falsifying this document may result in a fine.

I certify that I have examined this document and that to the best of my knowledge the entries are true, accurate, and complete.

M. W. D. [signature] — Company executive; President — Title

970-206-4263 — Phone; 18-Jan-22 — Date

APPENDIX C

SELECT HSE PROGRAMS AND PROCEDURES

1.0 INTRODUCTION

This safe work practice (SWP) addresses situations during which heat illness is likely to occur and provides procedures for preventing and treating heat-related injuries and illnesses. This SWP is applicable to all Tetra Tech employees performing outdoor activities at both domestic and international project locations. This SWP incorporates safety regulations of the States of California and Washington to protect outdoor workers from heat-related illness. An "outdoor place" is an open area such as an agricultural field, forest, park, equipment and storage yard, outdoor utility installation, tarmac, and road. An outdoor workplace also can include a construction site at which no building shell has been completed, and areas of a construction site outside of any building shells that may be present.

Many factors contribute to heat illness and UV exposure, including personal protective equipment (PPE), ambient temperature and humidity, workload, sun exposure, and the physical condition of the employee, as well as predisposing medical conditions. However, the primary factors of heat illness are elevated ambient temperatures in combination with fluid loss. Because heat illness is one of the more common health concerns during field activities, employees must be familiar with the signs, symptoms, and various treatment methods of each form of heat illness. Health effects from heat illness may range from transient heat fatigue or rashes to serious illness or death. Tracking the weather is imperative during outdoor field projects because heat-related illness and fatalities occur primarily during heat waves.

2.0 Definitions

The following are typical terms and definitions associated with heat illness prevention and monitoring activities:

Acclimatization – Gradual adaptation of the body to work under temperature conditions to which it is exposed. Acclimatization peaks in most people within 4 to 14 days of regular work taking up at least 2 hours per day in the heat.

Ambient Temperature – Temperature of the surroundings.

Electrolytic Sports Drink – A beverage containing sodium and potassium salts that replenish the body's water and electrolyte levels after dehydration caused by physical activity.

Environmental Risk Factors for Heat Illness – Working conditions under which heat illness could occur. Environmental risk factors include air temperature, relative humidity, radiant heat from the sun and other sources, conductive heat sources such as the ground, air movement (or lack of), workload severity and duration, and protective clothing and PPE worn by employees.

Heat Illness – A serious medical condition resulting from the body's inability to cope with a particular heat load. Symptoms include heat cramps, heat exhaustion, and heat stroke (see Table 1).

Heat Index – An index that combines air temperature and relative humidity to indicate the human-perceived equivalent temperature (i.e., how hot it feels outdoors).

Heavy Work – Digging/hand-auguring, heavy lifting, cutting trees, using heavy hand tools, and similar tasks.

Light Work – Walking, writing notes, handling samples, and similar tasks.

Medium Work – Bailing wells, moving light equipment, driving nails, and similar tasks.

Personal Risk Factors for Heat Illness – Factors such as an individual's age, degree of acclimatization, health, water consumption, alcohol consumption, caffeine consumption, and use of prescription medications that affect the body's water retention or other physiological responses to heat.

Preventive Cool Down and Recovery Period – Period of time needed to recover from the heat in order to prevent heat illness.

Relative Humidity – The amount of water vapor that exists in a gaseous mixture of air and water vapor.

Shade – Blockage of direct sunlight. Canopies, umbrellas, and other temporary structures or devices may be used to provide shade. One indicator that blockage is sufficient is absence of a shadow of an object within the area of blocked sunlight. Shade is not adequate when heat in the area of shade defeats the purpose of shade, which is to allow the body to cool. For example, a car sitting in the sun does not provide acceptable shade to a person inside it unless the car is running with air conditioning.

Wet Bulb Globe Temperature (WBGT) - a measurement used to indicate heat stress. WBGT takes into account the effects of humidity

3.0 Employee Duties and Responsibilities

Written procedures help Project Managers (PM), Site Safety Coordinators (SSC), and field team members reduce the risk of heat-related illnesses, and ensure that emergency assistance is provided without delay to all Tetra Tech employees. The following are the duties and responsibilities of the Project Team for implementing and managing the Heat Illness Prevention and Monitoring SWP.

3.1 Project Management

The PM must understand and agree to the responsibility for implementing this SWP for worker safety. The PM will assure that all employees at the work site comply with this SWP.

- The PM must designate an appropriate field team member to serve as the SSC who will implement this SWP and who will perform and document necessary monitoring requirements for worker safety.
- The PM will ensure necessary resources required to implement this SWP and necessary monitoring resources for worker safety are acquired and present at the work site prior to initiation of project activities in hot environments.
- The PM will work with the Director of Health and Safety and identify at risk employees.
- The PM will ensure all field team members are trained in heat illness management and emergency response procedures prior to working outdoors.
- The PM and SSC will modify working hours to schedule work during the cooler hours of the day, when possible. When a modified or shorter work-shift is not possible, more water and rest breaks shall be provided.
- The PM and SSC will verify that the elements of this SWP are documented in the Health and Safety Plan, as necessary.

3.2 Site Safety Coordinator

- The SSC must understand and agree to the responsibility for implementing this SWP in the field and implement the necessary monitoring requirements for worker safety during outdoor activities.
- The SSC must have appropriate Occupational Safety and Health Administration (OSHA)-related training and experience to understand and implement this SWP, and to ensure required monitoring for worker safety during outdoor activities.
- The SSC must ensure that resources needed to implement this SWP and required monitoring for worker safety are acquired and present at the work site prior to initiation of project activities in hot environments.
- The SSC must maintain all necessary resources required under the SWP during project activities in hot environments.
- The SSC must ensure implementation and appropriate documentation of required monitoring for worker safety during site activities.
- The SSC must be familiar with and continuously monitor all employees and must remain alert for onset of heat-related symptoms.
- The SSC and co-workers are encouraged never to discount any signs or symptoms of heat-related illness shown by one or more project team members, and to immediately report these signs or symptoms.
- The SSC will carry a cell phone or other means of communication to ensure that emergency services can be contacted and will verify that these resources are functional at the worksite prior to each shift.

3.3 Field Team

- The field team will be able to recognize the hazards of working in warm environments.

- Co-workers will use a "buddy system" to monitor each other closely for discomfort or symptoms of heat illness.

- Every morning, workers must attend a daily tailgate safety meeting to be reminded of site-specific emergency procedures.

- A copy of site specific heat illness procedures shall be available for employee review.

4.0 Description and Requirements

4.1 Effects of Hot Weather

As the environment heats up, the body tends to warm up as well. The body's internal thermostat maintains a constant temperature by pumping more blood to the skin, which is cooled by evaporation from increasing perspiration production. In this way, the body increases the rate of heat loss to balance the heat burden created by a hot environment. Such situations generally do not cause harm, as long as the body is allowed to adjust to cope with the increasing heat.

In a very hot environment, however, the rate of heat gain exceeds the rate of heat loss. In this situation, the body's coping mechanisms can be overwhelmed, resulting in heat illness and leading to a range of serious and possibly fatal conditions.

4.2 Preparation for Hot Weather Work

The following list describes the process for preparing to work in hot weather conditions:

- Identify work that can pose a risk of heat stress and Ultraviolet (UV) exposure.
- Identify at-risk employees.
- Identify possible controls:
  - Establish controls for hot weather situations
  - Determine mandatory work and rest regimens based on current conditions, workload, clothing requirements, temperature and humidity for Threshold Limit Value (TLV).
  - Identify required fluid and food replacement schedules.

— Provide a location to cool down during breaks.

— Establish requirements to address UV exposure.

— Monitor workers in extreme heat conditions.

- Establish emergency response procedures to be followed for heat-related emergency situations.
- Provide for first aid and establish the requirement that first aid be administered immediately to employees displaying symptoms of heat-related illness.
- Provide training to employees and verify training records about site legal and regulatory requirements and about the characteristics and effects of heat stress and the recognition and prevention of heat-related injuries (See Table 1).

5.0 Employee Training

Training is an important component of heat illness prevention. Employees are instructed to recognize and treat heat-related illnesses during 8-hour health and safety refresher and first aid training courses. The conditions, symptoms, and treatment for heat-related illnesses are listed below in Table 1.

TABLE 1
HEAT ILLNESS CONDITIONS

Condition	Causes	Signs and Symptoms	Treatment
Heat cramps	Fluid loss and electrolyte imbalance from dehydration	• Painful muscle cramps, especially in legs and abdomen • Faintness • Profuse perspiration	• Move affected worker to cool location • Provide sips of liquid such as Gatorade® • Stretch cramped muscles • Transport affected worker to hospital if condition worsens
Heat Exhaustion	Blood transport to skin to dissipate excessive body heat, resulting in blood pooling in the skin with inadequate return to the heart	• Weak pulse • Rapid and shallow breathing • General weakness • Pale, clammy skin • Profuse perspiration • Dizziness • Unconsciousness	• Move affected worker to cool area • Remove as much clothing as possible • Provide sips of cool liquid or Gatorade® (only if conscious) • Fan the person but do not overcool or chill • Treat for shock • Transport to hospital if condition worsens
Heat Stroke**	Life threatening condition from profound disturbance of body's heat-regulating mechanism	• Dry, hot, and flushed skin • Constricted pupils • Early loss of consciousness • Rapid pulse • Deep breathing at first, and then shallow breathing • Muscle twitching leading to convulsions • Body temperature reaching 105 or 106 degrees Fahrenheit (°F) or higher	• Immediately transport victim to medical facility • Move victim to cool area • Remove as much clothing as possible • Reduce body heat promptly by dousing with water or wrapping in wet cloth • Place ice packs under arms, around neck, at ankles, and wherever blood vessels are close to skin surface • Protect patient during convulsions
**** Any of these symptoms require immediate attention. If heat stroke is suspected, emergency medical personnel should be immediately contacted and on-site first aid provided.**			

Employee training procedures include, but are not limited to, the following:

- All employees (including and especially newly hired employees) will receive heat illness prevention training prior to working outdoors. This training will review the signs and symptoms of heat illness, detail the concept and importance of acclimatization and Tetra Tech's responsibility to provide water, shade, cool-down rests and access to first aid. Training will also communicate the employees' right to exercise their rights without retaliation.

- SSCs will hold short tailgate meetings daily to review important heat illness and prevention information with all field team members. Information communicated in tailgate meetings will include a reminder of the importance of frequent consumption of small quantities of water, up to 4 cups per hour when the work environement is hot and employees are likely to be sweating more than usual.

- The expectation to immediately report any symptoms or signs of heat illness in themselves or in co-workers.

- All workers will be assigned a "buddy" or experienced coworker to ensure that they understood the training and follow the company procedures.

- Training will include a review of how emergency services will be provided if necessary, procedures for contacting emergency medical services and if necessary transporting employees to a point where they can be reached by emergency medical services.

- PMs and SSCs will be trained before assignment to supervise outdoor workers.

6.0 Heat Illness Prevention and Monitoring Requirements

6.1 Identification of Work Conditions

Hot weather is a condition that will be encountered during Tetra Tech operations. When work takes place outdoors during warm weather, working conditions shall be identified for both heat stress conditions and UV exposure.

6.2 Heat Index

The Heat Index (HI) can be used as a first indicator of thermal comfort. The HI can be obtained by directly measuring the dry bulb temperature and relative humidity. The dry bulb temperature and relative humidity forecast can be obtained by checking the local weather station information or measured by using a wet bulb thermometer. A direct reading of HI can be obtained by placing a heat stress monitor in full shade at the workplace.

The HI does not take into account acclimation, clothing or nature of work; therefore, if the HI is at 80°F (26.7°C) or above, further evaluation is required to adjust workload and clothing.

6.3 Heat Exposure Limits and Measurement

The TLV is a means of providing heat exposure limits and gauging potential heat impacts. To determine the TLV, the Wet Bulb Globe Temperature (WBGT) index is measured. The WBGT is calculated using a formula that takes into account air temperature, speed of air movement, radiant heat from hot objects, sunshine and body cooling due to sweat evaporation. WBGT direct reading meters, often called 'heat stress analyzers,' are also available. These meters give direct WBGT readings; no calculations are necessary.

A trained person shall take WBGT measurements. If a WBGT direct reading meter is not available, two different methods are used to calculate WBGT in the workplace: one for workplaces with direct sunlight, and the other for workplaces without direct sunlight. In addition, when conditions of the workplace fluctuate widely, time-weighted WBGT is often used. The WBGT calculation is used in determining heat stress exposure guidelines and heat stress and clothing guidelines. Table 2 presents approximate WBGT values.

APPROXIMATE WBGT VALUE (°F) TABLE

Dry Bulb Temperature		Relative Humidity																			
°C	°F	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
18.33	65	59	59	60	61	62	62	63	64	64	65	66	67	67	68	69	70	70	71	72	73
18.89	66	59	60	61	61	62	63	64	65	65	66	67	68	68	69	70	71	71	72	73	74
19.44	67	60	61	61	62	63	64	65	65	66	67	68	69	69	70	71	72	72	73	74	75
20.00	68	60	61	62	63	64	64	65	66	67	68	69	69	70	71	72	73	74	74	75	76
20.56	69	61	62	63	63	64	65	66	67	68	69	69	70	71	72	73	74	75	75	76	77
21.11	70	62	62	63	64	65	66	67	68	69	69	70	71	72	73	74	75	76	77	77	78
21.67	71	62	63	64	65	66	67	68	69	69	70	71	72	73	74	75	76	77	78	79	79
22.22	72	63	64	65	66	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
22.78	73	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82
23.33	74	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
23.89	75	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
24.44	76	65	66	67	68	69	71	72	73	74	75	76	77	78	79	80	81	82	83	85	86
25.00	77	66	67	68	69	70	71	72	74	75	76	77	78	79	80	81	82	84	85	86	87
25.56	78	66	67	69	70	71	72	73	74	76	77	78	79	80	81	82	84	85	86	87	88
26.11	79	67	68	69	71	72	73	74	75	76	78	79	80	81	82	84	85	86	87	88	90
26.67	80	68	69	70	71	72	74	75	76	77	79	80	81	82	84	85	86	87	88	90	91
27.22	81	68	69	71	72	73	75	76	77	78	80	81	82	83	85	86	87	89	90	91	92
27.78	82	69	70	71	73	74	75	77	78	79	81	82	83	85	86	87	88	90	91	92	94
28.33	83	69	71	72	73	75	76	78	79	80	82	83	84	86	87	88	90	91	92	94	95
28.89	84	70	71	73	74	76	77	78	80	81	83	84	85	87	88	90	91	92	94	95	97
29.44	85	71	72	73	75	76	78	79	81	82	84	85	87	88	89	91	92	94	95	97	98
30.00	86	71	73	74	76	77	79	80	82	83	85	86	88	89	91	92	94	95	97	98	100
30.56	87	72	73	75	76	78	80	81	83	84	86	87	89	90	92	93	95	97	98	100	101
31.11	88	72	74	76	77	79	80	82	84	85	87	88	90	92	93	95	96	98	100	101	103
31.67	89	73	75	76	78	80	81	83	85	86	88	90	91	93	94	96	98	99	101	103	104
32.22	90	74	75	77	79	80	82	84	86	87	89	91	92	94	96	97	99	101	103	104	106
32.78	91	74	76	78	80	81	83	85	87	88	90	92	94	95	97	99	101	102	104	106	108
33.33	92	75	77	79	80	82	84	86	88	89	91	93	95	97	98	100	102	104	106	107	109
33.89	93	76	77	79	81	83	85	87	89	90	92	94	96	98	100	102	103	105	107	109	111
34.44	94	76	78	80	82	84	86	88	90	92	93	95	97	99	101	103	105	107	109	111	113
35.00	95	77	79	81	83	85	87	89	91	93	95	97	99	101	103	105	107	108	110	112	114
35.56	96	77	79	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116
36.11	97	78	80	82	84	86	89	91	93	95	97	99	101	103	105	108	110	112	114	116	118
36.67	98	79	81	83	85	87	90	92	94	96	98	100	103	105	107	109	111	113	116	118	120
37.22	99	79	82	84	86	88	91	93	95	97	99	102	104	106	108	111	113	115	117	120	122
37.78	100	80	82	85	87	89	91	94	96	98	101	103	105	108	110	112	115	117	119	121	124
38.33	101	81	83	85	88	90	92	95	97	100	102	104	107	109	111	114	116	119	121	123	126
38.89	102	81	84	86	89	91	93	96	98	101	103	106	108	111	113	116	118	120	123	125	128
39.44	103	82	84	87	89	92	94	97	100	102	105	107	110	112	115	117	120	122	125	127	130
40.00	104	83	85	88	90	93	96	98	101	103	106	108	111	114	116	119	121	124	127	129	132
40.56	105	83	86	89	91	94	97	99	102	105	107	110	113	115	118	121	123	126	129	131	134
41.11	106	84	87	89	92	95	98	100	103	106	109	111	114	117	120	122	125	128	131	133	136
41.67	107	84	87	90	93	96	99	101	104	107	110	113	116	119	121	124	127	130	133	136	138
42.22	108	85	88	91	94	97	100	103	106	108	111	114	117	120	123	126	129	132	135	138	141
42.78	109	86	89	92	95	98	101	104	107	110	113	116	119	122	125	128	131	134	137	140	143
43.33	110	86	90	93	96	99	102	105	108	111	114	117	120	124	127	130	133	136	139	142	145
43.89	111	87	90	93	97	100	103	106	109	113	116	119	122	125	128	132	135	138	141	144	148
44.44	112	88	91	94	98	101	104	107	111	114	117	121	124	127	130	134	137	140	143	147	150
45.00	113	88	92	95	99	102	105	109	112	115	119	122	126	129	132	136	139	142	146	149	153
45.56	114	89	93	96	99	103	106	110	113	117	120	124	127	131	134	138	141	145	148	152	155
46.11	115	90	93	97	100	104	108	111	115	118	122	125	129	133	136	140	143	147	150	154	158
46.67	116	90	94	98	101	105	109	112	116	120	123	127	131	134	138	142	146	149	153	157	160
47.22	117	91	95	99	102	106	110	114	118	121	125	129	133	136	140	144	148	152	155	159	163
47.78	118	92	96	100	103	107	111	115	119	123	127	131	134	138	142	146	150	154	158	162	166
48.33	119	92	96	100	104	108	112	116	120	124	128	132	136	140	144	148	152	156	160	164	168
48.89	120	93	97	101	105	110	114	118	122	126	130	134	138	142	147	151	155	159	163	167	171

Notes: Calculated values assume outdoor work in full sun, with a light (<5 mph) wind.
WBGT of green-shaded cells is less than dry-bulb temperature.

6.4 Heat Stress Exposure Guidelines

Heat stress exposure guidelines recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) are shown in Table 3: ACGIH Screening Criteria for Heat Stress Exposure. This table is used to determine the allocation of work in a work/rest cycle, which is dependent on the type of work and WBGT values.

Table 3: ACGIH Screening Criteria for Heat Stress Exposure

PERMISSIBLE HEAT EXPOSURE THRESHOLD LIMIT VALUE															
Clothing Type	Summer Lightweight			Cotton Coveralls			Winter Work			Permeable Water Barrier (Tyvek)			Fully-Encapsulating Suit (Level 4)		
Work Load	Light	Moderate	Heavy	Light	Moderate	Heavy	Light	Moderate	Heavy	Light	Moderate	Heavy	Light	Moderate	Heavy
Work/Rest Schedule / WBGT	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)
Continuous Work	86	80	77	82	76	73	79	73	70	75	69	66	68	62	59
75% Work, 25% Rest / Hr	87	82	79	83	79	75	80	75	71	76	72	68	69	64	61
50% Work, 50% Rest / Hr	89	85	82	85	81	79	81	78	75	78	74	71	71	67	64
25% Work, 75% Rest / Hr	90	88	86	86	84	82	83	81	79	79	77	75	72	70	68

Notes: Temperature is approximate WBGT from accompanying tables, based on outdoor work, temperature, and relative humidity measurement during work activities. Light Work includes walking, writing notes, handling samples, and similar activities (metabolic rate up to 200 kilocalories [kcal]/hour). Medium Work includes bailing wells, moving light equipment, driving nails, and similar tasks (metabolic rate of 200-350 kcal/hour). Heavy Work is digging, heavy lifting, cutting trees, using heavy hand tools, and similar tasks (metabolic rate above 350 kcal/hour).

Table 3 is based on five-day work weeks and eight-hour work days with conventional breaks. Conventional breaks include a 15-minute break in a four-hour period and a half-hour lunch in an eight-hour period. The ACGIH exposure limits are intended to protect most workers from heat-related illnesses. The limits are higher than that if they had been developed to prevent discomfort. A safety factor should be used to protect sensitive individuals or increase comfort.
Examples to clarify work load intensity:

- Rest: sitting (quietly or with moderate arm movements).
- Light work: sitting or standing to control machines, performing light hand or arm work (e.g., using a table saw), occasional walking, driving.
- Moderate work: walking about with moderate lifting and pushing or pulling, walking at a moderate pace, scrubbing in a standing position.
- Heavy work: digging, carrying, pushing/pulling heavy loads, walking at a fast pace, pick and shovel work, carpenter sawing by hand.
- Very heavy: very intense activity at a fast to maximum pace (e.g., shoveling wet sand).

For example, in order to minimize heat stress exposure, an employee who is acclimated and is performing heavy work such as shoveling dirt in a temperature of 78°F (25.6°C), would fall into a work/rest regimen of 100% work.

TLVs assume that workers who are exposed to these conditions are adequately hydrated, are not taking medication, are wearing lightweight clothing and are in generally good health.
When the WBGT is at a temperature that exceeds the TLV, 'Stop Work' should be enforced.

6.5 Heat Stress and Clothing Guidelines

The exposure limit should be adjusted for workers wearing heavy clothing. ACGIH recommendations for these conditions are listed in Table 4: Correction of TLV for Clothing.

Table 4: Correction of TLV for Clothing

Clothing Type	WBGT Correction (in °F [°C])
Work Clothes (long-sleeved shirts and pants)	0 (0)
Cloth coveralls (woven material)	+3 (0)
Spunbonded Meltdown Spunbonded polypropylene coveralls	+6 (+0.5)
Polyolefin coveralls	+8 (+1)
Double-layer woven clothing	+9 (+3)
Limited-use vapor-barrier coveralls	+18 (+11)

For example, an acclimated worker wearing double-layer woven clothing doing moderate work in 30°C would have a corrected exposure level of 30 + 3 = 33°C (91.4°F). This would lower the allowable exposure to 0-25% work from 25-50% work.

For Fire Retardant Clothing (FRC), there is no WBGT correction. FRC can be obtained in various weight materials. The lightest weight FRC should be worn during work in warm environments. No second layer of clothing should be worn except for cotton undergarments.

These values are not to be used for completely encapsulating suits. The assumption is that coveralls are worn with only modest clothing underneath, not a second layer of clothing.

6.6 Identifying At-risk Employees

A screening program for identifying at risk employees shall include identification of health conditions that are aggravated by extreme environmental temperatures. How a person functions under conditions of heat stress will be unique that person and will depend on:

- Age.
- Weight.
- Metabolism.
- Alcohol or drug use.
- Pre-existing medical conditions.

- Level of physical fitness.
- Use of medications.
- Individual sensitivity to heat.
- Possibility of hypertension.

Note: Employees with any 'at-risk' conditions shall have more stringent work/rest regimens or controls

6.7 Health and Safety Controls

Controls shall be based on a risk assessment approach. Conditions and available controls will vary from site to site. Therefore, the HASP shall define and document the site-specific control plan. Controls shall be appropriate for the risks that are associated with heat hazards.

6.7.1 Acclimation

The human body can adapt to heat exposure to some extent. This physiological adaptation is called acclimation. Acclimation is a response by the body that results in increased heat tolerance.

People differ in their ability to acclimate to heat. Usually, acclimation is obtained in four to five days. However, it is lost in approximately the same amount of time. After a period of acclimation, the same activity will produce fewer cardiovascular demands. The worker will perspire more efficiently, leading to better evaporative cooling, and thus will more easily be able to maintain normal body temperatures.

All site workers who could be exposed to hot weather conditions shall be acclimated or go through an acclimation process, as necessary. Where workers are already acclimated, no acclimation process is necessary. A previously acclimated person is someone who has already been in similar working and heat conditions. Employees newly assigned to a high heat area will be closely observed by the SSC or designees for the first 14 days of the employee's assignment.

All employees shall be closely observed by a supervisor or designee during a heat wave. For acclimization purposes only, a heat wave is defined as any day in which the predicted high temperature for the day will be at least 80 degrees Fahrenheit and at least ten degrees Fahrenheit higher than the average high daily temperature in the preceding five days.

6.7.2 Fluid and Nutrient Replacement

Cool (50°-60°F [10°-15°C]) water or other cool liquid, except alcoholic beverages, should be made available to workers.

Provision of Water (Not Temperature Dependent)

Water is the principal preventive measure to minimize the risk of heat-related illnesses. Tetra Tech employees shall have access to potable drinking water (or electrolytic sports drink). Where the supply of water is not plumbed or otherwise continuously supplied, water shall be provided in sufficient quantity at the beginning of the work shift to provide **1 quart per employee per hour for drinking for the entire shift**. Frequent drinking of water shall be encouraged by the SSC. Water provision requirements include the following:

- At least 2 quarts of water per employee will be available at the start of the shift.
- The SSC will monitor water containers every 30 minutes, and employees are encouraged to report low levels or dirty water to the SSC when observed.
- The SSC will provide reminders to the field team members to drink frequently, and more water breaks will be provided as needed.
- During the daily tailgate safety meeting each morning, the SSC will remind the field team about the importance of frequent water consumption throughout the shift.
- Water containers will be placed as close to the workers as safety conditions allow.
- When drinking water levels within a container drop below 50%, the water shall be replenished immediately.
- If a common water source is used, disposable/single-use drinking cups will be provided to employees each day.
- Communication devices such as radios, cell phones, or air horns may be used to remind field team members to take water breaks.

Although some commercial replacement drinks contain salt, this is not necessary for acclimated people, because most people have enough salt in their normal diets. Commercial replacement drinks contain high amounts of sugar and may contribute to an individual's inability to cope with the warm environment. If used, commercial replacement drinks should not be used at full strength and should be diluted with water on at least a one-to-one ratio.

Energy drinks shall not be used while working in warm environments.

Poor nutrition, over eating and under eating are factors contributing to heat stress. During hot conditions, employees should eat small, regular meals.

6.7.3 Additional Control Measures

Outdoor workers are exposed to not only potential heat illness, but also UV radiation. Long-term exposure to UV radiation poses additional risks and can lead to a variety of skin disorders, including skin cancer and cataracts of the eyes.

Protection from UV exposure, sunscreen and appropriate eye protection should be considered in addition to the additional controls listed below:

<u>Access to Shade</u>

Access to rest and shade or other cooling measures are important preventative steps to minimize the risk of heat-related illnesses and exposure to UV radiation. Tetra Tech employees working in temperatures exceeding 80 degrees Fahrenheit for any period shall be provided access to an area with shade that is either open to the air or provided with ventilation or cooling. Such access to shade shall be permitted at all times. The amount of shade present shall be at least enough to accommodate the number of employees on recovery or rest periods, so that they can sit in a normal posture fully in the shade without having to be in physical contact with each other. When the outdoor temperature in the work area does not exceed 80 degrees Fahrenheit, shade shall be made available as addressed in this section or employees may be provided timely access to shade upon request.

Procedures for the provision of shade include the following:

- SSC will set up an adequate number of shaded areas as needed. Examples of shaded areas include vehicles with air conditioning, umbrellas, canopies, or other portable devices. Shading should be placed in close proximity to the work activity (no more than 50-100 yards away, or at the closest location safety conditions allow). Employees will be allowed and encouraged to take preventative cool down rest in the shade when they feel the need to do so to protect themselves from overheating. Employees should have access to an office, construction trailer, or other places with air conditioning.

- Any individual who takes a preventative cool down rest shall be monitored and asked if they are experiencing symptoms of heat illness.

- If an employee exhibits signs or reports symptoms of heat illness while taking a preventative cool down rest or during a preventative cool down rest period, appropriate first aid or emergency response measures must be provided.

- Any employee experiencing signs and symptoms of heat illness shall not be ordered back to work until signs and symptoms of heat illness have abated but in no event less than 5 minutes in addition to the time needed to access the shade.

- Every morning a short tailgate meeting will occur to remind workers about the importance of rest breaks and the location of shade.

- As safety conditions allow, SSCs shall provide areas for employee breaks that are:
  - Readily accessible
  - In the shade, open to air, and ventilated
  - Near sufficient supplies of drinking water, shade provided during meal periods shall be enough to accommodate the number of employees who remain outside.

7.0 Heat Illness Monitoring

A medical monitoring program shall be planned with the assistance of a medical or industrial hygiene professional. The monitoring program shall be specify the leading indicators to be used (e.g. heat rate, body temperature, blood pressure, respiration rate, and other) and frequency of measurement.

Heat illness monitoring will be conducted by the SSC or his/her designee when work conditions warrant implementation of a work/rest schedule based on temperature conditions and PPE requirements associated with project activities. Monitoring will be conducted as follows:

- Heart Rate: Count the radial (wrist) pulse during a 30-second period as early as possible in the rest period; if heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle by one-third without changing the rest period.
  - If the heart rate still exceeds 110 beats per minute at the next period, shorten the following work cycle by one-third.
- Body Temperature: If body temperature exceeds 99.6 degrees Fahrenheit (°F) (37.6 degrees Celsius [°C]), shorten the next work cycle by one-third without changing the rest period. If body temperature still exceeds 99.6 °F at the beginning of the next rest period, shorten the following work cycle by one-third. Do not permit a worker to wear impermeable PPE when his or her body temperature exceeds 100.6 °F (38.1 °C). Use any of the following thermometers:
  - Oral Thermometer – Use a clinical thermometer (3 minutes under the tongue) to measure the oral temperature at the end of the work period.
  - Tympanic (ear) Thermometer
  - Temporal (swipe) Thermometer

The SSC will document throughout the entire work shift results of heat illness monitoring for each team member participating in work activities. Any employee exhibiting signs and symptoms of heat illness shall not be left alone or sent home without being offered onsite first aid and/or being provided with necessary emergency medical services in accordance with Site HASP emergency response procedures.

8.0 HIGH HEAT PROCEDURES

<u>Extra Measures During Heat Waves</u>

Extreme environmental conditions during a heat wave can cause an employee's physical and mental conditions to change rapidly into a serious medical condition. Workers previously fully acclimatized are at risk for heat illness during a heat wave because during a heat wave, the body does not have enough time to adjust to a sudden, abnormally high temperature or other extreme conditions. The onset of heat illness may be confused with other problems and may not always be obvious before it becomes life-threatening. Therefore, the following extra measures may be required to prevent and/or respond to heat illness during heat waves or when temperatures exceed 95 degrees Fahrenheit. These measures will be discussed at the preshift tail gate meeting before commencement of work.

- **Communication** – Make sure voice, observation or electronic means of communication (text messaging or cell phone if service is available) is maintained so that site personnel can contact a supervisor when necessary. Designate one or more employees at the site as authorized to call for emergency services, when designated person(s) are not available any employee can call for emergency services.

- **Alertness to the Weather** – Make sure to monitor the weather and the specific locations where work activities are occurring. Continue to stay updated throughout the work shift on the changing air temperatures and other environmental factors. **<u>Use current weather information to make the appropriate adjustments in work activities throughout the workday.</u>**

- **Extra Vigilance and Observation** – Apply real-time communication methods as stated above as well as a mandatory "Buddy System" to account for the whereabouts of employees at more frequent intervals throughout the work shift and at the end of the work shift. Employee observation methods may also include, supervisor or designee direct observation if less than 20 employees are at the site.

- **Additional Water Consumption** – Remind employees throughout the work shift to drink small quantities of water more frequently and have effective replenishment measures in place for provision of extra drinking water to ensure available supplies.

- **Additional Cooling Measures** – Other alternative cooling measures may be necessary in addition to shade (e.g., allowing employees to spend time in air-conditioned places or having them spray themselves with water).

- **Additional and/or Longer Rest Breaks** – Remind employees of their right to take a more frequent and cool down rests when necessary.

- **Change of Work Scheduling and Assignments** – One or more of the following additional measures may be necessary:

  — Start the work shift earlier in the day or later in the evening.

  — Cut work shifts short or stop work altogether.

  — Bring in more personnel to accommodate longer, more frequent breaks as necessary to meet production requirements.

  — Reduce the severity of work by scheduling slower paced, less physically demanding work during the hot parts of the day, and the heaviest work activities during the cooler parts of the day (early morning or evening).

9.0 Establish Emergency Response

Specific procedures to be followed for heat related first aid and emergency response shall be established relevant to project location and task and documented in the Site-specific HASP. The HASP emergency response procedures must include clear and concise directions to the work site that can be provided to emergency responders. The HASP will also identify local emergency services and if necessary provide a means to transport employees to a place where they can be reached by emergency responders.

10.0 Variation to the Heat Illness Prevention and Monitoring Program

Before deviation from the requirements of this document, a designated manager shall authorize the variation. The exception process does not need to be followed for variations that impose more stringent requirements that those outlined in this document.

11.0 Disclaimer

This safe work practice (SWP) is the property of Tetra Tech, Inc. (Tetra Tech). Any reuse of the SWP without Tetra Tech's permission is at the sole risk of the user. The user will hold harmless Tetra Tech for any damages that result from unauthorized reuse of this SWP. Authorized users are responsible for obtaining proper training and qualification from their employer before performing operations described in this SWP.

Revision Date	Document Authorizer		Revision Details
	Name	Approval Date	
12/19/2018	Chris McClain	12/21/2018	Revision to align with Cal-OSHA Heat Illness Prevention

1.0 PURPOSE

This safe work practices (SWP) describes situations where cold stress is likely to occur and discusses procedures for the prevention and treatment of cold-related injuries and illnesses. Cold conditions may present health risks to employees during field activities. Types of cold stress include: trenchfoot, frostbite, and hypothermia. When the body is unable to warm itself, serious cold-related illnesses and injuries may occur, and permanent tissue damage and death may result.

1.1 SCOPE

This policy applies to members of the Tetra Tech workforce who work for extended periods in conditions of low temperatures, especially in combination with wind or moisture.

2.0 ROLES AND RESPONSIBLITIES

Tetra Tech firmly believes protecting the health and safety of our employees is everyone's responsibility.

2.1 Project Managers

- Provide adequate resources to evalute cold stress hazards prior to work beginning.
- Provide proper personal protective equipment as necessary to the job.
- Arrange for employee training on cold stress prevention techniques.
- Assign a competent person or Site Safety Coordinator to conduct daily weather assessment and to adjust daily operations and prevention measures as necessary.

2.2 Competent Person/Site Safety Coordinator (SSC)

- Be competent to assess or measure weather conditions in cold stress environments
- Conduct regular hazard assessments of the weather to determine appropriate controls.
- Communicate proper controls and prevention strategies to Tetra Tech workers

2.3 Tetra Tech Staff

- Recognize the hazards of working in cold environments *(See Appendix B).*
- Mitigate the risk of cold stress by establishing and enforcing engineering controls, appropriate work practices, and protective clothing guidelines.
- Monitor for for signs of cold stress in co-workers and help to provide adequate warming periods.

3.0 COLD STRESS ASSESSMENT & PREVENTION

If an employee is or may be exposed to cold stress conditions; a cold stress assessment should be performed prior to starting work to determine the potential for hazardous exposure and to properly identify safety controls measures. Project Managers and Site-Safety Coordinators can complete this through conducting an Activity Hazard Analysis (AHA), outlined in the *DCN 02-21F Tetra Tech Activity Hazards Analysis.*

Activity Hazard Analysis will consider factors such as the:

- Areas and activities with an equivalent chill temperature (ECT) below 19.4 ° F (-7 ° C) *(Appendix A).*
- Fine dexterity tasks that require work with bare hands.
- Contact with metal surfaces or use of evaporative liquids (gasoline, alcohol, or cleaning liquids).
- Working on or near bodies of water.
- Areas about which employees have expressed concern.

Based on the outcomes of the AHA, the Project Manager will designate a Site Safety Coordinator (SSC) when cold stress hazards are anticipated. The SSC shall check temperature, wind speed, and the conditions of the worker, as often as needed, to determine the appropriate controls and changes to control strategies. The SSC will be responsible for conducting daily and just in time education and communication to workers on cold stress prevention strategies.

3.1 Prevention Measures

Project Managers, in collaboration with the Site Safety Coordinator, shall adopt work schedules and work practices that help protect employees from the effects of cold stress. Guidelines include, but are not limited to, the following:

- Monitor current weather conditions (see *the table in Appendix A for the effects of wind speed on air temperatures).*
- Establish a work/warm-up cycle *(see Appendix C, Scheduling Work in Extreme Cold).*
- Schedule work at the warmest times.
- Move work to warmer areas.
- Plan for worker weather acclimization.
- Assign additional workers to the job to shorten its duration.
- Encourage self-pacing and extra breaks in warm dry shelters, if required.
- Establish a buddy system, emphasizing mutual observation.
- Allow for reduced efficiency and productivity when employees are wearing protective clothing.
- Urge employees to drink warm, sweet fluids (sugar water, sports-type drinks) before beginning work and during breaks. Avoid drinks with caffeine (coffee, tea, sodas, or hot chocolate).
- Ensure a thermometer and chemical hot packs are available onsite.

- Review tools and machine controls to evaluate if gloved hands can operate in cold conditions and establish appropriate safety control measures.

- Cover metal handles of tools and control bars with thermal insulating materials for temperatures below -1°C (30.2°F).

- Provide adequate warming measures when work will need to be performed with bare hands for more than 10-20 minutes when skin or body is at risk of effects of air temperature and air speed on exposed flesh (see Appendix A).

- Have a survival kit in the workers vehicle consisting of at least the following:

  o Blanket or warm heavy coat

  o Candles and lighter or matches

  o Flashlight

  o Cell phone or alternative and battery charger

  o High-energy snacks (i.e. chocolate, dried fruit).

Employees who are at risk for occupational exposure to cold stress must be familiar with the causes and symptoms of cold-related injuries *(see Appendix B).* Personnel working in cold conditions should follow recognized procedures for controlling cold stress, this includes, but not limited to:

- Eat a well-balanced diet. *Note: Energy bars and dried fruits are good sources of quick energy. Nuts, seeds, and other proteins provide longer-lasting energy. Caffeine and nicotine, which can restrict circulation or accelerate heat loss, should be avoided.*

- Stay hydrated. *Note: Working in cold, dry air can cause significant water loss through the skin and lungs. Increased fluid intake prevents dehydration, which puts the extremities at greater risk of damage due to decreased blood flow.*

- Wear appropriate protective clothing that keeps the extremities warm and dry.

  a) Dress in layers. Wear clothes that are snug but not tight. This allows insulating air between the clothes and your skin. Layers can be adjusted to changing conditions.

  b) Wear appropriate underwear that wicks moisture away from the skin.

  c) Cover as much of the head, face, and neck as possible without restricting vision.

  d) If working in rain, snow, or extreme wind, wear an outer layer of waterproof or windproof garments that allow water vapor created by perspiration to escape.

  e) Wear insulated boots and socks with insulating properties.

  f) Wear gloves when skin or body is at risk of effects of air temperature and air speed on exposed flesh (see Appendix A).

  g) Change out of wet clothing as soon as possible.

  h) Wear tinted eye protection, if needed, when working in snow- or ice-covered terrain.

  i) Lone workers should have a check in plan for periodic checks with the office or specific contact to ensure safety.

  j) When traveling, call the office when you leave and again when you reach your destination.

- Take regular breaks and move to a dry, heated area to warm up.

- Never touch cold metal objects with exposed skin and wear gloves when cold metal surfaces are within close contract range.

- At the first sign of overexposure, stop work and go indoors or to a dry, heated area to warm up. Don't push yourself to finish a task.

4.0 EMERGENCY RESPONSE

Employees will be trained to recognize the signs and symptoms of frostbite and hypothermia (see Appendix C) in themselves as well as in coworkers. Employees are required to report incidents of cold stress to the Site Safety Coordinator. If a worker exposed to cold shows signs or reports symptoms of cold stress or injury, the worker must be removed from further exposure and treated by an appropriate medical provider. Emergency response and injury case management process will be outlined in the project Health and Safety Plan (HASP) and be documented according to the *DCN 02-02 Tetra Tech Incident Reporting and Investigation Program*.

5.0 TRAINING

Training is an essential component of cold stress prevention. Employees will be taught to identify and treat cold-related injuries during various mandatory training events such as, but not limited to, annual refresher training, site-specific training, tailgate meetings, and first aid training courses.

The training and education material provided to workers who have not previously worked in a cold stress environment should include the following information:

- Recognition of the signs and symptoms of impending hypothermia or excessive cooling of the body even when shivering does not occur
- Recognition of impending frostbite
- Proper re-warming procedures and appropriate first aid treatment
- Methods for weather acclimization in cold work environments
- Proper use of clothing
- Proper eating and drinking practices

- Safe work practices appropriate to the work that is to be performed

- The dangers associated with working around unstable snow and ice build ups as applicable.

6.0 RECORDKEEPING REQUIREMENTS

Cold Stress awareness training shall be documented and available for review to the employee, client, or regulatory authority upon request. Recordkeeping will comply with the *DCN 01-04 Tetra Tech Recordkeeping and Reporting Requirements Program.*

DEFINITIONS

If a definition is not listed in this section, please contact your supervisor. If your supervisor is unaware of what the term means, please contact your Health and Safty Representative .

Core body temperature—The temperature in the brain, the heart, and the abdominal organs. It changes very little (normal range: 97.6–98.8°F or 36.3–39.9°C) and is vital for the normal functioning of these organs.

Cold stress—The strain placed on the body when heat losses are greater than normal and compensatory thermoregulatory mechanisms are required to maintain normal body temperature. The main factors that contribute to cold stress are environmental: cold air temperatures, high-velocity air movement, dampness of the air, and contact with cold water or surfaces. Other factors include age, weight, fitness level, acclimatization to cold, fatigue, use of medications, and use of alcohol or nicotine. Cold-related injuries are either localized (frostnip, frostbite) or generalized (hypothermia).

Equivalent Chill Temperature (ECT)—The air temperature that would produce the same cooling effect on exposed flesh as a given combination of air temperature and air movement. Commonly called the wind chill index, it is a useful tool in determining the clothing requirements and potential hazards of different air temperatures and wind speeds.

Frostbite—The freezing of tissues in some part of the body as a result of exposure to extreme cold or contact with cold objects. Blood circulation may cease in the affected areas, and blood vessels can be irreparably damaged. In milder cases, the symptoms include a patchy inflammation of the skin, accompanied by slight pain. In more severe cases, there is often tissue damage without pain. Frostbitten skin is susceptible to infection and gangrene. There are three stages of frostbite:

- Frostnip—the affected body parts begin to feel cold and stiff with a prickling pain; the skin is usually white and blotchy.
- Superficial frostbite—ice crystals form in the skin cells, causing the area to feel hard and waxy. The skin looks purplish, and blisters may appear. Nerve endings, blood vessels, and muscle tissue are damaged, so the affected area becomes numb and sensations of cold and pain go away.
- Deep frostbite—tissue is frozen through to the bone, causing blood clots and gangrene. If the victim receives medical attention soon enough, the frozen limb may be saved from amputation.

Hypothermia—A decrease in the core body temperature that impairs normal metabolic, muscular, and cerebral functions. This condition occurs when the body loses heat faster than it is replaced. Symptoms begin when the core body temperature drops below 95°F (35°C); if it falls below 90°F (32.2°C), the condition is critical and eventually fatal. Hypothermia is a threat when an individual is exposed to water temperatures below 60°F (15.6°C) or air temperatures below 50°F (10°C). Symptoms include intense shivering, muscle tension, fatigue, feelings of cold or numbness, slurred speech, stumbling, lethargy, erratic behavior, or irritability.

Trench foot—An injury to nerve and muscle tissue in the feet after they have been wet and cold (but not frozen) for a prolonged period. Also known as “immersion foot.”

References & Standards

OSHA, Department of Labor, Fact Sheet OSHA 98-55, “Protecting Workers in Cold Environments.”
OSHA, Department of Labor, OSHA Publication 3156, “The Cold Stress Equation.”
CDC, Department of Health and Human Services, “Cold Stress.”
US SAR Task Force, Department of Homeland Security, “Cold Water Survival.”
Infastructure Health and Safety Association; Ontario, Canada, Construction Health and Safety Manual, “Cold Stress”

Related Programs, Procedures & Forms

DCN 01-04 Recordkeeping and Reporting Requirements Program
DCN 02-02 Incident Reporting and Investigation Program
DCN 02-21 Project Safety Management Program
DCN 02-21F Activity Hazard Analysis

damages that result from unauthorized reuse of this SWP. Authorized users are responsible for obtaining proper training and qualification from their employer before performing operations described in this SWP

Revision Date	Document Authorizer		Revision Details
	Name	Approval Date	
2/7/2012	Chris McClain Denny Cox	2/7/2012	Update from 2008 format
July 2020	Amber Bill Chris McClain	09/2020	Updated to include Roles and Responsibilities, Emergency Response Procedures, Record Keeping Requirements, and Cold Stress Definitions.

Appendix A
Effects of Windspeed and Temperature

Air temperature and air speed play important roles in cold stress. The following tables illustrates the effects of air temperature and air speed on exposed flesh, expressed as Equivalent Chill Temperature (ECT), also known as the wind chill index.

The ACGIH criteria, in the Fahrenheit scale:

Estimated wind speed (in mph)	Actual temperature reading (degrees Fahrenheit)											
	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
	Equivalent chill temperature (degrees Fahrenheit)											
Calm	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
5	48	37	27	16	6	-5	-15	-26	-36	-47	-57	-68
10	40	28	16	4	-9	-24	-33	-46	-58	-70	-83	-95
15	36	22	9	-5	-18	-32	-45	-58	-72	-85	-99	-112
20	32	18	4	-10	-25	-39	-53	-67	-82	-96	-110	-121
25	30	16	0	-15	-29	-44	-59	-74	-88	-104	-118	-133
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109	-125	-140
35	27	11	-4	-20	-35	-51	-67	-82	-98	-113	-129	-145
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116	-132	-148
Wind speeds greater than 40 mph have little additional effect	**LITTLE DANGER** In < 1 hour with dry skin. Maximum danger of false sense of security.				**INCREASING DANGER** Danger from freezing of exposed flesh within one minute.				**GREAT DANGER** Flesh may freeze within 30 seconds.			
	Trench foot and Immersion foot may occur at any point on this chart.											

Note: Equivalent chill temperature requiring dry clothing to maintain core body temperature above 36 C (96.8 F) per cold stress TLV.

Wind Chill Temperature Index Celcius Scale:

WIND CHILL TEMPERATURE INDEX
Frostbite Times are for Exposed Facial Skin

Wind Speed (km/h)	Air Temperature (°C)										
	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50
5	4	-2	-7	-13	-19	-24	-30	-36	-41	-47	-53	-58
10	3	-3	-9	-15	-21	-27	-33	-39	-45	-51	-57	-63
15	2	-4	-11	-17	-23	-29	-35	-41	-48	-54	-60	-66
20	1	-5	-12	-18	-24	-30	-37	-43	-49	-56	-62	-68
25	1	-6	-12	-19	-25	-32	-38	-44	-51	-57	-64	-70
30	0	-6	-13	-20	-26	-33	-39	-46	-52	-59	-65	-72
35	0	-7	-14	-20	-27	-33	-40	-47	-53	-60	-66	-73
40	-1	-7	-14	-21	-27	-34	-41	-48	-54	-61	-68	-74
45	-1	-8	-15	-21	-28	-35	-42	-48	-55	-62	-69	-75
50	-1	-8	-15	-22	-29	-35	-42	-49	-56	-63	-69	-76
55	-2	-8	-15	-22	-29	-36	-43	-50	-57	-63	-70	-77
60	-2	-9	-16	-23	-30	-36	-43	-50	-57	-64	-71	-78
65	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79
70	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-80
75	-3	-10	-17	-24	-31	-38	-45	-52	-59	-66	-73	-80
80	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81

FROSTBITE GUIDE

Increasing risk of frostbite for most people in 10 to 30 minutes of exposure
High risk for most people in 5 to 10 minutes of exposure
High risk for most people in 2 to 5 minutes of exposure
High risk for most people in 2 minutes of exposure or less

APPENDIX B
COLD STRESS DISORDERS

The body's first response to cold stress is to conserve body heat by reducing blood circulation through the skin. This effectively makes the skin an insulating layer. A second physiological response is shivering, which increases the rate of metabolism. Shivering is a reliable sign that cold stress is significant and hypothermia may be present. However, these responses are relatively weak as a protection mechanism. Behavior is the primary human response to preventing excessive exposure to cold. These include increasing clothing insulation, increasing activities, and seeking warm locations.

Insulation is a critical characteristic of clothing designed to be worn in cold conditions. Clothing materials used for their insulation characteristics include cotton, wool, silk, nylon, down, and polyester. Better insulation is usually achieved by layering clothes rather than wearing one garment. Another advantage of layers is that a person can add or remove layers to adjust for differing insulation needs during the work period.

The insulating value of clothing is greatly diminished by moisture, either in the work environment or in the form of sweat. Once clothing is wet, it should be replaced immediately with dry clothing.

Disorders	Cause	Symptoms	Prevention	First Aid Procedure
Hypothermia	Overexposure, exhaustion, or dehydration; low tolerance (genetic or acquired); drug and alcohol use	Chills, pain in extremities, fatigue or drowsiness, euphoria, slow and weak pulse, slurred speech, collapse, shivering, loss of consciousness, core body temperature below 95°F (35°C)	Wear layered clothing; avoid moisture and stay dry; bring along extra dry clothes; carry blankets, matches, first aid kit; use buddy system if possible.	Move to warm area and remove any wet clothing; apply modest external warmth (external heat packs, blankets, etc.); drink warm, sweet fluids if conscious; transport to hospital.
Frostbite	Exposure to cold; vascular disease	Burning sensation at first, coldness, numbness, tingling; skin color white or grayish yellow to reddish violet to black, blisters; response to touch depends on depth of freezing	Wear layered clothing; protect the face, ears, nose, fingers, toes; avoid moisture and stay dry; wiggle toes and fingers if they begin to lose feeling or tingle; go inside and warm up.	Move to warm area and remove any wet clothing; apply modest external warmth (external heat packs, blankets, etc.); drink warm, sweet fluids if conscious; treat as a burn (do not rub the affected area); transport to hospital.
Frostnip	Exposure to cold (above freezing)	Possible itching or pain; skin turns white	Similar to Frostbite	Similar to Frostbite
Trench Foot	Exposure to cold (above freezing) and dampness	Severe pain, tingling, itching; edema, blisters; response to touch depends on depth of freezing	Similar to Frostbite	Similar to Frostbite
Chilblain	Inadequate clothing; exposure to cold and dampness; vascular disease	Recurrent, localized itching; painful inflammation; swelling; severe spasms	Similar to Frostbite	Remove to warm area and seek medical attention.
Raynaud's disease	Exposure to cold and vibrations; vascular disease	Fingers tingle; intermittent blanching and reddening; fingers blanch with cold exposure	Similar to Frostbite	Remove to warm area and seek medical attention.

APPENDIX C
WORK/WARM-UP SCHEDULE FOR A 4-HOUR SHIFT

A WORK/WARM-UP SCHEDULE IS AN EXAMPLE OF AN ADMINISTRATIVE CONTROL. THE ACGIH STANDARD CONTAINS A WORK/WARM-UP SCHEDULE FOR A 4-HOUR SHIFT FOR WORKERS WHO ARE PROPERLY CLOTHED.

Table 7-1: Work/Warm-up Schedule for a Four-Hour Shift

Air temperature (sunny sky)		No noticeable wind		8 km/h wind (5 mph)		16km/h wind (10 mph)		24 km/h wind (15 mph)		32 km/h wind (20 mph)	
°C (approx.)	°F (approx.)	Max work period	No. of breaks	Max work period	No. of breaks	Max work period	No. of breaks	Max work period	No. of breaks	Max work period	No. of breaks
-26° to -28°	-15° to -19°	Normal breaks	1	Normal breaks	1	75 minutes	2	55 minutes	3	40 minutes	4
-29° to -31°	-20° to -24°	Normal breaks	1	75 minutes	2	55 minutes	3	40 minutes	4	30 minutes	5
-32° to -34°	-25° to -29°	75 minutes	2	55 minutes	3	40 minutes	4	30 minutes	5	**Non-emergency work should stop**	
-35° to -37°	-30° to -34°	55 minutes	3	40 minutes	4	30 minutes	5	**Non-emergency work should stop**			
-38° to -39°	-35° to -39°	40 minutes	4	30 minutes	5	**Non-emergency work should stop**					
-40° to -42°	-40° to -44°	30 minutes	5	**Non-emergency work should stop**							
-43° and below	-45° and below	**Non-emergency work should stop**									

Source: Adapted from Threshold Limit Values (TLV) and Biological Exposure Indices (BEI) booklet (ACGIH: Cincinnati) 2016, page 210.

NOTES

1. Applies to moderate to heavy physical work in any 4-hour period.
2. Warm-up breaks should be in a warm environment for 10 minutes.
3. Normal breaks means a break after 2 hours of work.
4. Guidelines apply to workers wearing dry clothing.
5. If there is limited physical activity, apply the schedule one step lower (more protective).

TETRA TECH

Diving Safe Practices Manual

April 2022

Safety Excellence

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REVISION RECORD

Revisions to this document will be reviewed and approved through the same level of authority as the original document. The marine operations program manager must authorize all changes made to the Diving Safe Practices Manual (DSPM). At a minimum, annual reviews of the DSPM will be conducted to ensure the manual's adequacy and applicability. Revisions or changes will be documented and summarized below.

Revision	Date	Pages Affected	Reason	Authorized By
Rev 0	April 15, 2019	All	Issued for Tetra Tech Munitions Response Operating Unit.	Scot Wilson
Rev 1	February 15, 2021	All	Annual Review.	Scot Wilson
Rev 2	April 29, 2022	All	Annual Review.	Scot Wilson

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ABBREVIATIONS AND ACRONYMS

ACDE	Association of Commercial Diving Educators
ACFM	actual cubic feet per minute
ACS	air control system
ADCI	Association of Diving Contractors International
AED	automated external defibrillator
AGE	arterial gas embolism
AHA	activity hazard analysis
ANSI	American National Standards Institute
Army	U.S. Army
ATA	atmosphere absolute
CFR	Code of Federal Regulations
CRL	corporate reference library
CPR	cardiopulmonary resuscitation
DCS	decompression sickness
DDC	district diving coordinator
DDESB	Department of Defense Explosives Safety Board
DOP	diving operations plan
DOT	Department of Transportation
DPIC	designated person in charge
DRB	diving review board
DS	diving supervisor/ field operations lead
DSO	diving safety officer
DSR	diving safety representative
DSPM	diving safe practices manual
EM	engineers manual
ESSQ	environment, safety, security and quality
FFW	feet of freshwater
FSW	feet of seawater
HAZWOPER	hazardous waste operations and emergency response
HASP	health and safety plan
MEC	munitions and explosives of concern

ABBREVIATIONS AND ACRONYMS (Continued)

MMRP	military munitions response program
NIOSH	national institute for occupational safety and health
NOAA	national oceanographic and atmospheric administration
NOSSA	naval ordnance safety and security activity
OSHA	occupational safety and health administration
PFD	personal flotation device
PPM	parts per million
PSI	pounds per square inch (gauge)
SSA	surface-supplied air
SADS	surface air delivery system
SCUBA	self-contained underwater breathing apparatus
SDS	senior diving supervisor
SHM	safety and health manager
SOP	standard operating procedures
SSHO	site safety and health officer
SUXOS	senior UXO supervisor
TP	technical paper
TMR	Tetra Tech Munitions Response
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USN	U.S. Navy
U.S.	United States
UXO	unexploded ordnance

1.0 PURPOSE

This Tetra Tech Munitions Response (TMR) Diving Safe Practices Manual (DSPM) provides TMR employees and subcontractors with the requirements and guidance for conducting safe diving operations. Contractors working directly for the client will be required to have safe practices that meet or exceed the requirements of this manual while operating or using TMR-owned or leased equipment or property.

This manual ensures TMR diving operations meet and/or exceed the requirements of federal and state agencies. The project management team, designated dive supervisor/lead divers, project quality managers, and site safety and health officers (SSHOs) will ensure compliance with Occupational Safety and Health Administration (OSHA) regulations and standards by implementing these procedures during dive operations.

This manual was prepared in accordance with the OSHA regulations. Federal, state, and local regulations were also considered during the preparation of this manual. If a conflict arises between the current edition of this manual and applicable or updated federal or other legal directives or statutes, the latter shall always take precedence.

2.0 FEDERAL AND STATE STANDARDS REQUIREMENTS

This manual was developed using guidelines, procedures, rules, and regulations from the following government and civilian agencies:

- OSHA
- United States (U.S.) Army Corps of Engineers (USACE)
- The Association of Diving Contractors International (ADCI)
- U.S. Navy (USN)
- U.S. Coast Guard (USCG)
- U.S. Army (Army)
- National Oceanographic and Atmospheric Administration (NOAA)

This manual provides the **minimum regulatory standards** for team composition, diving procedures, equipment maintenance, and operations.

3.0 SCOPE

This document contains procedures applicable to all TMR projects involving underwater operations that use divers or snorkelers to perform work or support scientific research projects. The procedures in this document shall meet the requirements in 29 *Code of Federal Regulations* (CFR) 1910.401, Subpart T. Requirements that are not specifically included in this DSPM will be included in the project specific Diving Operations Plan (DOP) which is part of the project specific Health and Safety Plan (HASP).When contracted to dive for clients who mandate following USACE standards, additionalequipment, procedures, and review requirements will be addressed in the project specific DOP.

The specific requirements are identified in Section 30 of USACE Engineers Manual (EM) 385-1-1, Safety and Health Requirements Manual. If there are any conflictsbetween this manual, OSHA, and/or federal and state/ local regulations, the **most stringent regulations will take precedence**, provided site safety is not compromised. All conflicts will be detailed, with procedures provided in the project specific DOP.

4.0 REVISIONS

A review of this manual will be conducted annually. Revisions will be periodically completed based on new advances in diving practices, technological advances, changes in regulations, methods, and the procurement of new diving systems or equipment.

5.0 DIVING REVIEW BOARD

The Marine Operations Program Manager is designated the Chairman of the TMR Diving Review Board (DRB) and is responsible for updating this manual. The Diving Safety Officer (DSO) will maintain the qualification records of personnel approved for diving and will recommend approval of all other divers (including subcontracted divers) involved with TMR projects to the chairman. The Senior Diving Supervisor (SDS) is responsible for the operational readiness of the TMR dive equipment and supporting assets. The SDS also provides supervision of the TMR divers, makes recommendations to the Chairman for dive staff assignments.

6.0 GENERAL RESPONSIBILITIES

This manual will be reviewed by the Chairman, DSO, and the TMR senior diving supervisor (SDS) for technical content involving TMR diving. They will ensure diving operations are conducted in a safe and efficient manner throughout the company. Their responsibilities include:

- Review existing policies and procedures to ensure safe, effective diving operations.
- Develop recommendations to improve diving operations.
- Review and discuss diving accident report releases by various sources and ensure the distribution of copies to Dive Team members.
- Review any TMR near-miss or actual diving mishaps and develop procedures and policies to prevent future occurrences.
- Ensure that the TMR dive program conforms to all the guidelines in this DSPM, as well as all applicable federal, state, and local laws and regulations.
- Coordinate proper recordkeeping for diving personnel, diving operations, and dive equipment maintenance.
- Coordinate periodic diver training and safety programs as needed.
- Review, prior to approval, prospective TMR dive operations that use non-standard diving modes and procedures or carry above average risk.

- Review the qualifications and performance of all divers and potential Diving Supervisors/ Lead Divers.
- Stay updated on new safety procedures, as well as OSHA, USN, USCG, USACE, and ADCI requirements.
- The Quality Department will review this manual for compliance with appropriate laws and regulations.
- Approval authority rests with the TMR President, with review by the Marine Operations Program Manager.
- The Chairman of the DRB will be responsible for all required corporate recordkeeping in accordance with this manual, and maintenance of all identified references.
- For unexploded ordnance (UXO) diving operations, the Marine Operations Program Manager will review and approve all TMR employees and subcontractor personnel involved in UXO diving.

The DSPM will never substitute for prior planning, sound judgment, and a continuing concern for maximum safety. Safety is not a rulebook; it is a state of mind and must be continually maintained in our workplace culture. However, not all circumstances or situations can be explained and detailed in this DSPM. For this reason, TMR only recommends deviating from these guidelines when, in the opinion of the diving supervisor/ field operations lead (DS), an emergency exists where the health and safety of personnel is a concern. The DS will have final authority regarding safe conditions at the dive site. A written event report will be submitted to the Chairman of the DRB within 48 hours of the deviation from the DSPM to document possible changes to this manual and conformation to OSHA and other regulatory requirements.

6.1 Waiver of Requirements

The DRB may grant a waiver for specific requirements of training, examinations, and minimum activity to maintain certification.

6.2 Marine Operations Manager/Chairman, DRB

The Marine Operations Program Manager is the Chairman of the TMR DRB. The DRB is composed of the Chairman, the DSO, and the SDS. The Chairman of the DRB is responsible for managing the TMR Diving Program in conjunction with the assigned board members; they will maintain the diving logs and references as required by OSHA in 29 CFR 1910.401, Subpart T. The DSO will maintain qualifications and physical records for all TMR divers in conjunction with the military munitions response program (MMRP) Field Operations Manager. The Chairman will review and approve divers, including subcontractors who are assignedto individual projects. The chairman identifies DSs. Upon concurrence of the DRB, the chairman forwards the recommendations to the TMR management team who officially assigns them to the position in writing.

6.3 DSO/DRB Member

The diving safety officer (DSO), as a permanent DRB member, is responsible for the safe conduct of UXO and construction diving operations. The DSO is responsible for the appropriate diver training and qualifications for UXO operations. The DSO will submit to the Chairman the names of qualified UXO divers to be certified by TMR to work on TMR projects. The DSO will maintain a recent copy of the USN Diving Manual. OSHA, USACE, USCG, American National Standards Institute, applicable local regulations and the Association of Diving Contractors International Consensus and Technical Standards.

The DSO will make these manuals available to the diving supervisors as required.

6.4 SDS/DRB Member

The senior diving supervisor (SDS) will be a senior TMR diver designated by the Chairman and will be a permanent member of the DRB. The SDS is responsible for the operational readiness of the TMR dive equipment and supporting assets. The SDS will supervise a designated diving equipment maintenance technician. The diving equipment maintenance technician and other personnel needed to support program readiness will be approved by the Chairman and TMR management team as needed and are not permanent staff members. The SDS provides supervision of the TMR divers and makes recommendations for dive staff assignments. The SDS is the subject matter expert for development of new diving procedures, technology, and capabilities.

6.5 Senior UXO Supervisor

A senior UXO supervisor (SUXOS) will be designated, in writing by the TMR field operations management team to projects that have both a UXO removal/investigation requirement and a diving requirement. The SUXOS will coordinate all ordnance response requirements and establish safe proceduresfor the investigation and removal of all UXO hazards.

On larger operations involving both diving and UXO operations, the DS will normally supervise diving, and the SUXOS will oversee the UXO response. The same person can serve as SUXOS and DS,if that person has both qualifications on smaller projects. The SUXOS shall be a qualifiedTMR environmental safety supervisor person in accordance with the guidelines outlined in Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP) 18, Reference (e).

6.6 Diving Supervisor/ Lead Diver

The diving supervisor (DS) will be designated in writing as the Designated Person in Charge (DPIC) for each diving operation. This designation is based on knowledge, experience, and level of training. The DS is the DPIC of the overall diving operation and is responsible for the planning and execution of the dive, as well as the safety and health of the dive team. The DS will be a qualified TMRqualified SUXOS. In carrying out these duties, their responsibilities will include, but will not be limited to:

- Ensuring that all dive team members who are exposed to, or control the exposure of others to, hyperbaric conditions will be trained in diving-related physics and physiology.
- Ensuring that each dive team member will be assigned tasks in accordance with the employee's experience or training. Limited additional tasks may be assigned

to an employee undergoing training, provided that these tasks are performed under the direct supervision of an experienced dive team member.

- Ensuring that a dive team member will not be required to be exposed to hyperbaric conditions against the employee's will, except when necessary to complete decompression or treatment procedures.
- Ensuring that a dive team member will not be permitted to dive or otherwise be exposed to hyperbaric conditions for the duration of any physical impairment or condition which is known and is likely to adversely affect the safety or health of a dive team member.
- Investigating and evaluating each incident of decompression sickness based on the recorded information, consideration of the past performance of decompression table used, and individual susceptibility.
- Taking appropriate corrective action to reduce the probability of or recurrence of decompression sickness.
- Preparing a written evaluation of the decompression procedure assessment, including any corrective action taken, within 10 days of the incident of decompression sickness.
- Being fully aware of all relevant governmental regulatory agency regulations that apply to the diving operation and the diving mode employed.
- Being in immediate control and available to implement emergency procedures during diving operations. The dive supervisor/lead diver is not permitted to dive unless another qualified person is present and has been formally appointed and designated to assume this responsibility.
- Ensuring, prior to diving, that all additional parties are informed that diving operations are about to be undertaken. These parties include, but are not limited to, craft masters, boat pilots, harbormasters, managers of pipelines, and managers for civil engineering sites and inland waterways.
- Ensuring that diving operations are conducted from a suitable and safe location on the surface.
- Establishing a project specific DOP, and ensuring that sufficient air supply, supplies, and proper equipment are available for the safe and timely completion of the job task. This must be approved by the TMR DRB prior to conducting any diving evolution.
- Briefing the dive team as to the plan of attack, and soliciting suggestions outlined in Attachment 1, Diving Supervisor Dive Plan Brief, native file format located in the Guidelines Templates and Tools folder in the Corporate Reference Library (CRL). During the briefing, they will make team assignments, designate required equipment, review diving signals, establish a positive diver recall method, and cover emergency procedures.
- Using the TMR Diving Supervisor Pre-Dive and Post-Dive Checklists (see Attachments 2, Diving Supervisor/Lead Diver Pre-Dive Checklist, and 3, Diving Supervisor/Lead Diver Post-Dive Checklist, which are also available in the native file format located in the Guidelines Templates and Tools folder in the CRL

- Ensuring all members of the diving team are familiar with the emergency procedures contained in the Emergency Procedures (see Attachment 4, which is available in the native file format located in the Guidelines Templates and Tools folder in the CRL).
- Being aware of the procedures to follow and the routes to take to obtain medical support in the event of an accident, either diving- or non-diving-related.
- Ensuring that a two-way communication system is available and tested.
- Ensuring that the Emergency Phone Numbers Checklist (see Attachment 5, which is available in the native file format located in the Guidelines Templates and Tools folder in the CRL) is completed and posted at the dive site.
- Determining the qualifications and proficiency of all personnel and ensuring that no dives are made by unqualified persons.
- Verifying that all equipment required is on scene and in working order.
- Ensuring that all relevant operating instructions, manuals, decompression schedules, treatment tables, and regulatory publications are available on the dive site.
- Maintaining a dive profile log for each diver, which includes depth, bottom time, and residual nitrogen time (see Attachments 6 and 7, which are also available in the CRL).
- Terminating diving operations at any time when, in their opinion, safe diving procedures are not being followed or conditions prevent safeguarding the divers. The diving supervisor/lead diver will not resume diving operations until the unsafe conditions have been removed or corrected.
- Ensuring that, after every dive, the Post-Dive Checklists in Attachment 3, which is available in the native file format located in the Guidelines Templates and Tools folder in the CRL, are used.
- Ensuring that, after any treatment or unplanned dive conducted outside the no-decompression limits, the diver is instructed to stay awake and remain in the vicinity of the chamber for at least 1 hour.
- Reporting all accidents or incidents involving personnel as required by TMR procedures and relevant governmental regulations.
- Ensuring all reports and paperwork are completed and submitted at the end of the diving day.
- Maintaining certification in cardiopulmonary resuscitation (CPR), first aid (American Red Cross or equivalent), automated external defibrillator (AED), and emergency oxygen administration.

6.7 Divers and Snorkelers

Divers must be at least 18 years of age, be medically certified as "fit to dive," this statement must be in writing by a qualified physician on the diver’s final medical clearance cover sheet. They must have a knowledge of diving theory, diving-related physics, and physiology. They will provide copies of their certifications to the DRB before being allowed to dive. On divingprojects involving UXO operations, the minimum age of the diver must be 21 years, they must be cleared by the Bureau of Alcohol, Tobacco, Firearms and Explosives per regulation concerning the handling of explosives.

Divers must have a full understanding of the diving equipment in use, and of the tasks assigned. A diver is assigned by the DS to perform specific tasksunderwater and topside. The diver must be qualified for the diving technique, equipment selected, and the task assigned. Each diver will meet the following requirements:

- Know how to use the tools, equipment, and systems relevant to assigned tasks.
- Know the techniques of the assigned diving mode.
- Accomplish all tasks assigned by the DS. If the diver is assigned a task for which they do not consider themselves to be qualified either by training or experience, the diver will immediately inform the DS.
- Read, understand, and comply with all TMR policies and with applicable government regulations as they relate to their qualifications or performance while engaged in diving.
- Maintain a high level of physical fitness.
- Immediately obey all commands or instructions from the DS return to the surface, or first decompression stop, as appropriate.
- Keep topside personnel advised of conditions on the bottom.
- Be responsible for the diving gear worn and ensure that it is complete, in good repair, and ready for use at any time in accordance with regulations or instructions concerning its use, maintenance, repair, and testing.
- Report to the DS any defect or malfunction of the diving equipment provided for the diving operation.
- Ensure the deepest depth of the dive has been established before ascent.
- Report to the DS any recent medical treatment or illness so that the proper determination can be made concerning the diver's fitness to dive.
- Immediately report all symptoms or suspected symptoms of decompression sickness as early and accurately as possible.
- Always follow safe diving practices during the diving operation, whether topside or in the water. The diver will bring any questionable items to the attention of the DS diver and will be alert for the safety of all.
- Remain awake and in the vicinity of the decompression chamber for at least one hour following recompression treatment or a hyperbaric exposure beyond no-decompression limits.
- Know and observe the rules for ascending to altitude, including flying after diving.
- Ensure that their diving equipment has been properly maintained, prepared, and tested before each dive. This requirement should never be delegated to others.
- Maintain a divers' logbook, which details all dives, medical examinations, courses taken, and personal equipment maintenance.

- Ensure their medical certificates are up to date and recorded in the diving logbooks. Divers will present their logbooks to the diving supervisor/lead diver at every job when requested.
- Ensure that they are not exposed to hyperbaric conditions against their will, except when necessary to complete decompression or treatment procedures.
- Maintain certification and demonstrate hands on proficiency in CPR, First Aid, AED, and emergency oxygen administration as outlined in the regulatory guidelines.

A diver may refuse to dive, without fear of penalty, whenever they feel it is unsafe for them to make the dive. It is the diver's responsibility and duty to refuse to dive if, in their judgment, conditions are unsafe or unfavorable, or if they would be violating the precepts of their training, abilities or the regulations and guidelines in this manual or the project DSPM.

6.8 Standby Diver

The standby diver is a fully qualified diver, assigned as a safety contingency to provide emergency assistance, and is ready to enter the water when conducting diving operations. When assigned during buddy diving, where two divers are conductingthe dive together, they will be ready to enter the water prior to commencing the dive, and then may remove tank, mask, and fins at the DS's discretion.Under no circumstances will they leave the dive site. The standby diver receives the same briefings and instructions as the working divers, wears the same diving equipment,monitors the progress of the dive, and is fully prepared to respond if called upon for assistance. While acting as a standby diver, **in addition to** the requirements listed above,the standby diver will:

- Be rested and fully capable of performing emergency rescue assistance.
- Be sufficiently free of residual nitrogen to allow for enough bottom time for the prescribed task at the working depth without exceeding the no-decompression limits for that depth.
- Be dressed appropriately to allow prompt entry into the water as directed by the DS.
- Remain at their station throughout the entire dive.
- Refuse any tasks that might interfere with their duties as a standby diver whenever there is a diver in the water.

6.9 Dive Tender

The tender is a member of the dive team who works most closely with the diver on the bottom. Though it is preferred that the tender be a qualified diver, it is not mandatory. If the tender is not a qualified diver, they must be familiar with line pull signals and all emergency procedures. The tender is assigned by the DS to continuously tend (monitor) the diver. There may be multiple tenders assigned to a diving station. They will devote their full attention to tending the diver or station they are assigned to, from preparation of the dive through its completion. They will not be assigned any other task while the diver is in the water. The tender shall further:

- Assist the diver in dressing and undressing and confirm that the diver's equipment is functioning properly.
- Always tend the diver's safety line and be aware of the diver's depth and location.
- Set up and operate all equipment as directed by the DS.
- Immediately inform the DS if they are assigned a task for which they do not consider themselves qualified either by training or experience.
- Be alert and immediately report any conditions that are hazardous or unsafe.
- Assist in topside work as required or directed.
- Maintain certification in CPR, first aid, AED, and emergency oxygen administration.

  Maintain certification and demonstrate hands on proficiency in CPR, First Aid, AED, and emergency oxygen administration.

7.0 DIVING POLICY

It is the policy of TMR to consistently provide safe diving operations that meet the client's required level of work and that are following applicable laws and regulations. This work shall be consistent with the project-defined scope, schedule, budget, and level of quality. To accomplish this objective, TMR will provide the appropriate qualified personnel, resources, and guidance to the Operating Units where diving operations are required. Such resources may include specialized diver expertise that may be in another office, or corporate affiliate, or maybe subcontracted to an appropriate subcontractor.

This DSPM addresses procedures for the safe utilization of self-contained underwater breathing apparatus (SCUBA) and surface-supplied air (SSA) diving operations. Surface air delivery system (SADS) operations are covered under TMR SCUBA procedures. Mixed-gas diving is not authorized for employees of TMR covered under these procedures. All dives will be planned to adhere to the Standard Air, No Decompression, or Shallow Water dive tables set forth in the USN Diving Manual, refer to Attachment 10, available in the Guidelines Templates and Tools folder in the CRL.

The individual local or state requirements will be reviewed and incorporated into the project specific DOP. This review will be performed prior to commencing any diving operations within the affected state. Prior to diving, the project specific DOP must be approved by the Chairman of the TMR DRB for UXO and construction diving or the Tetra Tech scientific DSO for scientific diving, with the approved copy forwarded to and retained by the TMR Chairman of the DRB.

8.0 SCIENTIFIC DIVING

Scientific diving will be conducted in accordance with Tetra Tech Corporate Safety DCN 02-15 Scientific Diving Program[1] in the Corporate Health and Safety Manual. If scientific diving operations are conducted using TMR diving systems and oversight by a TMR DS

[1] https://tetratechinc.sharepoint.com/:b:/r/sites/Health-Safety/Health%20%20Safety%20Manual/02_General%20Health%20and%20Safety%20Programs/DCN%2002-15%20Scientific%20Diving%20Program.pdf

is required (e.g., UXO escort operations) or tasking involves intrusive diving operations in a UXO environment, the procedures outlined in this manual, project specific DOP and applicable underwater UXO standard operating procedures will be followed.

9.0 REQUIREMENTS FOR DIVING AND SNORKELING

9.1 General Requirements

The requirements presented in this section will be used in conjunction with procedures and requirements for individual dive techniques presented in the following sections of the DSPM. All dives will be executed under the regulations and guidelines outlined in Section 2.0.

- The qualifications of personnel and equipment requirements for snorkeling are the same as diving, except for the required air supply for diving.
- A ladder extending a minimum of 3 feet below the diving platform below the surface of the water and appropriate handrails will be provided to assist the diver on entry and exit from the water. (*Note: Inflatable boats are exempt from this requirement.*)
- A means will be provided to assist an injured diver from the water.
- When diving from vessels, the international code alpha and recreational dive flag with a minimum dimension of 23 square inches will be displayed whenever diving operations are being conducted. The flag will not be removed until diving operations have been completed and all divers are safely out of the water. TMR divers will comply with all site-specific local, state, federal, and international regulations regarding marking of diving activities.
- For enclosed areas, i.e., Intracoastal Waterway or marinas, individual buoys with recreational diver flags will mark the outline of the diving area. The divers may have a "marker" buoy with the recreational dive flag to determine their exact location. A rigid replica of the International Code Alpha flag at least 1 meter in height and visible from all directions will be displayed at the dive location.
- A diver will be stationed at the underwater point of entry when diving is conducted in enclosed or physically confining spaces.
- Positive communications to the recompression facility, the designated medical facility, and any required transportation to these facilities (medivac, ambulance, etc.) will be checked daily. This communication will include cellular telephone or radio communications with a constantly manned location with telephone access at the dive site. Diving operations will not be conducted without established communications.
- The DS will not be permitted to dive unless another qualified supervisor is present and has assumed the DS roles and responsibilities.

9.2 Snorkeling Requirements

TMR employees engaged in snorkeling operations will comply with the general requirements for diving and the following additional requirements, unless otherwise specified in a project specific and approved DOP:

- Snorkeling will be conducted only with prior approval and acceptance of the district diving coordinator (DDC) and/or the TMR DSO.
- Snorkeling will be allowed only for shallow water site assessments and reconnaissance. It will not be used for structural inspections or other work.
- An on-site snorkeling team shall be made up of no less than two persons: snorkeler and observer/assistant. Additional site personnel may be required by the DDC or DSO based on site hazards and conditions. Snorkeling team plans and procedures shall be developed and enacted by a team supervisor who is qualified and experienced in snorkeling and incorporated in the DOP.
- Snorkeling will only be done on the surface of the water. Breath-hold or free diving of any kind is not permitted.
- Generally, untethered snorkeling will NOT be allowed in waters deeper than 5 feet of seawater (FSW), in bodies of water that a snorkeler cannot wade across, or anywhere a differential in pressure threat may exist.
- Snorkeling in open waters greater than 5 feet deep may be allowed by the DDC, based on an acceptable Activity Hazard Analysis (AHA) and compliance with the following:
  - Any requirements incorporated in the approved DOP.
  - A single snorkeler shall be tethered with a harness and a maximum of 40 FSW of floating line. The tether must be constantly tended from the shore or boat.
  - The snorkeler must wear a device providing a minimum of 15.5 pounds of positive buoyancy (Type III personal flotation device [PFD], fully inflated snorkeling vest, etc.).
  - There are no potential tether entanglement hazards in the snorkeling area (e.g., overhanging branches, surface stumps, rocks, etc.).
- All snorkelers and observers/assistants will be certified as skin divers (snorkelers) or open water divers by a nationally recognized organization (e.g., Professional Association of Diving Instructors, National Association of Underwater Instructors, etc.) or the U.S. Forest Service Snorkel Safety Program.
- An observer/assistant will always accompany each untethered snorkeler either along the shore or in a boat and be within 50 feet of the snorkeler.
- Two untethered snorkelers in the same body of water may act as observer/assistant for each other if they remain within 50 feet of each other.
- Non-snorkeling observer/assistants shall wear a PFD and be equipped with a throw bag and/or ring buoy with at least 70 FSW of line and must be capable of performing a rescue on the specific snorkeler(s) in an emergency.
- Areas of extreme water velocity and turbulence will be avoided, especially those immediately upstream from debris jams or bedrock outcrops.
- Snorkelers will be provided with appropriate thermal protection.
- Employees will be determined medically fit by a licensed physician (doctor of osteopathy or medical doctor) prior to snorkeling. This certification shall be signed by a physician familiar with sports medicine, and state that each snorkeler is

physically and medically fit to perform snorkeling activities according to commonly accepted sports medicine guidelines.

- All snorkeling team members shall be certified in first aid and CPR. Certification shall be in accordance with most recent emergency cardiovascular care guidelines, and/or American Heart Association or American Red Cross standards.
- A first aid kit will be available at each location where snorkeling is being performed. A means of securely transporting an unconscious person, such as a litter or stretcher, shall be provided when snorkeling is conducted in areas inaccessible to vehicles or boats.
- A means of communication capable of contacting emergency services must be available at locations where snorkeling is performed.
- Each snorkeler will be equipped with a professional grade mask, fins, snorkel, and snorkeling vest.
- A snorkeling protocol will be developed and included in the project DOP. It will contain as a minimum, the following:
  - An AHA for each specific snorkeling mission (Particular detail will be given to currents and other environmental considerations.)
- Records for snorkeling activities will be maintained and will include as a minimum:
  - Snorkeler's annual physician certifications
  - AHAs
  - A snorkeling plan incorporated in the DOP that is based on the requirements of USACE EM 385-1-1; Section 30.A.15.a-e
- Snorkelers will wear apparel which provides appropriate protection from environmental conditions. The apparel must include fins or other appropriate foot protection.

9.3 SCUBA / SADS Diving Requirements

TMR employees engaged in SCUBA diving operations will comply with the general requirements for diving and the following additional requirements, unless otherwise specified in a project specific and approved DOP:

- The minimum sized SCUBA tank allowed as primary air is a standard 80 cubic-foot aluminum tank pressurized to at least 90 percent, or 2,700 pounds per square inch (PSI) at the beginning of dive operations.
- Divers shall terminate their dive so that they reach the surface with a minimum tank pressure of 500 PSI.
- Audio communications are preferred in all diving situations. However, this type of communication is not required for a diver who is accompanied by another diver (buddy), or who can communicate with the tender on the surface via a safety line using line pull signals.
- The planned time of such a diving operation will not exceed the no decompression limits according to the USN Dive Manual, or the air supply duration of the cylinders in use, exclusive of the reserve supply. The cylinder pressure will be determined immediately before each dive.

- Each diver will be equipped with a knife, a diving wristwatch, a depth gauge or dive computer, a facemask, a submersible cylinder pressure gauge, and a buoyancy compensator.
- A weight belt or integrated weight system with a quick release that is appropriate for the suit and the depth of the dive will be worn.
- A cylinder harness with a quick release will be worn to secure the SCUBA cylinders to the diver.
- The weight belt and cylinder harness will be independently attached to permit release of either one without interference by the other.
- A personal flotation or buoyancy compensation device will be worn. An exception will be considered during approval of the DOP for diving in enclosed spaces or under the ice.
- SCUBA diving operations will not be conducted at depths deeper than 100 feet.
- DSO or DDC exemption approval is required for dives to any depths from 100 feet to 130 feet, and if approved, a recompression chamber must be available on site and within 5 minutes of reaching the surface.
- During all SCUBA dives, a standby diver will be available while a diver is in the water.
- A SCUBA diver will be line-tended from the surface or accompanied by another diver in the water in continuous visual contact during the diving operations. If any SCUBA diver is tended, they will wear a harness meeting the following standard:
  - Each tethered SCUBA diver shall wear a safety harness with a positive buckling device, attachment point for the safety line, and a lifting point to distribute the pull force of the line over the diver's body while maintaining the body in a heads-up vertical position when unconscious.
- A diver-carried independent reserve breathing gas supply consisting of the following will be provided for each diver:
  - Each diver shall be equipped with a minimum 30 cubic-foot bailout bottle for emergency use pressurized to at least 90 percent of its working PSI rating and equipped with a separate first- and second-stage regulator. An "octopus" is not considered to be an alternate air source.

SADS – This system is a configuration of the SCUBA diving system. It is used for very shallow water operations performed in water **not to exceed 3 feet**. The SCUBA diving requirements listed above are applicable for all SADS diving operations.

9.4 Surface-Supplied Air Diving Requirements

Employees engaged in SSA diving will comply with the general requirements for diving, and the following additional requirements, unless otherwise specified in a project specific and approved DOP:

- The approximate depth of each dive will be determined prior to the start of operations.
- A weight belt appropriate for the suit and depth of the dive will be worn, except when conditions dictate otherwise for the safety of the diver.

- A five-point safety harness, with a positive buckling device, will be worn under all other types of equipment (*except when diver is dressed in heavy gear*). This harness will have an attachment point for the umbilical to distribute the weight of the diver's body and prevent any strain from being placed on the diver's mask or helmet if/when the umbilical is pulled on. The safety harness will also have a lifting point to distribute the pull force of the line over the diver's body. The safety harness may be equipped with a backpack to contain a bailout bottle.
- SSA dives will not exceed 190 FSW and will not enter exceptional exposure dives as set forth in the USN standard air decompression tables.
- A decompression chamber will be ready for use on site for any dive outside the no-decompression limits or deeper than 100 FSW.
- Each diver will be continuously tended by another dive team member while dressed on the side and while in the water.
- A diver will be stationed at the underwater entry point when penetration diving is conducted in enclosed or physically confining spaces.
- A standby diver will be available while a diver is in the water.
- Each diver will have a primary air supply capable of supplying the diver(s) with the specified air volume, pressure, and flow rate, in accordance with the manufacturer's specifications associated with the diving apparatus worn, throughout the planned depth of the dive, including any required decompression.
- Each dive location air control systems (ACS) will have a reserve breathing air supply, in line, capable of supporting the dive operation.

  Each diver must have a reserve breathing supply available that can be turned on immediately by the diver in the event of loss of air. The reserve breathing air supply shall be of sufficient capacity to recover the diver and complete emergency recompression (if required) in the event of loss of primary air but no less than 30 ft^3 (0.85 m^3). Heavy-gear diving is exempted from these provisions because the gear carries its own reserve.
- On all dives deeper than 100 FSW or outside the no-decompression limits, an extra breathing gas hose capable of supplying gas to the diver in the water will be available to the standby diver.
- On all dives deeper than 100 FSW or outside the no-decompression limits, an in-water stage will be provided.

10.0 DIVER TRAINING AND QUALIFICATIONS

The following section describes the minimum requirements for TMR divers. Additional training may be needed for site-specific conditions, or as required under federal, state, or local regulations.

The level of experience or training required by the standard depends on the job the employees are required to do. All dive team members must have either experience or training in the use of tools, equipment, systems, techniques, operations, operational procedures, and emergency procedures that are pertinent to, and necessary for, the assigned tasks for the diving mode.

It is essential that those dive team members who are exposed to hyperbaric conditions, or those members who control the exposure of others, have knowledge of the physiological effects of diving and the related effects of pressure. Accordingly, this standard also requires that employees be trained in diving-related physics and physiology. Employee qualifications achieved through field experience and classroom training may be used to meet the requirements of the standard.

- Divers must have federal training certificates (USACE, NOAA, and/or military diving schools) or civilian diving school certificates of completion for the appropriate training level issued by any ANSI/ACDE accredited schools.
- Each dive team member must be trained and demonstrate hands on proficiency in CPR (American Red Cross orequivalent), first aid, AED, and emergency oxygen administration.
- Each member of the TMR diving team will be qualified to conduct the work assigned by completion of training and/or experience. This qualification will be documented by completion of a certified course of instruction, to include one or more of the following: a certified commercial course (Association of Commercial Diving Educators accredited), a civilian certification with experience for the profile of the dive, or a documented military diver training and experience.
- All divers will maintain a personal dive log that will document all hyperbaric exposures. Additionally, dates of diving physicals and a record of all relevant training will accompany the log. The following minimum information should be included in the log:
  - Location of exposure
  - Maximum depth
  - Time left surface, total bottom time, and time reached surface
  - Type of breathing apparatus and mixture used
  - Task performed
  - Decompression table and schedule used
  - Any decompression sickness symptoms or injury
  - Signature of the DS
  - Comments

10.1 Entry Level Tender Training

All TMR non-divers who have the required skills and training to participate in diving-related activities must be trained and certified by qualified TMR diving personnel or an internationally recognized agency.

10.2 SCUBA Training

All TMR divers will provide a copy of their diver certification to the Chairman of the DRB that represents successful completion of a swimming evaluation, practical diver training, written examination, and open water evaluation. Scientific divers will also provide a copy of their diver certification to the DRB. The certificate from the training activity will be used to document the location and date of training. The dive log will document the depth and number of diving qualification dives.

10.3 Surface-Supplied Diver Training

The training certificate to document previous training and dive log to document the number of dives and depth of diving qualifications will be provided. Training dives will be required to ensure all divers are current in the type of equipment and the depth expected of the diving project.

11.0 PERSONNEL REQUIREMENTS

In establishing the number of dive team members required for a dive, proper consideration must be given to 29 CFR 1910.421(d), Planning and Assessment, and 29 CFR 1910.421(e), Hazardous Activities. The second provision requires employers to provide a means to assist an injured diver from the water, such as a small boat or stokes basket, which may necessitate additional dive team members.

11.1 Self-Contained Underwater Breathing Apparatus (SCUBA)

For diving that requiring the use of SCUBA and SADS, the minimum number of divers are required for the work:

Dive Team Composition SCUBA – Untethered, 0 to 100 FSW	
Personnel	**Number**
Diving Supervisor	1
Divers (in visual contact)	2
Standby Diver*	1
TOTAL TEAM	**4**

Dive Team Composition SCUBA – Tethered with communications, 0 to 100 FSW	
Personnel	**Number**
Diving Supervisor **	1
Diver in water	1
Standby Diver* (tethered with communications)	1
Tender	1
TOTAL TEAM	**4**

** The standby diver will be rested and capable of performing emergency rescue assistance. When work is limited to no decompression limits, the standby diver shall be sufficiently free of residual nitrogen to allow for 25 minutes of bottom time at the working depth without exceeding "No Decompression Limits."*

*** The supervisor may be the standby tender for dives under 100 FSW.*

11.2 Surface-Supplied Diving (0-100 FSW with no Decompression Diving)

For surface-supplied diving, from 0 to 100 FSW, the minimum number of divers required to perform the work is listed below:

Dive Team Composition Surface Supplied Air – 0 to 100 FSW Within No Decompression Limits		
Personnel	**Number**	**Penetration Dive**
Diving Supervisor *	1	1
Diver	1	2
Standby Diver**	1	1
Tender	1	2
TOTAL TEAM	**4**	**6**

** The supervisor may be the standby tender for dives under 100 FSW.*

*** The standby diver will be rested and capable of performing emergency rescue assistance. When work is limited to no-decompression limits, the standby diver shall be sufficiently free of residual nitrogen to allow for 25 minutes of bottom time at the working depth without exceeding "No Decompression Limits."*

11.2.1 Deploying the Standby Diver as a Worker Diver

The standby diver may be deployed as a working diver provided **all** the following conditions are met:

1) Surface-supplied no-decompression dive of 60 FSW or less;
2) Divers are in proximity, (based on site specific requirements), with unimpeded access to each other;
3) Divers always have communications with each other;
4) No entanglement hazards exist;
5) Prior to deploying the standby diver, the work area shall be determined to be free of hazards (i.e., suctions, discharges) by the first diver on the job site;
6) The dive is NOT a penetration or confined space dive; and
7) Each diver has a full-time tender (which brings the minimum number of team members to five).

11.3 Surface-Supplied Diving (Deeper than 100 FSW or decompression diving)

For surface-supplied diving deeper than 100 FSW, or decompression diving, the minimum number of divers required to perform the work is listed below:

Dive Team Composition Surface Supplied Air – 0 to 100 FSW Requiring Decompression All Surface Supplied Air, 101 to 190 FSW			
Personnel	**No Decompression Dives**	**Decompression Dives**	**Penetration Dives**
Diving Supervisor	1	1	1
Chamber Operator*	1**	1***	1
Diver	1	1	2
Standby Diver**	1	1	1
Tender	1	1	2
Standby Diver Tender	1	1	1
TOTAL TEAM	**5/6**	**5/6**	**8**

** The Competent Person/chamber operator may be any non-diving member of the dive team when the chamber is only for emergency use when diving within the no-decompression limits. Saturation diving requires that a life support technician will serve as the chamber operator.*

*** The standby diver will be rested and capable of performing emergency rescue assistance. When work is limited to no-decompression limits, the standby diver shall be sufficiently free of residual nitrogen to allow for 25 minutes of bottom time at the working depth without exceeding "No Decompression Limits."*

**** The Competent Person/chamber operator may be any non-diving member of the dive team if all diving ceases during chamber decompression.*

11.4 Other Diving Operations

Additional dive crew members may be required for any diving operations involving an increased likelihood of diver entrapment or the potential for rendering the diver unconscious or incapacitated from chemical, physical, electrical, or topside hazards. These operations include, but are not limited to:

- Diving on ordnance and/or explosives projects
- Diving from a small boat
- Diving in remote areas where assistance from non-diving crew personnel is not immediately available, but within communication range
- Penetration diving, both horizontal and vertical
- Diving requiring crane operations
- Diving in any situation where the diver uses surface-tended equipment
- Diving from a platform greater than 8 feet above the water surface

12.0 MEDICAL REQUIREMENTS

Each diver will receive a diving physical examination initially when assigned diving duties and yearly thereafter. In addition, a medical examination will be conducted whenever a diver has been hospitalized for more than 24 hours due to an injury or illness. A determination as to their fitness to continue to dive will be prepared by the examining physician. The physician will prepare a written report containing the following statement: “Based on the following, I certify the diver as ‘Fit to Dive’.” In addition, the report will contain the following information:

- Medical requirements of this standard and a summary of the nature and extent of hyperbaric exposure to which the diver will be exposed, including diving modes and types of work to be assigned (TMR will provide the dive information).
- The diver’s medical history (a diver’s Medical History and Supplemental Diving Questionnaire, available in the CRL), which will be filled out completely and will be provided to the examining physician.
- The results of the medical examination. A basic diving physical examination will be conducted initially and annually for all TMR divers, which will include a chest X-ray, vision testing, audiogram, pulmonary function test, blood chemistry panel, complete blood count with differential, urinalysis with microscopic analysis (U.S.), and any additional tests required by the examining physician. An electrocardiogram will be performed. An exercise stress test may be indicated based on a risk factor assessment performed by the doctor.
- The examining physician’s opinion of the employee’s fitness to be exposed to hyperbaric conditions, including any recommendations or limitations to such exposure. TMR will provide the employee with a copy of the physician’s written report.

Determination of the employee’s fitness to dive will be based on the physician’s written report and review by the DRB. If the physician has recommended a restriction or limitation on the employee’s exposure to hyperbaric conditions, and the employee does not agree with the physician’s findings, the employee has the right to obtain his own diving-certified physician to perform a diving physical. If the second physician does not agree with the findings of the first physician, a third physician will be consulted for resolution.

13.0 EQUIPMENT CONSIDERATIONS

The DS, in conjunction with the DRB, will establish the equipment requirements for individual projects. This list will be included in the DOP and will includethe required dive gear, boat equipment, and any required task-specific equipment. This list should be submitted to the project manager when the DOP has been approved. Each equipment modification, repair, test, calibration, or maintenance service that is required will be recorded by means of a tagging or logging system. This system will includethe date, serial number of the item, nature of the work performed, and the initials of the person who conducted the work.

13.1 Equipment Maintenance

Typically, TMR underwater operations use a variety of diving systems and component equipment. Dive equipment is considered life support equipment and should be treated as such.

- All equipment will be maintained in accordance with the directives set forth by OSHA and the Manufacturer's Specifications.
- Any maintenance performed on equipment will be logged on the maintenance form and forwarded to the diving systems equipment manager for entry into the equipment maintenance log.
- DS shall have the required expertise to maintain the systems used by TMR.
- Dive Team Members shall treat all equipment in a responsible manner and immediately inform the DS of any potential equipment problems that they may observe.
- Bi-annual air quality tests will be performed on all breathing air compressors, and the results kept on file by the Chairman of the DRB.
- Equipment requiring periodic calibrations shall be sent to their respective manufacturers or licensed professionals for proper maintenance and calibration. The DS shall inform the diving systems equipment manager of any equipment taken offline.

Using the information provided by the diving systems equipment manager, the TMR equipment manager will manage, and report equipment concerns in accordance with TMR Procedure PO-18, Warehouse Management.

13.2 Air Supply Requirements

Air used in diving operations will be procured from a facility where the compressors meet the requirements established in Compressed Gas Association Pamphlet G-7.1 or more stringent standards. The tanks will be filled with compressed air from a source that complies with, at a minimum, 29 CFR 1910.430 (equipment). The breathable air supplied to the diver will be tested every 6 months and will not contain:

- A level of carbon monoxide greater than 10 parts per million (ppm)
- A level of carbon dioxide greater than 1,000 ppm
- A level of oil mist greater than 5 milligrams per cubic meter
- A level of hydrocarbons, other than methane, greater than 25 ppm
- Noxious or pronounced odor

A copy of the latest air test results will be reviewed and/or obtained and filed with the diving systems maintenance log and associated project DOP. When using local established vendors, a check of current certification is requiredevery 6 months. If air test results are not available, TMR will draw an air sample from thecompressor for appropriate analyses prior to using air from this source.

13.3 Regulators

The dive equipment maintenance manager will be responsible for inspecting and scheduling maintenance on their regulators prior to the first use and every 12 months thereafter. Documentation of the inspections and maintenance will be maintained in the TMR diving systems maintenance log and associated system files.

13.4 Compressed Air Cylinders

Compressed breathing air cylinders will:

- Be constructed with seamless steel or aluminum that meets U.S. Department of Transportation (DOT) 3AA and DOT 3AL specifications.
- Have identification symbols stamped into the shoulder of the cylinder.
- Be inspected internally and externally for corrosion and pitting on an annual basis. If a defect is found that may impair the safety of the pressure vessel, a hydrostatic test must be performed.
- Be hydrostatically tested every fifth year in accordance with DOT regulations. The test dates will be stamped into the shoulder of each cylinder. Documentation of each cylinder inspection will be maintained in the TMR diving files.
- Be stored in a ventilated area and protected from excessive heat.
- Be secured from falling.
- Have shutoff valves recessed into the cylinder or protected by a cap, except when in use, when installed with a manifold, or when used for SCUBA diving.

13.5 Air Compressor Systems

Air compressors used to supply air to the diver will:

- Be equipped with a volume tank that has a check valve on the inlet side, a pressure gauge, a relief valve, and a drain valve.
- Have intakes located away from areas where exhaust fumes or other air contaminants may be present.
- Be tested every 6 months by means of samples taken at the connection to the distribution system to ensure that the air supplied meets all applicable standards (see Section 3.6.1, above). Non-oil lubricated compressors do not have to be tested for oil mist.
- Be equipped with a moisture separator and filtration system.

A log shall be maintained showing all tests, repairs, maintenance, and run time on all air compressors systems.

13.6 Surface Supplied Air

The diver's surface-supplied air supply may originate from an air compressor, a bank of high-pressure air flasks, or a combination of both. Regardless of the source, the air must:

- Meet the purity standards stated above;
- Be supplied in an adequate volume for breathing;

- Have a rate of flow that properly ventilates the helmet or mask; and
- Be provided at enough pressure to overcome the bottom water pressure and the pressure losses due to flow through the diving hose, fittings, and valves.

The air supply requirements depend on specific factors for each dive, such as depth, duration, level of work, number of divers being supported, and type of diving system being used.

The capacity of the primary air supply must meet the consumption rate for the designated number of divers for the full duration of the dive (bottom time plus decompression time). The maximum depth of the dive, the number of divers, and the equipment to be used must be considered when sizing the supply.

The secondary air supply must be sized to support recovery of all divers using the equipment and dive profile of the primary supply, if the primary supply malfunctions or fails at the worst-case time (i.e., immediately prior to completion of planned bottom time of maximum dive depth, when decompression obligation is greatest).

13.6.1 Breathing Gas Supply Hoses

Breathing gas supply hoses will:

- Have a working pressure at least equal to the pressure of the total breathing gas system;
- Have a rated bursting pressure at least 4 times the working pressure;
- Be tested annually (at a minimum) to 1.5 times their working pressure;
- Have their ends taped, capped or plugged when not in use;
- Have connections made of corrosion resistant material, and be resistant to accidental disengagement; and
- Have connectors with a working pressure at least equal to the hose to which they are attached.

13.6.2 Divers' Air Supply Hoses

Umbilical's will:

- Be marked (starting from the diver's end) at 10-foot increments for the first 100 feet; and 50-foot increments thereafter;
- Be made of kink-resistant material;
- Have a working pressure greater than the pressure equivalent of the maximum depth of the dive plus 100 PSI.

13.7 Gauges and Timekeeping Devices

The following requirements apply to each diver's gauge or timekeeping device:

- Each depth gauge will be deadweight tested or calibrated against a master reference gauge every 6 months, and when there is a discrepancy greater than 2 percent of full scale between any two equivalent gauges.

- A cylinder pressure gauge that is capable of being monitored by the diver during the dive will be worn by each SCUBA diver and surface-supplied diver when equipped with a bailout bottle.
- Each SCUBA diver will wear a diving watch capable of displaying elapsed time.
- A timekeeping device will be available at each dive location.
- Dive computers will be approved for use after the review and approval of the DRB (see paragraph 13.10 below).

13.8 Buoyancy Control

The following requirements apply to each diver's buoyancy control device:

- A dry suit or buoyancy compensator not directly connected to the helmet or mask will be equipped with an exhaust valve.
- Helmets or masks directly connected to a dry suit or other buoyancy-changing device will be equipped with an exhaust valve.
- When used for SCUBA diving, a buoyancy compensator will have an inflation source separate from the breathing gas supply and a manual inflator hose.
- An inflatable flotation device capable of maintaining the diver at the surface in a face-up position, having a manual activated inflation source independent of the breathing gas supply, an oral inflation device, and an exhaust valve is required for SCUBA diving, except when diving in enclosed spaces or under the ice.

13.9 Masks and Helmets

The following requirements apply to each diver's mask or helmet:

- Surface-supplied masks/helmets will have a non-return valve at the attachment point between helmet or mask and hose that will close readily and positively. Masks/ helmets will also have an exhaust valve.
- Surface-supplied air masks and helmets will have a minimum ventilation rate capability of 4.5 actual cubic feet per minute at any depth at which they are operated, or they will have the capability of maintaining the diver's inspired carbon dioxide partial pressure below 0.02 atmosphere absolute (ATA) when the diver is producing carbon dioxide at the rate of 1.6 standard liters per minute.

13.10 Dive Computers

Dive computers that calculate decompression time based on time and depth are not to be used unless authorized by the DS and incorporated into the projectspecific DOP. They must be checked for accuracy prior to use.

13.11 Backpacks

Backpacks worn during diving operations without integrated flotation devices and weight systems must be equipped with a quick-release device.

13.12 Handheld Power Tools

Handheld power tools are not normally used during SCUBA diving operations, but, if used, they will be used in accordance with the following safeguards:

- Handheld power tools and equipment will be de-energized before being placed into or out of the water.
- Handheld power tools will not be supplied with power from the dive location until requested from the diver.
- Two-way voice communications between divers and topside must be used.

13.13 Dive Tables

Dive tables shall be made available to divers at all diving locations.

13.14 Welding/Cutting/Burning

Welding, cutting, and burning procedures are not addressed in this manual. When a diving project requires welding, cutting, or burning operations, those specific procedures will be addressed in the project specific DOP for that project.

13.15 First Aid/CPR/AED/Emergency Oxygen

A first aid kit, appropriate for diving operations, will be available at the dive site. This kit will contain a Divers Alert Network/ American Red Cross standard first aid handbook or equivalent, a bag-type resuscitator with transparent mask and tubing, and astokes litter or backboard with flotation capabilities.

Additionally, a portable source of emergency oxygen will be available at the dive site for transport of a diving-related casualty to the hyperbaric treatment facility. An AED will also be on site during all active diving operations.

13.16 Equipment Procedures Checklists

Pre-dive and post-dive checklists for both SSA and SCUBA operations will be used during setup and breakdown of the dive station.

14.0 RECORDKEEPING REQUIREMENTS

The following records are required by 29 CFR 1910.401, Subpart T, and will be maintained as follows:

- The TMR Chairman, via the DRB, will maintain all historical records.
- Records will also be retained in the project, office, or department files, in accordance with TMR Procedure PO-08 Document Control and Records Management.
- Records and documents will be maintained in accordance with 29 CFR 1910.401, Subpart T, and will be provided upon request to employees, designated representatives, and others as determined by TMR.

14.1 Dive Profile Log (Depth-Time Profile)

The TMR Dive Smooth Log (Attachment 7, which is available in the native file format located in the Guidelines Templates and Tools folder in the CRL) will be forwarded to the Chairman of the DRB and maintained for 1 year. If there has been a diving-related illness or injury on the project, the records will be maintained for a period of 5 years. After the 5-year time limit, the records will be forwarded to the National Institute for Occupational Safety and Health (NIOSH). The Tetra Tech scientific DSO will maintain copies for all scientific divers.

14.2 Diving-Related Injury Records

Any diving-related injury or illness, which requires any dive team member to be transported to a hospital for treatment related to any diving incident, will be reported to the safety and health manager (SHM) and documented by specifying the circumstances of the incident and extent of the injuries in the section provided in the Dive Profile Log.

The SSHO will subsequently report this accident/ incident to the TMR organization in accordance with procedure DCN 02-02, event reporting and investigation. The Dive Smooth Log and written Accident/Incident Report will then be forwarded to the designated SHM, and copied to the Chairman of the DRB. The Chairman will include the DiveProfile Log sheet in the TMR Dive Log, which is available in the native file format locatedin the Guidelines Templates and Tools folder in the CRL.

14.3 Recording of Dive

As stated above, a Dive Profile Log sheet will be completed for each dive, and, upon completion of the dive, will be forwarded to the Chairman of the DRB. The Chairman of the DRB will include the Dive Profile Log sheet in the TMR Dive Log, which will document all dives conducted by TMR personnel. The Diver's Medical History and Supplemental Diving Questionnaire must be completed for each diver before they commence diving.

14.4 Decompression Procedure Assessment Evaluation

In the event of a diving-related incident that requires treatment by recompression, the section of the Dive Profile Log sheet for Decompression Procedure Assessment Evaluation will be completed and forwarded to the Chairman of the DRB, who will include the log in the TMR Dive Log. The Dive Log will be maintained for a period of 5 years. The Chairman of the DRB or designee will conduct the accident investigation.

14.5 Equipment Inspections and Testing Records

The current log entry or tag for required equipment must be maintained until the equipment is removed from service.

14.6 Records of Hospitalization

All medical records generated by a hospitalization visit must be forwarded to the TMR Medical Provider.

14.7 Diver Medical Records

The Tetra Tech Corporate Safety Procedure DCN 3-02F, MS-2, Release of Medical and

Exposure Records[2] form is retained by TMR Human Resources Department. The Tetra Tech Corporate Safety Procedure DCN 3-02F, MS-1, Physician's Certification form[3] is retained by the Tetra Tech Medical Provider, and copies are maintained in project site files by the SSHO. All personal information protected by the Health Insurance Portability and Accountability Act is maintained by Tetra Tech's independent medical provider. Employee medical records will be handled in accordance with Tetra Tech Corporate Safety Procedure DCN 1-04, Recordkeeping and Reporting Requirements[4].

Diver qualification medical records that are signed by the TMR Medical Provider will be maintained for the duration of employment plus 30 years in accordance with 29 CFR 1910.1020(d).

14.8 Diving Safe Practices Manual

The current version of this DSPM is required to be maintained at the dive location.

14.9 Forwarding of Records

Employers are no longer required to notify and/or transfer records to NIOSH. OSHA's 29 CFR 1910.1020(h)(1) provides that whenever an employer is ceasing to do business, they must "transfer all records subject to this section to the successor employer. The successor employer shall receive and maintain these records.

14.10 Termination of Diving Operations

If TMR ceases to do business, the successor employer will receive and retain all dive and employee medical records required by 29 CFR 1910.1020(h)(2); The employer shall notify affected current employees of their rights of access to records at least three (3) months prior to the cessation of the employer's business

14.11 Training Records

Copies of each diver's successful completion of a military or federally accredited dive training or civilian accredited commercial dive training certification, and any other certificates of any specialized training (relevant to the job), will be forwarded to the Chairman, of the DRB via the DSO and kept on the project site. Additionally, any training conducted in preparation for the job will be documented and retained on site and copies forwarded to the Chairman of the DRB.

15.0 OPERATIONS PLANNING

This section provides guidance on effective dive planning for any size operation. The success of any diving operation is a direct outcome of careful, thorough planning. The site-

[2] https://tetratechinc.sharepoint.com/:b:/r/sites/Health-Safety/Health%20%20Safety%20Manual/03_Environmental%20and%20Remediation%20Operations/DCN%2003-02F%20MS-2%20Release%20of%20Medical%20and%20Exposure%20Records.pdf

[3] https://tetratechinc.sharepoint.com/:b:/r/sites/Health-Safety/Health%20%20Safety%20Manual/03_Environmental%20and%20Remediation%20Operations/DCN%2003-02F%20MS-1%20Physicians%20Certification%20Form.pdf

[4] https://tetratechinc.sharepoint.com/:b:/r/sites/Health-Safety/Health%20%20Safety%20Manual/01_Health%20and%20Safety%20Program%20Administration/DCN%2001-04%20Recordkeeping%20and%20Reporting%20Requirements.pdf

specific circumstances of each operation determine the scope of the planning effort, but certain considerations apply to every operation.

The DOP provides a basic outline of minimum required information to successfully planthe diving operation. A project specific DOP will be developed and implemented by the DRB, Project Manager and designated DS for each separate diving project. The SSHO for the project shall complete applicable self-assessmentchecklists. The project DOP for federal clients will comply with EM-385-1-1.30.A.16. A project DOP shall be developed to address the general diving and to include the following:

- Describe dive team composition, personnel qualifications, and responsibilities, along with the proper up-to-date documentation.
- Provide name and qualifications of the designated person in charge/diving supervisor responsible for diving activities (that is, years and type of experience and training background).
- Describe safe work practices for other activities to be performed during this project (for example, use of ladders, fall protection, use of electrical power tools, and use of personal protective equipment).
- Describe site-specific training, diver workups, equipment uses, and other training requirements (e.g., hazard communication, first aid, and CPR).
- Describe methods to identify and protect wetlands, endangered species, or cultural/historic resources, if applicable.
- Describe procedures for operating in inclement weather, including lightning, high winds, and severe rainstorms.
- Describe the Emergency Response Plan for equipment, incident response, treatment, evacuation, and notifications.
- Provide supplemental diving safety procedures.

The DOP can reference overlapping plans or other pertinent project documents to minimize redundancy.

15.1 Risk Management and Assessment

Identifying the risks of the dive and developing a plan of action to minimize one's exposure to risk is crucial to safe and effective diving operations. The DOP will be developed to address possible emergencies that may arise at each specific dive site. This plan shall incorporate steps for extraction of a stricken diver from the water, subsequent first aid and emergency response, and evacuation to a higher level of care. Job hazard analysis forms and safety checklists that are site-specific may be substituted providing they meet or exceed the requirements outlined in this manual and are approved by the diving supervisor/lead diver. Each team member shall be provided a copy of the DOP prior to starting a job.

Once on the job, the DS shall give a safety briefing to the dive team prior to each day of diving, and at the start of a new task. Emergency procedures will be reviewed on site to include local emergency/rescue points of contact. Wherever practicable, dives will be planned within the No Decompression Limits according to the USN dive tables and procedures.

The project manager, field management team and DS, prior to the start of any fieldwork, must complete detailed planning and all required forms. Dive Team members must be made aware of the following:

- All known and potential safety issues at the job site as reflected on the AHA form.
- Required scope of work and individual responsibilities as detailed in the Pre-Dive Briefing Form.
- Equipment and tool requirements for all tasks
- Contingency and emergency plans
- All quality procedures and any issues as reflected in the quality management forms

Diving shall be discontinued if sudden squalls, electric storms, heavy seas, unusual tide, or any other condition exists that, in the opinion of the DS, jeopardizes the safety of the divers. It must be noted here that **ANYONE ON A TMR DIVE TEAM CAN STOP WORK** on a job if they feel that the work environment is or becomes unsafe.

Prior to diving, the DS shall be responsible for examining the dive site to identify potential hazards. Some examples of potential surface and subsurface hazards include the following:

- Surface vessel traffic and/or vehicular traffic
- Swift currents and sea state
- Subsurface/underwater debris
- Overhead crane operations
- Mooring lines
- Pedestrian traffic/onlookers
- Petroleum products and/or other materials that are hazardous to divers and/or tenders
- Airborne contaminants
- Contaminated water
- Outfall and intake pipes
- Flotsam/jetsam (marine debris)
- Propeller/thrusters and intake/discharges of moored vessels
- Potential for structural collapse
- Hazardous marine life
- Limited access and/or confined workplace
- Fishing lines and nets
- Turbid (limited visibility) water
- Hazardous materials
- Abandoned piles and/or other structures
- Sonar equipment likely to be used or tested on nearby vessels

15.2 Termination of Dive Operations

The working interval of a dive will be terminated under any of the following conditions:

- The activities are completed as planned.
- A diver requests termination.
- A diver fails to respond correctly to communications.
- Communications are lost and cannot be quickly re-established between the diver and a dive team member at the dive location, or between the designated person-in-charge and the person controlling the vessel in live boating operations.
- A diver begins to use diver-carried reserve breathing gas or the dive location reserve breathing gas.
- The DS determines that any unsafe condition exists.

16.0 CONSIDERATIONS FOR DIVE PLANNING

TMR diving mode options include SSA SCUBA (including the SADS configuration), and snorkeling. Specific tasks and environmental conditions will dictate the safest and most efficient diving mode; however, there are certain requirements that must be followed regardless of the chosen dive mode selected.

16.1 Primary Breathing Air Supply

Air will be the primary breathing gas used during diving operations. A low-pressure air compressor, volume tank and filter assembly or high-pressure cylinders, with a regulated supply, provide the breathing air during SSA diving. Compressed air cylinders worn by the diver or mounted on the SADS supply the primary breathing air during SCUBA diving operations.

16.2 Reserve Breathing Air Supply

High-pressure air cylinders connected to the dive manifold supply the reserve air to the SSA Diver. Additionally, the diver carries a reserve breathing air supply known as a bail-out system. The bail-out system provides a reserve air supply for the diver when surface-supplied air is compromised.

A redundant and separate tank and regulator carried by the diver provide the reserve air supply for SCUBA (including on SADS configured) diving operations.

16.3 Exposure Protection

The site and environmental conditions are directly related to the type and amount of exposure protection required for a diver’s comfort and safety. In cold or contaminated water, a dry suit with an adequate thermal undergarment is required. In the absence of contaminants, a neoprene wetsuit may be worn. A lightweight wetsuit, dive skin, or swimsuit with chaffing coveralls may be considered in warmer climates, providing the environment in which the dive will take place is free of contamination. Divers will wear some form of hand and foot protection while working in the water to minimize the possibility of injury. A neoprene or Lycra wetsuit hood is suggested when using SCUBA to provide protection for the diver's head and ears.

16.4 Dive Team Assignments

Each TMR Dive Team will have, as a minimum, four qualified personnel. The marine operations program manager will assign personnel to the dive teams. Personnel requirements are outlined in Section 11. Team assignments will be based on the scope of the project and the availability of qualified personnel. The logistics of the project and any unusual safety considerations at the job site may dictate additional personnel requirements.

- Additional personnel may be required to supplement the dive team to comply with standards set forth by a client or agency. In these instances, the required standards will be reviewed and strictly adhered to.
- All diving projects undertaken by the company for government clients (e.g., USN or the USACE) will be carried out in strict compliance with DDESB TP-18 and EM-385-1-1 Section 30.

16.5 Decompression Procedures

The standard of practice is to plan dives as no decompression dives according to the USN no-decompression dive table limits. Should situations arise that necessitate the use of decompression diving to complete the scope of work safely and efficiently, USN Standard Air Dive Tables and outlined ascent procedures will be implemented and incorporated into the DOP at that time.

16.6 Water Entry/Egress

A securely attached ladder or platform will be provided for the diver to enter and exit the water. The ladder must extend at least 3 feet below the surface of the water and be capable of supporting the combined loads of both the diver and tender.

Divers shall enter the water in a controlled manner. In turbid or low visibility water conditions, there is always a possibility of submerged hazards or protruding objects that could pose a danger to the diver; therefore, extreme caution must be exercised during water entry.

Equipment required for the safe extraction of an unconscious diver from the water shall be provided at each dive site.

16.7 Warning Display

An International Alpha code flag and recreational "Diver Down" flag shall be prominently displayed during all diving operations. Flags will be placed in a highly visible position to provide as much warning as possible for all approaching vessels. For work in navigable waters, flag dimensions shall be at least one meter in height and width (or as specified by local jurisdictions) and navigation lights and shapes displaying underwater operations (red/white/red and ball/diamond/ball) at night.

16.8 Pre-Dive Brief

Prior to each dive, the DS shall conduct a pre-dive Briefing to inform each Dive Team Member of the following:

- Diver's health and readiness
- Standard and emergency procedures for diving mode employed and location of work
- Review of the AHAs, equipment checklists, and hazards or environmental variables that will impact diving operations
- Quality procedures
- Any deviations from standard procedures which may be necessitated by the operation
- Diver re-call procedure
- Factors which will terminate the dive

17.0 SPECIAL CONSIDERATIONS FOR DIVE PLANNING

In addition to the requirements above, there are many other items or circumstances that must be considered when planning a dive, regardless of the chosen diving mode.

17.1 Hazardous Environmental Conditions

Effective dive planning must provide for extremes in environmental conditions. Diving will be discontinued if sudden squalls, electric storms, heavy seas, unusual tide, excessive current or any othercondition exists that, in the opinion of the DS, jeopardizes the safety of the divers.

17.2 Communications

Adequate communications for the dive site will be provided as follows:

- **Diver to diver** – Wireless through water communication is preferred for SCUBA operations, but diver-to-diver hand signals or line pull signals, in accordance with the Navy Diving Manual, are acceptable, refer to Attachment 8 USN Diving Line Pull and Hand Signals, which is also available in the native file format located in the Guidelines Templates and Tools folder in the CRL. Surface-supplied diving requires an operational two-way audio communication system between the diver and topside.
- **Surface to Diver/Diver to Surface** – Wireless through water communication is preferred for SCUBA operations, but line pull signals in accordance with the USN Diving Manual, are acceptable. SSA diving requires an operating two-way audio and video communication systems between the diver and topside.
- **Emergency Assistance** – Telephone communications will be maintained on site via cell phone, or two-way radio communications with a constantly manned location to activate emergency services if required.

17.3 Cold Water Diving

Cold water diving is defined as diving in water at or below a temperature of 37 degrees Fahrenheit. Cold water diving requires the use of special equipment and techniques. All dives conducted in cold water will be in accordance with Attachment 9, Cold Water Considerations and Safety Precautions, which is available in the native file format located in the Guidelines Templates and Tools folder in the CRL.

Hypothermia demands immediate treatment and prompt evacuation to a medical facility. The DS will also take into consideration hypothermia for the surface support personnel. The responding medical facility must be notified of the possibility of hypothermia prior to the commencement of diving operations. Emergency re- warming and evacuation plans should be established with the medical facility's recommendations.

Diving under the ice requires extremely specialized training and equipment and **will not**

be performed by TMR employees under this policy.

After approval of the DRB and project DDC (if applicable); Standard Operating Procedures (SOPs) addressing the special requirements and support will be developed prior to commencing any under ice diving and included in the project specific DOP.

17.4 Diving at Altitude

Diving operations may be required in bodies of water at higher altitudes. Because of the reduced atmospheric pressure, dives conducted at altitude require more decompression than identical dives conducted at sea level. Standard air decompression tables, therefore, cannot be used as written.

Planning must address the effects of the atmospheric pressures that may be lower than those at sea level.

- No correction is required for dives conducted at altitudes between sea level and 300 feet; the additional risk associated with these dives is minimal.
- At altitudes between 300 and 1,000 feet, correction is required for dives deeper than 145 FSW (actual depth).
- At altitudes above 1,000 feet, correction is required for all dives.

High-altitude diving requires special equipment and techniques and will be conducted in accordance with the provisions of the USN Diving Manual.

After approval of the DRB and project DDC (if applicable); SOPs addressing the special requirementsand support will be developed prior to commencing any high-altitude diving and includedin the project specific DOP.

17.5 Diving on UXO

Diving involving the potential interaction with munitions or munition remnants, specifically munitions and explosives of concern (MEC), combines the inherent risk of diving and the explosive hazards of munitions. UXO is the most hazardous classification of MEC. Diving to investigate, recover, or dispose of munitions found underwater, regardless of the type or fuzing, will only be accomplished by specifically trained and qualified UXO divers. Divers must be qualified in accordance with DDESB TP-18. Unknown items found in this environment will be treated as MEC (UXO) until properly identified and classified in a different less hazardous category.

Generally, it is safer for divers to work in pairs rather than alone. However, when diving on in an environment when MEC may be present, the use of two divers doubles the exposure to the potential munition items and the amount of bottom time expended and increases the risk to life from a possible unintentional detonation. Consequently, the Diving Supervisor, should employ a single tended or marked diver when any intrusive activity, manipulation, or removal of the munitions is anticipated. However, the option to use two or more divers for underwater munitions operations is authorized with prior approved planning.

When performing activities not involving intentional contact with MEC and using anomaly avoidance techniques within a munitions environment, it is preferred to deploy two UXO divers. Deploying one UXO diver and one non-UXO diver is allowable if approved in the DOP and authorized by an approved explosive safety submittal or explosive safety plan.

The development and use of SOPs within the DOP to address the hazards associated with munitions is required when conducting UXO diving.

17.6 Diving in Contaminated Water

Divers may encounter dangerous or unpleasant forms of pollution such as effluent from a sewer or industrial outfall, oil leaking from a wellhead or damaged fuel tank, toxic materials, biological hazards,volatile fuels leaks, and munitions including chemical warfare material can cause severe problems.

The dive team should not conduct the dive until the contaminant has been identified, the safety factors evaluated, and the process for decontamination set up. When diving in a known or suspected radiological environment, proper radiological procedures must be followed.

When diving in contaminated waters, the appropriate dress should be a fully contained dry suit with gloves and hood, with a positive-pressure full face mask or the Dirty Harry surface-supplied diving system. Technical advice for contaminated water diving is available from the NOAA Hazardous Materials Department at (206) 526-6317.

18.0 DIVING HAZARDS

In addition to environmental hazards, and the hazards directly attributable to diving, a diver may occasionally be exposed to operational hazards that are not unique to the diving environment. These hazards are described below.

- **Underwater Obstacles** – Various underwater hazards, such as broken pilings, rocks, wrecks, dumping grounds, and discarded munitions, offer serious hazards to divers.
- **Electrical Shock** – Electrical shock is rare underwater but may occur when using power equipment underwater or topside. A ground fault interrupter must be used with electrical equipment employed on the dive site, both on the surface and underwater.

- **Explosions** – Explosions may occur during demolition tasks or during ordnance clearance operations, intentionally or accidentally. When using explosives, or as identified during UXO diving, separate SOPs and work plans will be developed to cover all aspects of the use or possibility of encountering explosives/ordnance underwater. All divers will be out of the water prior to any planned detonation of explosives or ordnance.
- **Explosives** – All diving-related explosives will be pre-approved. The procedures for explosives handling, use, storage, and underwater procedures will be detailed in the specific DOP for the project.
- **Sonar** – Additional precautions are required when diving in the vicinity of vessels that employ active sonar. Ships use low-frequency sonar for object location and depth finding. It is a dense, high-energy pulse of sound that can cause damage to divers' ears. Avoid diving in the vicinity of low-frequency sonar and approach no closer than 600 yards. The optimal separation distance is 3,000 yards.

Additionally, the USN Diving Manual has a worksheet to compute actual time and distance restrictions for various types of sonar. This worksheet considers such variables as depth, time, diving apparatus, and wetsuit hoods. High-frequency (greater than 100 kilohertz), short-duration sonar, such as that used with side-scan and hand-held sonar, poses little danger to the diver. The diver will abort the dive if active low-frequency sonar is energized while they are in the water.

- **Marine Life** – Certain marine life, because of its aggressive or venomous nature, may be dangerous to man. Some species of marine life are extremely dangerous, while some are merely an uncomfortable annoyance. Most marine life poses little threat, as they tend to leave humans alone. The diver's best defense against injury is knowledge. All divers should be able to identify the dangerous species that are likely to be found and should be able to deal with each appropriately. The USN Diving Manual provides specific information about dangerous marine life.
- **Ascent to Altitude including Flying after Diving** – Leaving the dive site may require temporary ascent to a higher altitude. For example, divers may drive over a mountain pass at higher altitude or leave the dive site by air. Ascent to altitude after diving increases the risk of decompression sickness because of the additional reduction in atmospheric pressure. The higher the altitude, the greater the risk. The cabin pressure in commercial aircraft is maintained at a constant value regardless of the actual altitude of the flight. Though cabin pressure varies somewhat with aircraft type, the nominal value is 8,000 feet.

For all diving projects, divers will wait at least **12 hours** before flying after any dive, or **24 hours following multiple days of repetitive dives**. The ascent to altitude table located in the USN Diving Manual gives the surface interval (hours, minutes) required before making a further ascent to altitude. The surface interval depends on the planned increase in altitude and the highest repetitive group designator obtained in the previous 24-hour period. Enter the table with the highest repetitive group designator obtained in the previous 24-hour period and read the required surface interval from the column for the planned change in altitude.

18.1 Boating

All boating activities will be conducted according to applicable state, USCG, and Tetra Tech Procedure. Further, the following guidelines will be adhered to:

- Diving operations involving live boating will not be conducted unless cleared by the DDC and/or DSO in writing and documented in the approved DOP or subsequent Field Change Request.
- Live boating **will not** be conducted unless:
    1) Approved by the DDC and/or DSO
    2) In SSA diving at depths that are no deeper than 100 FSW,
    3) In rough seas that significantly impede diver mobility or work function, in non-daylight hours.
- The propeller of the vessel will be stopped before the diver enters or exits the water.
- A device will be used that minimizes the possibility of entanglement of the diver's hose or tending lines in the propeller of the vessel.
- Two-way voice communication between the DS and the person controlling the vessel will be available while the diver is in the water.
- Each diver engaged in live boating operations will carry a diver-carried reserve breathing gas supply.

19.0 OTHER HAZARDS

Other diving-related hazards that may be encountered by TMR divers are described below.

19.1 Noise

Some operations may require the use of generators, pumps, compressors, engines, and other equipment that can generate high levels of noise. Short-term exposure to extremely loud noise and/or long-term exposure to low level noise can cause hearing loss. Personnel assigned to a high noise area will wear proper hearing protection and be enrolled in a hearing conservation program.

19.2 Lifting Hazards

During some operations, there may be several instances when personnel will be called on to lift and/or carry a heavy load, sometime over rough or unstable terrain. When doing so, personnel should be instructed to observe the following rules:

- Test the load to ensure it can be moved safely.
- Plan the move to ensure the travel path is clear.
- Keep the back in its normal arched position while lifting, bend at the knees to lift.
- Lift with the legs and stand up in one smooth motion.
- Move the feet to change direction, do not twist at the waist.

20.0 DIVING EMERGENCY PROCEDURES

20.1 Surface Supplied Diving

20.1.1 Loss of Primary Air Supply

- Activate the secondary back up breathing air supply.
- If necessary, ensure diver goes on bail-out bottle.
- Alert the standby diver.
- Have Diver surface and proceed to ladder or stage.
- Terminate the dive (if instructed by the DS).

20.1.2 Loss of Communications

- Attempt to establish line-pull signals.
- Alert the standby diver.
- If unable to establish any form of communications with the diver within 60 seconds, immediately deploy the standby diver for assistance.
- Ensure diver proceeds to the ladder or stage.
- Terminate the dive.

20.1.3 Fouled or Entrapped Diver

- Diver informs the surface.
- Alert the standby diver.
- Diver determines the nature and extent of entrapment.
- Diver attempts to free themselves.
- If required, deploy the standby diver to assist the diver.
- When free, diver, standby diver and/or tender confirm that direct contact with each other is re- established.

20.1.4 Injured Diver in Water

- Diver informs the surface (if possible).
- Alert the standby diver.
- Diver determines nature and extent of injury.
- Deploy the standby diver to assist diver (if necessary).
- Standby diver remains with diver.
- Extract the diver and provide first aid or emergency oxygen accordingly.
- Request immediate medical assistance and emergency evacuation (if required).

20.1.5 Severance of Complete Umbilical

- Diver activates bail-out bottle.

- Establish line pull signals, if possible, try to inform surface support of the situation.
- Top side crew should secure primary the air supply and activate the air supply to the pneumo hose. If the diver can maintain a hold of the severed section of the hose, they can use it for breathing air and follow it up to the surface.
- Diver surfaces and terminates the dive.

20.1.6 Unconscious Diver

- Attempt to establish voice and line pull communications with the diver.
- Deploy the standby diver.
- Determine the nature and extent of the diver's situation.
- Secure the diver and ensure an open airway; open the dive helmet free flow if the diver is not breathing.
- Extricate the diver, provide First Aid, CPR, AED, and/or emergency oxygen accordingly.
- Request immediate medical assistance and emergency evacuation.

20.1.7 Activate the secondary back up breathing air supply

- Inform the diver of the situation and establish line pull signals if necessary.
- Diver activates bail-out bottle (if necessary).
- Line up air spread to route secondary air source to diver.
- Determine the cause, restore primary air supply prior to continuing the dive.
- Diver surfaces and terminates the dive if primary air not restored.

20.1.8 Equipment Failure – Diver in the Water

- Inform the diver of the situation and establish line pull signals if necessary.
- Evaluate the effect on the diver.
- Alert the standby diver.
- Diver informs topside of their readiness.
- Terminate the dive.

20.2 SCUBA Diving

20.2.1 Out of Air – Primary Source

- Diver activates secondary the air supply.
- Diver informs buddy diver or topside crew.
- Terminate the dive.

20.2.2 Out of Air – Primary and Secondary Source

- Diver surfaces with controlled ascent and informs buddy diver or topside crew.
- Buddy diver gives secondary air source to diver (Buddy breathes).

- Terminate the dive.

20.2.3 Fouled or Entrapped Diver

- Diver determines the extent of entrapment.
- Diver attempts to correct the situation.
- Diver informs topside or buddy diver; deploy the standby diver if required
- When clear, diver returns to ladder and evaluates situation with the DS.
- DS decides to continue or terminate the dive.

20.2.4 Diver Injured in Water

- Diver determines nature and extent of injury.
- Diver informs topside or buddy diver.
- Alert the standby diver and deploy if necessary.
- Buddy/standby diver remains with the diver.
- Extract the diver and terminate the dive.
- Provide First Aid and/or emergency oxygen accordingly.
- Request medical assistance and emergency evacuation (in accordance with the DOP).

20.2.5 Equipment Failure

- Evaluate effect on the system and the diver
- Diver informs topside or buddy diver.
- Deploy the standby diver (if necessary).
- Terminate the dive.

20.2.6 Lost Diver and Communication

- Use the Buddy Recall System.
- DS and divers use through water comms.
- Divers 360 look then surface.
- Use the Buddy Recall System.
- Each diver surfaces.
- Initiate the emergency recall system (surface) if all divers do not surface.
- If a diver is not quickly located, the DS immediately initiates search procedures.
- Deploy standby diver (if necessary) at last known position.
- When located, divers return to ladder and evaluates the situation with the DS.
- DS decides whether to continue or terminate the dive.

20.2.7 Diver Rapid Ascent or Blow up to Surface

- Buddy diver surfaces in a controlled ascent.
- Both divers terminate the dive.
- Deploy the standby diver to assist; if necessary.
- Monitor the diver and provide emergency oxygen accordingly.
- Immediately notify emergency and medical personnel and inform them of omitted decompression.

20.2.8 Loss of Consciousness

- Buddy diver/standby diver initiates rescue procedures.
- Determine the nature and extent of the diver's situation.
- Secure the diver and ensure an open airway; overpressure second stage (if possible) if diver is not breathing.
- Standby diver initiates controlled ascent with secured stricken diver.
- Extricate diver, provide First Aid, CPR/AED and/or emergency oxygen accordingly.
- Request immediate medical assistance and emergency evacuation.

21.0 DIVING SPECIFIC EMERGENCY MEDICAL TREATMENT

21.1 DCS Type 1 – (Pain only)

Diver surfaces with or develops joint pain (dull ache) that gradually worsens over time, develops skin problems such as itching or a rash, or develops swelling and pain in lymph nodes. Time to onset of symptoms is 0 to 24 hours. Actions to be taken:

- Perform necessary first aid and give 100 percent emergency oxygen upon surfacing.
- Contact local emergency resources for transport to nearest hyperbaric facility.
- Follow USN Dive Manual Treatment Table procedures.

21.2 DCS Type 2 – Central Nervous System

Diver has DCS symptoms in water, or surfaces with any neurological symptoms (numbness, tingling, decrease touch sensation, muscle weakness, or paralysis). Time to onset of symptoms is 0 to 24 hours. Actions to be taken:

- Perform necessary first aid and give emergency oxygen upon surfacing.
- Contact local emergency resources for transport to nearest hyperbaric facility.
- Follow USN Dive Manual Treatment Table procedures.

21.3 Arterial Gas Embolism (AGE)

Diver surfaces or becomes unconscious within 10 minutes of surfacing, exhibits signs of a stroke or other neurological disorder, blurred vision, or convulsions. Actions to be taken:

- Perform necessary first aid or CPR.
- Administer emergency oxygen with the diver supine or in the recovery position.
- Contact local emergency resources for immediate transport to the nearest hyperbaric facility and initiate recompression treatment as soon as possible.

21.4 Chokes (Heart Pumps Frothy Blood)

Diver surfaces with chest pain aggravated by inspirations, an irritating cough, an increased breathing rate, increased lung congestion with subsequent heart attack. Death is imminent due to heart attack. Actions to be taken:

- Perform necessary first aid and give emergency oxygen upon surfacing.
- Contact local emergency resources for immediate transport to nearest hyperbaric facility.

21.5 Pneumothorax

Diver displays difficult or rapid breathing leans towards affected side and experiences pain while inhaling deeply. Hypotension, cyanosis, and shock may be present, leading to death. Actions to be taken:

- Position diver on affected side.
- Administer emergency oxygen and treat for shock.
- Contact local emergency resources for immediate transport to nearest medical facility (air must be vented from chest cavity).

22.0 VESSEL OPERATIONS DURING DIVING OPERATIONS

22.1 Safe Boating Guidelines

These procedures are for the safety of the employees and other vessels on the waterways during waterborne operations. If a conflict arises between the current edition of this section and the approved project specific DOP, applicable federal, state, local laws or other legal directives, the latter shall take precedence.

22.2 Preparing for Waterborne Operations

All personnel on board a vessel employed on a TMR assignment will be fully competent in the vessel operations, maintenance, and equipment usage. The DS shall complete any project sailing lists and pre-operation maintenance and safety inspection checklists prior to casting off.

22.3 Operations

All TMR employees regularly involved in boat operations must be knowledgeable and capable in rules of the road, vessel maintenance, marine safety, and vessel registration requirements.

22.4 Rules of the Road

As with vehicular traffic on land, rules exist to promote safe vessel movement on navigable waterways. All employees engaged in waterborne operations will know the rules of the road specific to the project area. The local rules can be researched through the USCG or the applicable state government agency that governs a body of water. Several topics included in the rules of the road, relevant to TMR operations, are listed below.

22.5 Navigation, Signals, Markers and Signs

Each crewmember will know the meaning and use of each signal for meeting and passing situations while underway, for leaving a mooring, and signals used in limited visibility conditions. The required signals will be used in accordance with the rules of the road.

Each crewmember will know and understand the meaning of all navigation markers, buoys, and lights on the waterways. The vessel operator will follow the directions of each navigation marker, buoy and light unless evidence indicates the marker is damaged and providing inaccurate information.

22.6 Anchoring and Mooring

Vessel crewmembers will know how to properly anchor and moor the vessel from which they are operating. They will ensure that the anchor, chain, all lines, fenders, bumpers, and cleats are in good working order. The anchor line should be at least seven times longer than the working water depth. Crewmembers will continually monitor anchor and mooring lines while moored in areas affected by tides and strong currents.

22.7 Required Safety Equipment

All vessels operated by TMR, except for vessels less than 18 feet in length, will have the following equipment on board and in operating condition:

- A fixed fire extinguishing system installed in machinery space(s) or B-1 type extinguishers
- Type 1 PFD required for each person on board plus one throw able Type 4 life ring or cushion
- A Coast Guard approved flare kit
- A sounding device to signal maneuvering intentions and position during periods of reduced visibility
- A fully charged and tested VHF radio, prior to departure from dock
- A bilge pump appropriately sized for the vessel
- Additional engine fluids
- Vessels operated by TMR that are less than 18 feet in length shall have a Type 1 PFD for each person onboard.

22.8 Vessel Maintenance

Due to the difficulty of performing repairs afloat, regular maintenance and necessary services shall be carried out onshore before commencing operations. Use of the owner's manuals, maintenance checklists, and repair logs are necessary to track equipment usage and inform future operators of equipment status.

Engine – The owner's manual will be stored on board each vessel in a watertight bag and compartment. Suggested maintenance schedules will be followed. The engine fuel and oil levels will be checked before each use. Other engine components and propeller(s) will be checked for proper function.

Batteries – Each battery will be checked for proper charge level, cleanliness of contact posts, condition of wiring, and water level if required. Batteries will be secured, and all electrical systems turned off after operations are completed. Bilge pumps are directly wired and as such, will remain in constant operation.

Fuel – Check fuel level of primary tanks and emergency supply tanks prior to embarkation. Refill all fuel tanks, with the proper fuel, to the full level after returning each day. Inspect all fuel lines, bilge, and areas around the vessel for leaks.

Electronic Systems – Inspect all circuits to ensure good connections and operation of all components and equipment. Have spare batteries, fuses, and wiring available for repairs. Ensure connection of shore power after returning, when deemed necessary.

Checklists and Logs – Accurately complete checklists and logs prior to and after each day's operation of the vessel.

Safety Equipment – Inspect all fire extinguishers for annual inspection and pressure, first aid kits for required and expired items, PFD for proper fit or deterioration and for spare carbon dioxide cartridges, signaling devices for expired or deteriorated items, and radios for proper functioning.

22.9 General Marine Safety

Dive operations conducted from the relative stability of a pier or shoreline requires safety awareness and constant diligence. Conducting operations from the deck of a pitching/rolling vessel only compound these requirements. All personnel will conduct themselves in a safe and responsible manner while near or on board any vessel and in accordance with SWP 5- 06 Working over or near water. These guidelines are in place for the safety and wellbeing of TMR employees involved in marine operations.

- A USCG-approved PFD must be available for each person on board the vessel. The PFD must have a proper fit for the individual who will be using it and each person should know how to don the PFD in the vessel and in the water. PFDs must be inspected regularly for damage and excessive wear.
- Shoes should have non-skid soles. Personnel should maintain three points of contact when transferring equipment or personnel to and from the vessel. Deck area should be clear of lines, hoses and unnecessary clutter.
- Personnel should not sit on the edge of a vessel or on lifelines while underway.
- Personnel should avoid sailing at night, in fog, in poor visibility, in ice flows, during flood conditions, debris flows, small craft advisories, gales, hurricanes, or other heavy surf conditions, whenever possible.

- Personnel should be familiar with and have the means to handle emergency situations, including man overboard, abandon ship, fire, loss of power or propulsion, storm, and use of emergency signaling devices, as well as how to recover a person in the water.
- Personnel should know what emergency and standard equipment is required on each TMR owned vessel, where it is located and how to operate that equipment.
- Detailed tide, current, and marine weather forecast should be obtained before commencing waterborne operations.
- Ensure that all equipment is secure or lashed properly when underway.
- Personnel should be familiar with, and anticipate water and weather states and conditions respectively, when mooring.

22.10 Vessel Registration

Each vessel operating on navigable waterways requires a state registration identification sticker or USCG Certification. The designated Equipment Manager will ensure that each TMR vessel maintains a current state registration for the state in which the vessel is located. Trailer registrations, if applicable, will also be kept up to date.

22.11 Chain of Command

22.11.1 Projects that are Captained and Crewed by a Subcontractor

The designated Captain of the vessel will have overall authority for the vessel and personnel aboard. They will work with the Project Manager, DS and SSHO to ensure the safety of all personnel.

22.11.2 Projects that are not Captained and Crewed by a Subcontractor

The Project Manager shall designate the vessel operator for each project. If a designee has not been assigned, the DS will assume or designate the position of vessel operator. The vessel operator has overall authority and responsibility ofthe crew, passengers, and vessel operations safety while moored or underway. Before embarking, the DS will assign crew positions and responsibilitiesto each team member. They will also designate a chain of command should the vessel operator become injured or is away from the vessel. The vessel operator will work with the DS and project SSHO to ensure the safety of all personnel.

22.12 Offshore Operations

When the vessel will be operating greater than 500 yards from the shoreline, in breaking waves, or in a strong current, additional safety precautions are warranted. Under such conditions, any vessel employed on a TMR assignment must adhere to the following:

- The vessel shall be operated by an experienced and qualified boat operator as approved by the Project Manager.
- The vessel operator must perform research on local conditions and be aware of potential hazards.

- A marine weather radio shall be on-board the vessel and periodically monitored to keep abreast of changing weather conditions.
- The vessel must be equipped with a backup propulsion system, such as an extra motor, that can return the vessel to a safe harbor in the event of failure of the primary propulsion system.
- The vessel shall be thoroughly examined by the vessel operator to verify the sound mechanical condition of the vessel and bilge pump, and the presence of appropriate safety equipment as designated above.

23.0 REQUIRED FORMS AND CHARTS

23.1 Forms

The vessel operator will ensure that all required forms are accurately and filled out before embarkation. Spare forms should be kept on board each TMR-operated vessel. The DOP and Attachment 11, Equipment Checklists, will provide the required forms listed below:

- BOAT PRE-OPERATION CHECKLIST
- DIVE EQUIPMENT CHECKLIST (GENERAL, MEDICAL, SCUBA, SADS)
- PRE-DIVE: SSA DIVE HELMET CHECKOFF SHEET
- PRE-DIVE: SURFACE SUPPLIED LIGHTWEIGHT (AGA)

23.2 Charts

The vessel operator will ensure that all required charts and maps for navigation to, from, and within the area of operations are on board before embarkation. All crewmembers will review and become familiar with these charts. These documents should be continually revised, as updates become available.

24.0 REFERENCES

ADCI (Association of Diving Contractors International). 2020. Consensus Standards for Commercial Diving Operations - Sixth Edition (Revision 6.4). Houston, TX. www.adc-int.org

CGA. 2018. G-7.1 Standards - Air quality standards; Compressed Gas Association. Chantilly, VA. www.cganet.com

DDESB (Department of Defense Explosives Safety Board). 2020. Technical Paper-18 Revision 1 - Minimum Qualifications for Personnel Conducting Munitions and Explosives of Concern-Related Activities. Washington, DC.

DOT (U.S. Department of Transportation). 2020. 49 CFR 178.37 - DOT Cylinder Maintenance, Retest and Certification Requirements. Washington DC. www.gpo.gov

OSHA (Occupational Safety and Health Administration). 2021. 29 CFR 1910.401 Subpart “T” - Commercial Diving Operations. Washington DC. www.osha.gov

OSHA (Occupational Safety and Health Administration). 2017. 29 CFR 1910.1020 Subpart Z (h)(1)(2) - Access to employee exposure and medical records. Washington DC. www.osha.gov

Tetra Tech Health and Safety Manual:

________ DCN 1-04, Recordkeeping and Reporting Requirements.[5]

________ DCN 02-02 Event Reporting and Investigation.[6]

________ DCN 02-15 Scientific Diving Program.[7]

________ DCN 3-02, MS 1, Physician’s Certification form.[8]

________ DCN 3-02, MS 2, Release of Medical and Exposure Records.[9]

[5] https://intranet.tetratech.com/healthsafety/Manual/DCN%2001-04%20Recordkeeping%20and%20Reporting%20Requirements.pdf
[6] https://intranet.tetratech.com/healthsafety/Manual/DCN%2002-02%20Incident%20Reporting%20and%20Investigation%20Program.pdf
[7] https://intranet.tetratech.com/healthsafety/Manual/DCN%2002-15%20Scientific%20Diving%20Program.pdf
[8] https://intranet.tetratech.com/healthsafety/Manual/DCN%2003-02F%20MS-1%20Physicians%20Certification%20Form.pdf
[9] https://intranet.tetratech.com/healthsafety/Manual/DCN%2003-02F%20MS- 2%20Release%20of%20Medical%20and%20Exposure%20Records.pdf

________ SWP 05-06 Working Over or Near Water.[10]

TMR (Tetra Tech Munitions Response):

________PO-08 – Document Control and Records Management.

________PO-18 – Warehouse Management.

________TMR HSE 01-10 – Boating

________TMR UXO SOP - Removal of MEC in a Marine Environment

________TMR UXO SOP - Underwater Intrusive Investigation Operations

USACE (U.S. Army Corps of Engineers).

________2014. EM 385-1-1, Section 30. Department of the Army, Washington DC. www.publications.usace.army.mil

USCG (U.S. Coast Guard). 46 CFR CH I Subpart "V" – Marine Occupational Safety and Health Standards - Shipping, Volume 7, Chapter 1 – Coast Guard, Part 197 – General Provisions, Subpart B. Commercial Diving Operations. Department of Transportation, Washington, DC. https://www.law.cornell.edu/cfr/text/46/part-197/subpart-B

USN (U.S. Navy). 2018. U.S. Navy Diving Manual, Volumes 1-5, Revision 7 Change A – Commander, Navy Sea Systems Command, Supervisor of Salvage and Diving. https://www.navsea.navy.mil/Portals/103/Documents/SUPSALV/Diving/US%20DIVING%20MANUAL_REV7_ChangeA-6.6.18.pdf

[10] https://intranet.tetratech.com/healthsafety/Manual/SWP%2005-06%20Working%20Over%20or%20Near%20Water.pdf

25.0 ATTACHMENTS

Attachment 1 – Diving Supervisor Dive Plan Brief

Attachment 2 – Diving Supervisor Pre-Dive Checklist

Attachment 3 – Diving Supervisor Post-Dive Checklist

Attachment 4 – Emergency Procedures

Attachment 5 – Emergency Phone Numbers Checklist

Attachment 6 – Working Dive Log

Attachment 7 – Dive Smooth Log

Attachment 8 – USN Diving Line Pull and Hand Signals

Attachment 9 – Cold Water Considerations and Safety Precautions

Attachment 10 – U.S. Navy Dive Tables

Attachment 11 – Equipment Checklists

GLOSSARY

Definitions are provided for the purpose of understanding their intent as they pertain to a procedure and projects requiring quality program planning. A Master List of Definitions is located in the CRL on the TMR intranet (https://tetratechinc.sharepoint.com/sites/OU-TMR). In addition, the definitions provided below are specific to this manual.

ASME Code or equivalent

ASME (American Society of Mechanical Engineers) Boiler and Pressure Vessel Code, Section VIII, or an equivalent code which the employer can demonstrate to be equally effective.

Arterial Gas Embolism (AGE)

An embolism caused by entry of gas bubbles into the arterial circulation system then act as blood vessel obstructions called emboli.

Atmosphere Absolute (ATA)

Total pressure exerted on an object, by a gas or mixture of gases at a specific depth or elevation, including normal atmospheric pressure.

Bell

An enclosed compartment pressurized (closed bell) or unpressurized (open bell), which allows the diver to be transported to and from the underwater work area and which may be used as a temporary refuge during diving operations.

Bottom Time

The total elapsed time from when the divers leave the surface to the time (rounded up to the next whole minute) they begin their ascent from the bottom or from the deepest depth attained. This time is measured in minutes.

Breath-Holding Diving

A diving mode in which the diver does not use a self-contained or surface-supplied air or oxygen supply.

Buddy Breathing

Sharing of a single air source between divers.

Buddy Diver

Second (paired) member of the dive team set.

Buddy System

Two comparably equipped self-contained underwater breathing apparatus (SCUBA) divers in the water in constant communication.

Buoyant Ascent

An ascent made using some form of positive buoyancy.

Bursting Pressure

The pressure under which a pressure-containment device would fail structurally.

Certified Diver

A diver who holds a recognized valid certification from an organizational member, internationally recognized certifying agency, or through military training.

Chairman, Diving Review Board (DRB)

A Tetra Tech member who is designated by the business unit leader, who manages and oversees the DRB.

Controlled Ascent

Any one of several kinds of ascents including normal, swimming, and air-sharing ascents where the diver(s) maintain control so a pause or stop can be made during the ascent.

Cylinder

A pressure vessel for the storage of gases.

Decompression Chamber

A pressure vessel for human occupancy. Also called a hyperbaric chamber.

Decompression Schedule

A specific decompression procedure for a given combination of depth and bottom time as listed in a decompression table. It is normally indicated as feet/minutes.

Decompression Sickness

A condition with a variety of symptoms, which may result from the presence of gas and bubbles in the tissues of divers after pressure reduction.

Decompression Table

A profile or set of profiles of depth-time relationship for ascent rates and breathing mixtures to be followed by divers after a specific depth-time exposure or exposures.

Decompression Time

Elapsed time from when the divers leave the bottom to the time when they reach the surface.

Descent Time

The total elapsed time from when the divers leave the surface to the time, they reach the bottom. Descent time is rounded up to the next whole minute.

Dive Computer

A microprocessor-based device that computes a diver's theoretical decompression status, in real time, by using pressure (depth) and time as an input to a decompression model, or set of decompression tables, programmed into the device.

Dive Location

The surface location from which diving operations are conducted, such as a vessel, barge, wharf, pier, riverbank or offshore rig.

Dive Location Reserve Breathing Gas

A supply system of air at the dive location that is independent of the primary system and enough to support divers during the planned decompression.

Dive Team

Divers and support employees involved in a diving operation, including the Diving Supervisor/Field Operations Lead.

Diver

An employee working in water using underwater apparatus, including snorkel, that supplies breathing gas at the ambient pressure.

Diver-Carried Reserve Breathing Gas

A diver-carried independent supply of air enough under standard operating conditions to allow the diver to reach the surface, or another source of breathing gas, or to be reached by another driver.

Diving Review Board

The TMR Review Board has oversight for all diving operations within the company. Board members will review the diving procedures and qualification of divers before authorization is given to conduct diving operations. The board is made up of qualified divers from the Marine Operations Group or TMR management team and approved by the President.

Diving Safety Officer

The individual who manages the diving safety and training programs on the Diving Review Board.

Diving Mode

A method of diving requiring specific equipment, procedures, and techniques (e.g., SCUBA, SSA, or snorkeling).

Equivalent Single Dive Time

The sum of the residual nitrogen time and the bottom time of a repetitive dive. Equivalent single dive time is used to select the decompression schedule for a repetitive dive. This time is expressed in minutes.

Heavy Gear

Deep-sea dress, including helmet, breast plate, dry suit, and weighted shoes. Advances in diving equipment and technology have led to heavy gear that does not include a breastplate. Surface-supplied diving gear, including helmet, dry suit, and weighted shoes (e.g., with the helmet directly connected to the dry suit, forming a self-contained pressure envelope for the diver) constitutes heavy gear as well.

Hyperbaric Conditions

Pressure conditions more than surface atmospheric pressure.

In-water stage

A suspended underwater platform that supports a diver in the water.

Lead Diver

A certified diver with the experience and training to lead the diving operations.

Live Boating

The practice of supporting a surface-supplied-air diver from a vessel which is underway

Mixed-Gas Diving

A diving mode in which the diver is supplied in the water with a breathing gas other than standard air.

No Decompression (No "D") Limits

The depth-time limits of the ‘‘no-decompression limits and repetitive dive group designation table for no-decompression air dives,’’ USN Diving Manual or equivalent limits which the employer can demonstrate to be equally effective.

Penetration Diving

Passing through an enclosure or limited access area where the diver’s tending line or umbilical requires tending by another diver.

Pressure-Related Injury

An injury resulting from pressure disequilibrium within the body as the result of hyperbaric exposure. Examples include decompression sickness, pneumothorax, mediastinal emphysema, air embolism, subcutaneous emphysema, or ruptured eardrum.

Pulmonary Over Inflation Syndrome

Disorders that are caused by gas expanding in the lungs, and include arterial gas embolism, pneumothorax, mediastinal and subcutaneous emphysema.

Recompression/Decompression Chamber

A pressure vessel for human occupancy, such as a surface decompression chamber, closed bell, or deep diving system, used to decompress divers and to treat decompression sickness.

Repetitive Dive

Any dives conducted within 12 hours of a previous dive.

Repetitive Group Designation

A letter that is used to relate directly to the amount of residual nitrogen remaining in a diver's body.

Residual Nitrogen

Nitrogen gas that is still dissolved in a diver's tissues after surfacing.

Residual Nitrogen Time

Time, in minutes, which must be added to the bottom time of a repetitive dive to compensate for the nitrogen still in solution in a diver's tissues from a previous dive.

Safety and Health Manager (SHM)

The individual responsible for all safety aspects of the diving evolution. The on-site SSHO qualified person reports to the SHM on all safety related matters.

Scientific Diving

Diving performed solely as a necessary part of a scientific, research, or educational activity by employees whose sole purpose for diving is to perform scientific research tasks. Scientific diving does not include performing any tasks usually associated with commercial diving such as: Placing or removing heavy objects underwater; inspection of pipelines and similar objects; construction; demolition; cutting or welding; or the use of explosives.

SCUBA Diving

A diving mode independent of a surface supply in which the diver uses an open-circuit self-contained underwater breathing apparatus.

Single Dive

Any dives conducted more than 12 hours after a previous dive.

Standby Diver

A designated safety diver at the dive location properly equipped and available to assist a working diver in the water.

Surface Air Delivery System

A SCUBA diving mode where the breathing gas is supplied from the surface on a floating platform by means of a pressurized umbilical hose and controlled by the diver. The umbilical consists of a low pressure gas supply hose, strength member, high pressure hose and gage. The umbilical is positively attached to the diver’s safety harness and supplies a full-face mask outfitted with a through water communication system

Surface Interval

The time a diver has spent on the surface following a dive. It begins as soon as the diver surfaces and ends as soon as he starts his next descent.

Surface-Supplied Air Diving

A diving mode where the breathing gas is supplied from the surface by means of a pressurized umbilical hose. The umbilical generally consists of a gas supply hose, strength member, pneumofathometer hose, and communication line. The umbilical supplies a helmet or full-face mask. The diver may rely on the tender at the surface to keep up with the diver's depth, time, and diving profile.

Tended/Marked Diver

A diver who has a buoy line to the surface or is tended by another diver located in the diving boat or on the surface platform.

Treatment Table

A USN developed and tested depth-time and breathing gas profile designed to treat decompression sickness or pulmonary over inflation syndromes.

Total Bottom Time

The total elapsed time from when the divers leave the surface to the time (rounded up to the next whole minute) they begin their ascent from the bottom or from the deepest depth attained. This time is measured in minutes.

Total Decompression Time

The total elapsed time from when the divers leave the bottom to the time to the time all decompression obligations are met. For No Decompression dives, this is the time the diver reaches the surface. This time is measured in minutes.

Total Time of Dive

The total elapsed time from when the divers leave the surface to the time (rounded up to the next whole minute) until the diver reaches the surface. This time includes all ascent delays and decompression time. This time is measured in minutes.

Umbilical

The composite hose bundle between a dive location and the diver or bell, or between a diver and a bell, which supplies the diver or bell with breathing gas, communications, power, or heat as appropriate to the diving mode or conditions. This includes a safety line between the diver and the dive location or dive bell.

Volume Tank

A pressure vessel connected to the outlet of a compressor and used as an air reservoir.

Working Pressure

The maximum pressure to which a pressure containment device may be exposed under standard operating conditions.

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ATTACHMENT 1

DIVING SUPERVISOR DIVE PLAN BRIEF

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ATTACHMENT 1
DIVING SUPERVISOR DIVE PLAN BRIEF

PROJECT NAME/NUMBER: ______________________________

1. **NOTIFICATIONS –** The following list of notifications is not to be considered all-inclusive and should be modified to fit the intended task. Check off each representative as notified, include the phone number and person talked to:

   Harbor Master: ______________________________

   Pipeline Manager: ______________________________

   Boat Pilot: ______________________________

   Port Services: ______________________________

   Cognizant Authority: ______________________________

   Ambulance/Air Evacuation: ______________________________

   Recompression Chamber: ______________________________

   Medical Facility: ______________________________

   Coast Guard: ______________________________

   U.S. Army Corps of Engineers Representative: ______________________________

   U.S. Navy Representative: ______________________________

   Support Personnel: ______________________________

2. **PERSONNEL ASSIGNMENTS**

   Diving Supervisor/Field Operations Lead: ______________________________

   Senior UXO Supervisor: ______________________________

   Diver/s: ______________________________

   Tender: ______________________________

   Standby Diver: ______________________________

ATTACHMENT 1
DIVING SUPERVISOR DIVE PLAN BRIEF

PROJECT NAME/NUMBER: ____

Tender: ____

Coxswain: ____

Assistance: ____

	YES	NO	COMMENTS
• Has any diver been diving in the last 12 hours?	______	______	____________
• Is any diver taking any type of medication?	______	______	____________
• Does any diver have any aches or pains?	______	______	____________
• Can divers clear on the surface?	______	______	____________
• Is any diver wearing contact lenses?	______	______	____________
• Do divers feel well enough to make the dive?	______	______	____________
• Do divers have any problem making the dive?	______	______	____________
• Do divers know the emergency procedures for the diving mode?	______	______	____________

3. **ENVIRONMENTAL DATA**:

Temperature: Water: __________ Air: ____________________

Tide: High: __________/__________ Low: __________/__________

Visibility expected: ______________ Bottom type: ______________

Current speed/direction: ________________________________

Wind Direction/Speed: __________/__________

Landmarks: ____

ATTACHMENT 1
DIVING SUPERVISOR DIVE PLAN BRIEF

PROJECT NAME/NUMBER: ____

Sunrise/Sunset: ______________/______________

Wave action: Height: _____________ Direction: ______________________________

Dive platform: ____

4. **OBJECTIVES:**

Purpose of the dive (TASK): ____

Location: ____
General comments: ____

Dive schedule: __________/__________ Depth: __________ Max depth: _________

Dive mode to be used: ____

5. **ANTICIPATED HAZARDS**:

Boating: ____

- Ensure the "Code ALPHA" flag is flying from the vessel, or a 1-meter rigid "Code ALPHA" flag is prominently displayed from the non-vessel dive platform (pier, shore, etc.).
- Ensure the "Divers down" flag is also displayed.

Climate: ____

Sea Life: ____

Expected Ordnance: ____

Pollution: ____

Other: ____

6. **EQUIPMENT REQUIREMENTS**:

Diving Mode: ____

ATTACHMENT 1
DIVING SUPERVISOR DIVE PLAN BRIEF

PROJECT NAME/NUMBER: ____

Search Equipment: ____

Recovery Equipment: ____

Explosive Disposal Equipment: ____

Special Task Equipment: ____

7. GENERAL DIVING SAFETY PRECAUTIONS CHECKLIST

- Ensure divers are physically and mentally ready to perform the assigned dive task.
- Determine the exact depth of the dive site through use of lead line or Fathometer.
- Gauge diving and emergency air cylinders prior to diving.
- All dives will be no-decompression dives.
- Ensure the dive platform is in a position for rapid and safe recovery of the divers.
- Each diver is responsible for the condition of his/ her own diving equipment.
- Ensure the standby diver is well briefed and ready to enter the water.
- The buddy system will be used whenever possible. If the buddy system is not used or inappropriate for the dive, the diver will be tended.
- Ensure the international code "alpha" and "divers down" are prominently displayed. If diving is not conducted from a vessel, then a 1-meter square rigid replica of the "alpha" flag will be displayed.
- Ensure divers are briefed and protected against local harmful marine life.
- The Diving Supervisor/ Lead Diver must be aware of local ship and small boat traffic in the vicinity of the diving operation.
- Ensure the appropriate diving mode and dress have been selected for the task at hand.
- All dives conducted where there is not free access to the surface must be tended dives.
- Do not inflate life jacket or BCD where ascent to the surface is restricted.
- The Diving Supervisor/ Lead Diver will use the Pre-dive and Post-dive check-off sheets, Attachment 2 and 3, respectively.
- Review the methods of diver recall in accordance with the HASP.
- The dive will be aborted in the event of any equipment malfunction.
- Inflate your life vest if surfacing with injuries or excessive fatigue.
- Use the proper ascent and descent rates of 75 feet per minute for descent and 30 feet per minute for ascent.
- Divers will not position themselves between any objects (camels, pier, boat, etc.).

PROJECT NAME/NUMBER: ____

- Brief task-specific safety precautions (UXO diving, altitude diving, ordnance/ explosive safety, etc.).
- Brief special line-pull signals Attachment 8.
- Brief appropriate ordnance safety precautions.
- If necessary, review cold water precautions (EHS 2-02 Attachment 9).

8. **COMMUNICATIONS:**

Radio frequency: ____

Radio call signs:

Primary: ____

Secondary: ____

Telephone location: ____

Site cell phone number: ____

Other cell phones: ____

9. **SPECIAL CONSIDERATIONS**:

Meals: ______________ Water: _______________ Heat source: _______________

Clothing change: ____

10. **EMERGENCY PROCEDURES**: Review as outlined in Project HASP and DSPM (EHS 2-02 Attachments 4 and 5).

ATTACHMENT 2

DIVING SUPERVISOR PRE-DIVE CHECKLIST

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ATTACHMENT 2

DIVING SUPERVISOR PRE-DIVE CHECKLIST

PROJECT NAME/NUMBER:____

1. DIVING SUPERVISOR PRE-DIVE CHECKLIST FOR SCUBA DIVING

a. All divers shall have the following equipment, at a minimum:

_______ Proper dress for dive conditions, dry/wet suit, coveralls

_______ Safety Harness w/tending line or witness float attached for single diver
NOTE**: Mandatory for projects which fall under EM385-1-1 (if any diver is tended).**

_______ Adequate emergency breathing supply with separate independent regulator

_______ SCUBA with regulator

_______ Buoyancy Compensator (BC)

_______ Submersible cylinder pressure gauge

_______ Weight belt

_______ Mask

_______ Knife

_______ Depth gauge

_______ Diving watch or diving computer

_______ Fins

_______ Cylinder pressure is adequate for both the emergency air supply ***(90% capacity @ 2700 psig)*** and primary SCUBA supply ***(2500 psig minimum)***.

_______ All quick-release buckles and fastenings can be reached by either hand and are properly rigged for quick release.

_______ Weight belt is outside of all other belts, straps, and equipment, and is not likely to become pinched under the bottom edge of the cylinders.

_______ Buoyancy Compensator is not constrained, is free to expand.

_______ Check position of the knife to ensure that it will remain with the diver no matter what equipment he may jettison.

_______ Conduct time check and synchronize watches.

ATTACHMENT 2

DIVING SUPERVISOR PRE-DIVE CHECKLIST

PROJECT NAME/NUMBER:____

_______ Open cylinder valve and then back off 1/4 to 1/2 turn.

_______ Ensure all inflation hoses are attached and function properly.

_______ Depth gauge is zeroed.

_______ AGA/ FFM Pre-Dive Checks (Skip if not applicable):

- Adjust pressure equalizer pad.
- Ensure all screws on mask are tight, and exhaust valve retaining ring is tight.
- Check connection from mask to supply hose.
- Check comm wire connection and through water transmitter.
- Don Mask.
- Inhale deeply to turn on positive pressure. (If equipped)
- Check positive pressure flow.

________ Have diver breathe for 30 seconds. While doing this, diver should be alert for any impurities in the air or for any unusual physiological reactions.

_______ Conduct final review of the dive plan.

_______ Brief the divers on the following reasons for terminating the dive:

- The diver requests termination.
- The diver fails to respond correctly to communications or signals.
- Communications are lost and cannot be quickly reestablished.
- The diver begins to use his/her reserve breathing air.
- Puncture/tear of a dry suit.

_______ Divers physically and mentally ready to enter the water.

_______ Ladder is in place to retrieve divers from water.

_______ Divers know the maximum depth and bottom time.

_______ Review proper/special line pull signals.

_______ Code Alpha and Divers Down flags are displayed.

______ Conduct Dive Supe checks on Standby diver.

______ Ensure standby diver knows searching signals.

______ Verify that personnel and equipment are ready to give proper visual, sound, or radio signals to warn off other vessels.

______ Ensure O_2 kit is on dive station with adequate supply, and the O2 bottle has been gauged and documented.

______ Diver or divers are now ready to enter the water.

ATTACHMENT 2

DIVING SUPERVISOR PRE-DIVE CHECKLIST

PROJECT NAME/NUMBER:____

b. Surface Check :

_______ Conduct a breathing check of the SCUBA. Breathing should be easy, without resistance, and with no evidence of water leaks.

_______ Visually check dive partner's equipment for leaks, especially at all connection points (cylinder valves hoses at regulator and mouthpiece).

_______ Check face mask seal.

_______ Check partner for loose or entangled straps.

_______ Check buoyancy. SCUBA divers should strive for neutral buoyancy.

_______ If divers are wearing a dry suit, check valve function and for leaks.

_______ Orient yourself with your surroundings. Note any obstructions that you may encounter upon surfacing.

NOTES:

1. ***Ensure divers are not sick or have not been recently treated for an injury or illness.***
2. ***Ensure all dive station personnel are monitored during surface intervals when extreme weather conditions exist.***

ATTACHMENT 2

DIVING SUPERVISOR PRE-DIVE CHECKLIST

PROJECT NAME/NUMBER:____

2. DIVING SUPERVISOR'S PRE-DIVE CHECKLIST FOR SURFACE-SUPPLIED DIVING

CAUTION: ***This checklist is an overview intended for use with the detailed Operating Procedures (OPs) from theappropriate equipment checklists as outlined in Attachment 11 and the specific equipment O&M technical manual*.**

a. Basic Preparation:

_______ ***Dives deeper than 100 FSW or dives requiring decompression***, verify that a recompression chamber is present on the diving station and is on line.

_______ Verify that proper signals indicating underwater operations being conducted are displayed correctly.

_______ Ensure that all personnel concerned, or in the vicinity, are informed of diving operations.

_______ Determine that all valves, switches, controls, and equipment components affecting diving operations are tagged-out to prevent accidental shut-down or activation.

b. Equipment Protection:

_______ Assemble all members of the diving team and support personnel (winch operators, boat crew, etc.) for a pre-dive briefing.

_______ Assemble and lay out all dive equipment, both primary equipment and standby spares for diver (or standby diver), including all accessory equipment and tools.

_______ Check all equipment for superficial wear, tears, dents, distortion, or other discrepancies.

_______ Check all masks, helmets, view ports, faceplates, seals, and visors for damage.

_______ Check all harnesses, laces, strain relief, and lanyards for wear; replace as needed.

c. Helmets and Masks:

_______ Ensure that all set up and operating procedures have been completed in accordance with the appropriate Technical Manual and Operating Procedures.

d. General Equipment:

_______ Check that all accessory equipment – tools, lights, special systems, spares, etc. are on site and in working order. In testing lights, tests should be conducted with lights submerged in water and extinguished before removal, to prevent overheating and failure.

ATTACHMENT 2

DIVING SUPERVISOR PRE-DIVE CHECKLIST

PROJECT NAME/NUMBER:____

_______ Erect diving stage or attach diving ladder. In the case of the stage, ensure that the screw pin shackle connecting the stage line is securely fastened with the shackle pin seized with wire or a safety shackle is used to help prevent opening.

_______ Ensure first aid kits, portable O_2, and automatic external defibrillators are available and working.

e. Preparing the Diving System:

_______ Check that a primary and suitable back-up air supply is available with a capacityin terms of purity, volume, and supply pressure to completely service all divers and standby diver, including decompression, recompressions, and accessory equipment throughout all phases of the planned operation.

_______ Verify that all diving system operating procedures have been conducted to properly align the dive system.

_______ Ensure that qualified personnel are available to operate and stand watch on the dive system.

f. Compressors:

_______ Determine that sufficient fuel, coolant, lubricants, and antifreeze are available to service all components throughout the operation. All compressors should be fully fueled, lubricated, and serviced (with any spillages cleaned up completely).

_______ Check maintenance and repair logs to ensure the suitability of the compressor (both primary and back-up) to support the operation.

_______ Verify that all compressor controls are properly marked, and appropriate valves are tagged with "***Divers Air Supply - Do Not Touch***" signs.

_______ Ensure that the compressor is secure in the diving craft and will not be subject to operating angles, caused by roll or pitch that will exceed 15 degrees from the horizontal.

_______ Verify that oil in the compressor is an approved type. Check that the compressor oil does not overflow the FULL mark; contamination of air supply could result from fumes or oil mist.

_______ Check that compressor exhaust is vented away from work areas and, specifically, does not foul the compressor intake.

_______ Check that compressor intake is obtaining a free and pure suction without contamination. Use pipe to lead intake to a clear suction location if necessary.

_______ Check all filters, cleaners, and oil separators for cleanliness.

ATTACHMENT 2

DIVING SUPERVISOR PRE-DIVE CHECKLIST

PROJECT NAME/NUMBER:____

_______ Bleed off all condensed moisture from filters and from the bottom of volume tanks. Check all manifold drain plugs, and that all petcocks are closed.

_______ Check that all belt-guards are properly in place on drive units.

_______ Check all pressure-release valves, check valves and automatic unloaders.

_______ Verify that all supply hoses running to and from compressor have proper leads, do not pass near high-heat areas such as steam lines, are free of kinks and bends, and are not exposed in such a way that they could be rolled over, damaged, or severed by machinery or other means.

_______ Verify that all pressure supply hoses have safety lines and strain reliefs properly attached.

g. Activate the Air Supply in accordance with approved Operating Procedures:

i. Compressors:

_______ Ensure that all warm-up procedures are completely followed.

_______ Check all petcocks, filler valves, filler caps, overflow points, bleed valves, and drain plugs for leakage or malfunction of any kind.

_______ Verify that there is a properly functioning pressure gauge on the air receiver and that the compressor is meeting its delivery requirements.

ii. Cylinders:

_______ Gauge all cylinders for proper pressure.

_______ Verify availability and suitability of reserve cylinders.

_______ Check all manifolds and valves for operation.

_______ Activate and check delivery.

For all supply systems, double check "Do Not Touch" tags (tag out).

h. Diving Hoses:

_______ Ensure all hoses have a clear path and are protected from excessive heating and damage.

_______ Ensure that the hose (or any length) has not been used in a burst test program. No hose length involved in such a program will be part of an operational diving hose.

_______ Check that hoses are free of moisture, packing material, or chalk.

ATTACHMENT 2

DIVING SUPERVISOR PRE-DIVE CHECKLIST

PROJECT NAME/NUMBER:____

_______ Soap test hose connections after connection to air supply and pressurization.

_______ Ensure umbilical boots are in good condition.

i. Test Equipment with Activated Air Supply:

_______ Hook up all air hoses to helmets, masks, and chamber; make connections between back-up supply and primary supply manifold.

_______ Verify flow to helmets and masks from primary and secondary air supply.

_______ Check all exhaust and non-return valves.

_______ Hook up and test all communications.

_______ Check air flow from both primary and back-up supplies to chamber.

j. Recompression Chamber Checkout (Pre-dive only):

_______ Check that chamber is completely free and clear of all combustible materials.

_______ Check primary and back-up air supply to chamber and all pressure gauges.

_______ Check that chamber is free of all odors or other "contaminants."

_______ Hook up and test all communications.

_______ Check air flow from both primary and back-up supplies to chamber.

k. Final Preparations:

_______ Verify that all necessary records, logs, and timesheets are on the diving station.

_______ Check that appropriate decompression tables are readily at hand.

_______ Place the dressing bench in position, reasonably close to the diving ladder or stage, to minimize diver travel.

l. Dress Diver/s:

_______ Dress divers in accordance with requirements of approved workplan and in considerations of the site environmental conditions.

ATTACHMENT 3

DIVING SUPERVISOR POST-DIVE CHECKLIST

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ATTACHMENT 3

DIVING SUPERVISOR POST-DIVE CHECKLIST

PROJECT NAME/NUMBER:____

______ Check the physical condition of the diver.

______ Instruct the diver to report any physical problems or adverse physiologicaleffects including symptoms of decompression sickness.

______ Advise the diver of the location of the closest recompression chamber that isready for use.

______ Alert the diver to the potential hazards of ascending to altitude, including flyingafter diving (see DSPM Section 18)

______ Assemble diving equipment and return to site support facility.

______ Have divers shower and consume warm liquids, avoid beverages with caffeine.

______ Observe the divers on the surface for symptoms of diving disorders for aminimum of 10 minutes before allowing the divers to leave the dive site.

______ Wash all diving equipment in fresh water and hang to dry.

______ Reorder/replace equipment as necessary.

______ Complete a dive profile log for all divers and submit the log to the Chairman ofthe Diving Review Board for input into TMR's master dive log.

ATTACHMENT 4

EMERGENCY PROCEDURES

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ATTACHMENT 4
EMERGENCY PROCEDURES

GENERAL EMERGENCY PROCEDURES

1. Decompression Sickness or Arterial Gas Embolism:

- Recall all divers.
- Administer first aid, CPR and emergency O_2 as required.
- Notify Recompression Chamber.
- Begin transport to chamber on oxygen.

2. Fire in equipment:

- Evaluate effect of fire on diver AND topside crew.
- Terminate dive.
- Inform crew and diver of action planned.
- Activate plan outlined in Project DOP.

3. Explosive Detonation with Divers in the Water:

- Try to establish communications with the divers using standard line pull signals or communications.
- If contact is established with the divers, recall, recover, and administer first aid as required. Transport in accordance with project DOP as required.
- If communications cannot be established, activate the standby diver and recover the divers via the tending line, and administer first aid as required.
- Request medical assistance and remember that unconscious divers should be treated for possible AGE
- Discontinue diving operations until the cause of the explosion is determined.

4. Boat breakdown:

This situation is considered to constitute an emergency due to the loss of control of the divers.

- Recall and recover the divers.
- Discontinue diving operations.
- Deploy the anchor
- Request assistance via radio, phone, or signals.

5. Variations in ascent rate:

Always ascend at a rate of 30 feet per minute (FPM) (20 seconds per 10 feet of seawater [FSW]). Minor variations in the rate of travel between 20 and 40 FSW/minute are acceptable. Any variation in the rate of ascent must be corrected in accordance with the following procedures; however, a delay of up to 1 minute in reaching the first decompression stop can be ignored.

- **Travel Rate Exceeded.** On a Standard Air Dive, if the rate of ascent is greater than 30 FPM, STOP THE ASCENT, allow the watches to catch up, and then continue ascent. If the decompression stop is arrived at early, start the stop time after the watches catch up.

- **Delay greater than 1 minute, deeper than 50 FSW**. Add the total delay time (rounded up to the next whole minute) to the bottom time, re-compute a new decompression schedule, and decompress accordingly.
- **Delay greater than 1 minute, shallower than 50 FSW**. If the rate of ascent is less than 30 FPM, add the delay time to the diver's first decompression stop. If the delay is between stops, disregard the delay. The delay time is rounded up tothe next whole minute.

6. Unplanned Ascent (Blowup):

- **Ascent from 20 Feet or Shallower with No Decompression Stops Required.**No recompression is required if the diver surfaces from 20 feet or shallower but was within no-decompression limits and is asymptomatic. The diver should be observed on the surface for 1 hour. Consider administering O_2.
- **Ascent from 20 Feet or Shallower (Shallow Surfacing) with Decompression Stops Required.** If decompression is required and the diver surfaces from 20 FSW or shallower (missed the 20- and/or 10-foot stop) and is asymptomatic, thediver is returned to that decompression stop.
  - If the time from the surface back to the stop was less than 1 minute,add 1 minute to the stop.
  - If the time from the surface back to the stop was more than 1 minute andthe diver remains asymptomatic, multiply the 20- and/or 10-foot stops by1.5.
  - Observe diver for 1 hour. Consider administering O_2.
- **Ascent from Deeper than 20 Feet (Uncontrolled Ascent).** Any unexpected surfacing of the diver from depths in excess of 20 feet is considered an uncontrolled ascent. If the diver is within no-decompression limits and asymptomatic, he/she should be observed for at least 1 hour on the surface. Recompression is not necessary unless symptoms develop. Consider administering emergency O_2.
- **Asymptomatic Uncontrolled Ascent.** Asymptomatic divers who experience an uncontrolled ascent and who have missed decompression stops are treated by recompression based on the amount of decompression missed as follows:
  - **Oxygen Available.** Immediately compress the diver to 60 feet in the recompression chamber. If less than 30 minutes of decompression (total ascent time from the tables) was missed, decompress from 60 feet on appropriate Treatment Table. If more than 30 minutes of decompressionwas missed, decompress from 60 feet on appropriate Treatment Table.
  - **Oxygen Not Available**. If less than 30 minutes of decompression was missed, compress the diver to 100 feet in the recompression chamber andtreat on appropriate Treatment Table. If more than 30 minutes was missed, compress to 165 feet and treat on appropriate Treatment Table.

- **Symptomatic Uncontrolled Ascent.** If a diver has had an uncontrolled ascent and has any symptoms, he/she should be recompressed immediately in a recompression chamber to 60 FWS.
    - If the diver surfaced from 60 FWS or shallower, compress to 60 FSW and begin appropriate Treatment Table.
    - If the diver surfaced from a greater depth, compress to 60 FSW or depth where the symptoms are significantly improved, not to exceed 165 FSW, and begin appropriate Treatment Table.

7. Emergency Evacuation:

- Notify diver and dive team of emergency and abort dive.
- Evacuate all unnecessary personnel.
- Decompress the diver (if required) and recover. If decompression is not possible, follow omitted decompression procedures.

ATTACHMENT 4

EMERGENCY PROCEDURES

SCUBA EMERGENCY PROCEDURES

1. **Buddy Separation** – Make a 360-degree check, above and below; if your buddy is not found, surface immediately. Check the surface for bubbles and notify the Diving Supervisor/ Lead Diver immediately.
2. **Lost Diver** – The first stage of a lost diver is when communications have been lost and emergency recall has failed.
   - Initiate diver recall.
   - Wait 1 minute for response.
   - Deploy lost diver buoy.
   - Deploy standby diver (Dive Supervisor's/ Lead Diver's discretion); follow bubblesor conduct expanding circle line search from last known position.
   - Notify ships/ boats in the area to look out for lost diver and request assistancefrom the Coast Guard Rescue Center, if necessary.
3. **Loss of Air/Equipment Malfunction (SCUBA)**
   - Signal buddy/surface and abort dive.
   - Buddy breath/activate reserve/breath from emergency air supply.
   - Exhale to the surface.
4. **Mechanical Injury:**
   - Signal buddy/surface and abort dive.
   - Inform DS.
   - Rule out possible decompression sickness.
   - If immediate treatment required, recall all divers and transport to hospital.
5. **Fouled/Trapped Diver:**
   - Don't panic, stop and think!
   - Notify your buddy diver or topside, if possible (2-2-2 fouled and need assistance,or 3-3-3 fouled and can clear myself).
   - Carefully and calmly try to work yourself free of the entanglement.
   - If required, ditch your equipment and make a buoyant ascent to the surface.
   - If the diver is trapped, the buddy diver should mark the position of the trapped diver with a circle line, his tending line or any available method of marking the trapped diver's position, and then surface and report to the Diving Supervisor.
   - The Diving Supervisor/ Lead Diver will formulate a rescue plan, while the diver delivers additional air to the trapped diver.
   - The DS will then brief the rescue plan to the dive teamand execute the rescue.

ATTACHMENT 4

EMERGENCY PROCEDURES

SURFACE-SUPPLIED AIR EMERGENCY PROCEDURES

1. Loss of Breathing Media

- Re-establish breathing media supply:
  - Activate topside secondary breathing media supply
  - Diver initiate emergency procedure using bailout bottle.
  - **<u>ONLY AS A LAST RESORT</u>** – Pressurize the diver's pneumofathometer hose (135 PSI) and have the diver insert the hose into his/her helmet or mask.
- Alert standby diver.
- Have stricken diver go to bell, stage, or ladder.
- If required, send standby diver to assist.
- Terminate dive.

2. Loss of Communications

- Attempt to establish communications with line pull signals.
- Put constant air to the diver's pneumofathometer.
- Alert standby diver.
- If communications are established using line pull signals, abort dive, and decompress if required.
- If communications are not established, send stand-by diver to diver's assistance, abort dive, and decompress if required.

3. Fouled or Trapped Diver

- Avoid panic and ensure diver does NOT ditch equipment.
- Diver informs topside — gives a detailed report.
- Alert standby diver.
- Diver determines the extent of entrapment.
- Diver attempts to free yourself.
- If required, deploy standby for assistance.
- Abort dive and decompress if required

4. Injury in the Water

- Diver informs topside of injury and extent — gives a detailed report.
- Alert standby diver.

- If required, deploy standby diver to assist stricken diver.
- Abort dive and follow decompression protocol unless injury indicates a greater risk than omitted decompression. Check surface decompression tables for alternate protocol.
- Request required medical assistance.

5. Severance of Divers Air Supply

- Diver initiates emergency procedure using bailout bottle.
- **If pneumofathometer hose intact and then ONLY AS A LAST RESORT**—Pressurize the diver's pneumofathometer hose (135 PSI) and have the diver insert the hose into his helmet or mask.
- Alert standby diver.
- Abort dive and decompress.
- Deploy standby diver with more air and/or assist stricken diver if required.

6. Severance of Complete Umbilical

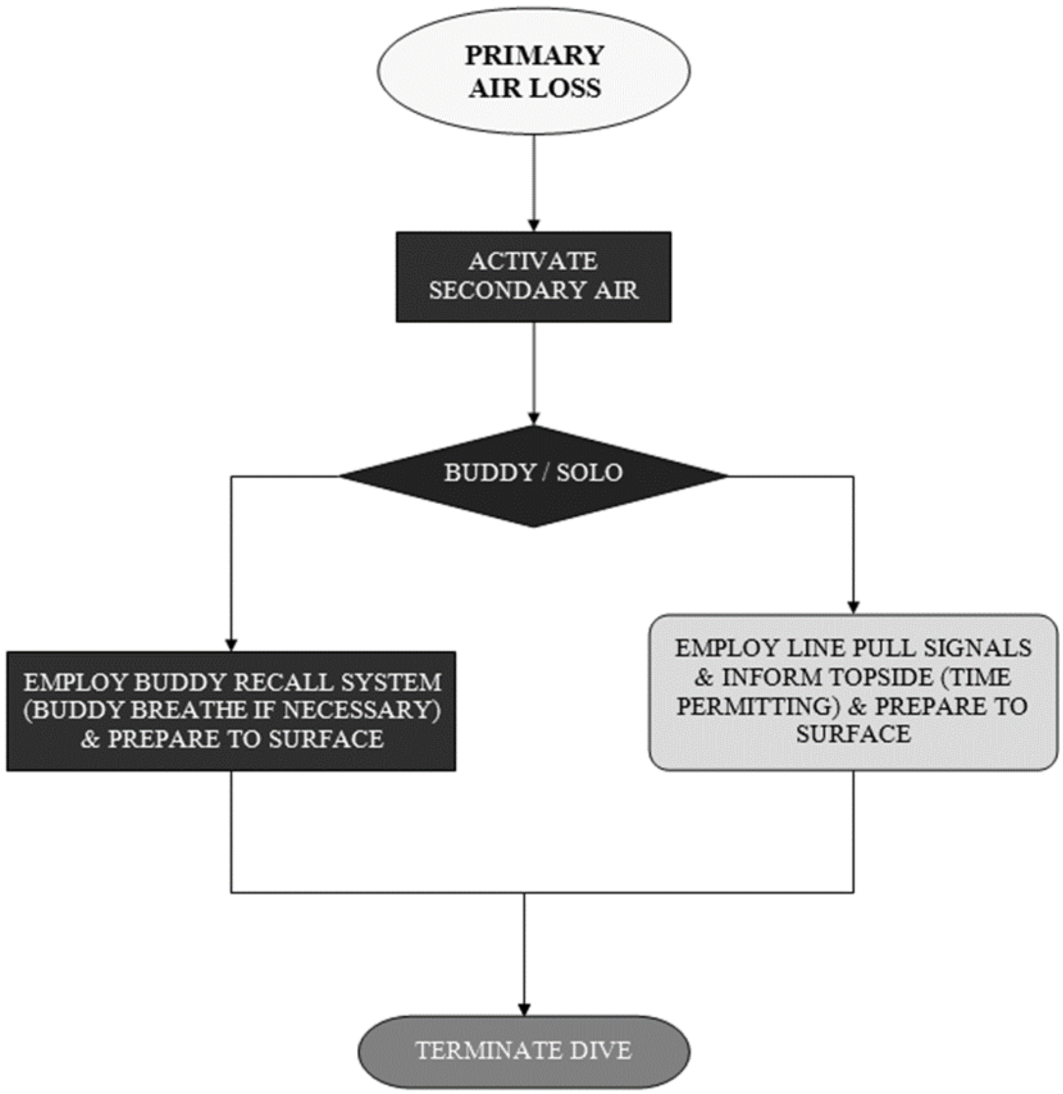
- Diver initiates emergency procedure using bailout bottle.
- Topside alerts standby diver.
- Deploy standby diver down stage line, diver's umbilical (if visible), or descent linewith additional air supply (pneumofathometer, if necessary) to assist stricken diverand inform topside of conditions.
- Abort dive and decompress. Check surface decompression tables for shorter water time.

ATTACHMENT 4

EMERGENCY PROCEDURES

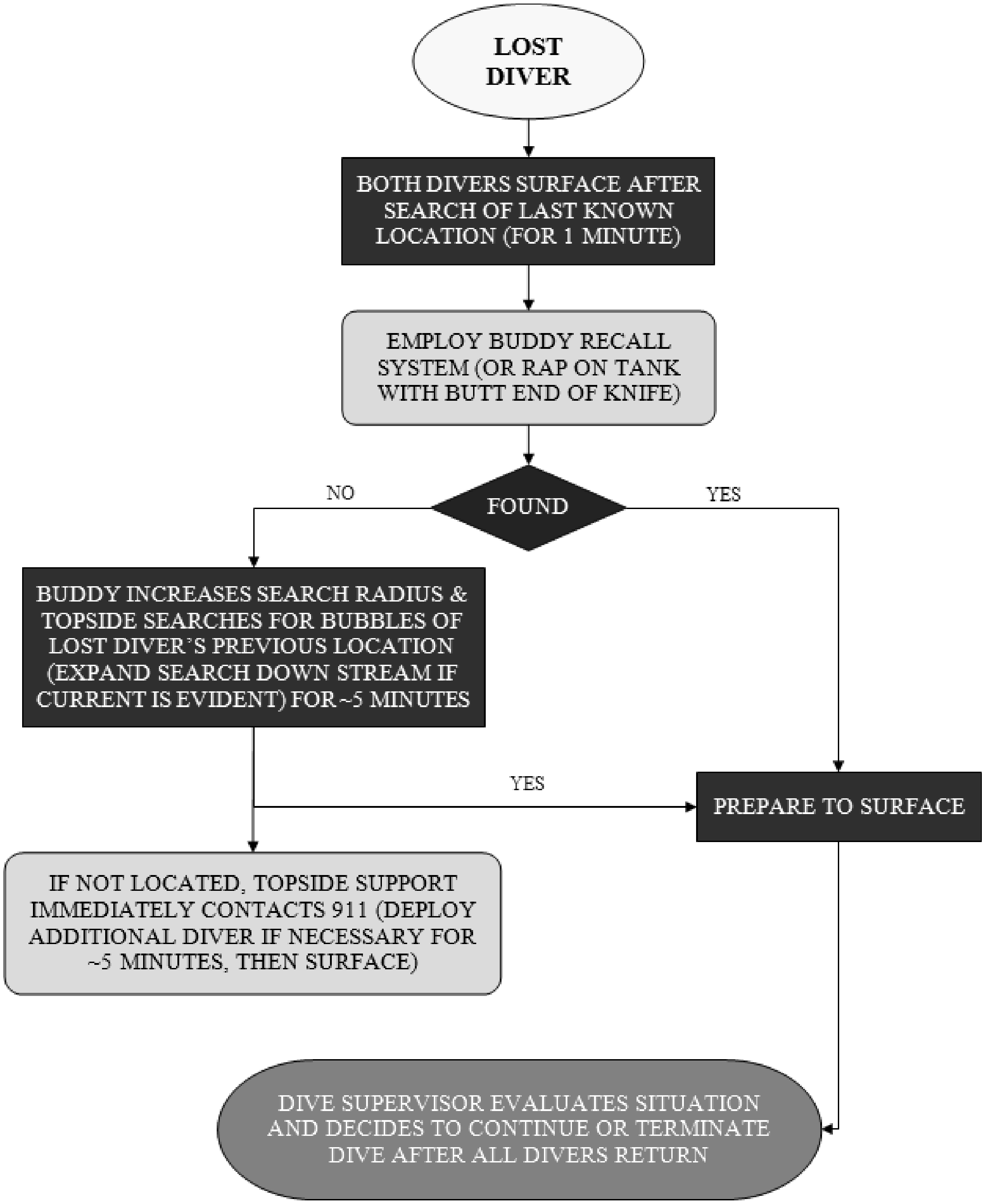
DIVING EMERGENCY DECISION FLOW CHARTS

SCUBA EMERGENCY PROCEDURES



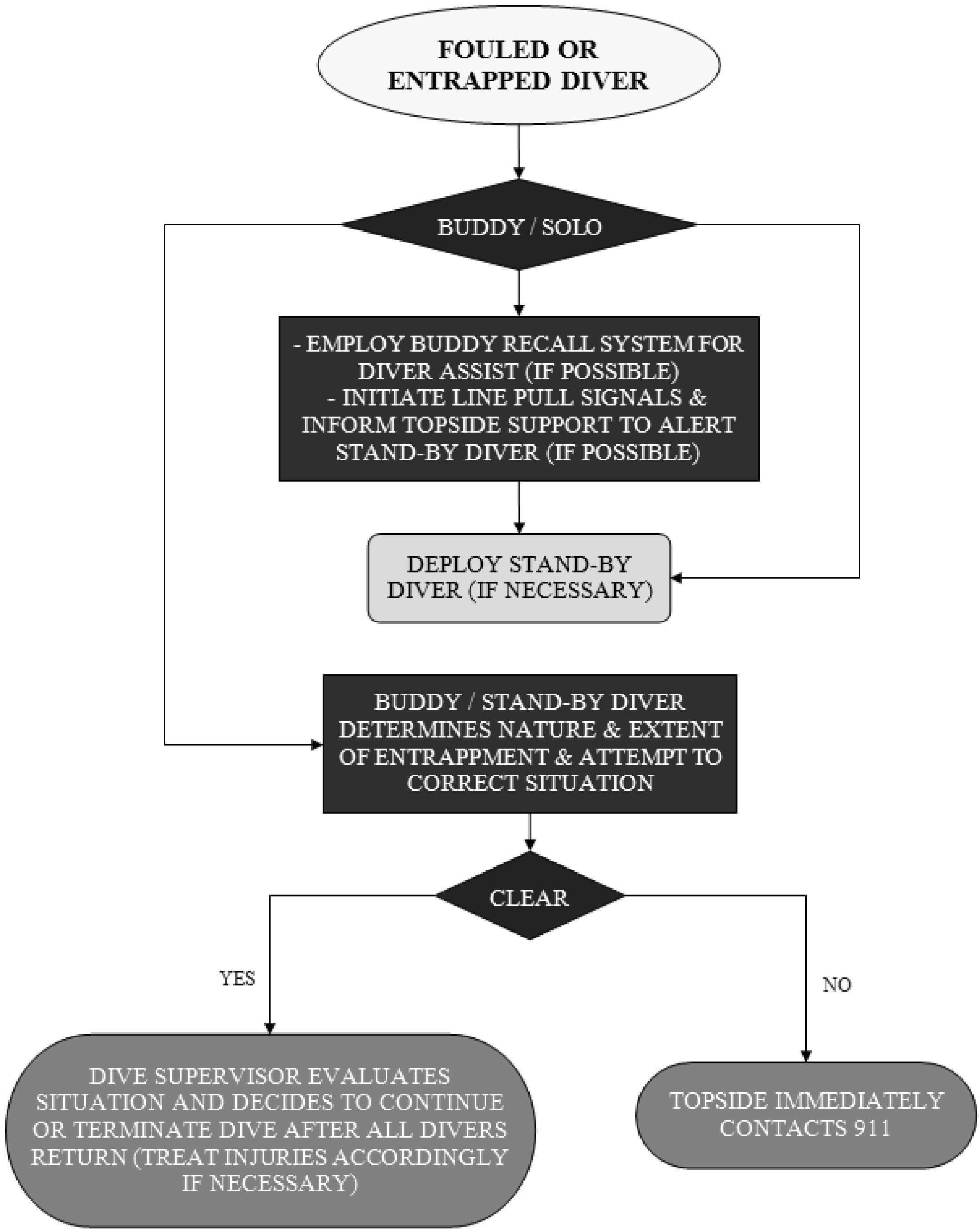
ATTACHMENT 4

EMERGENCY PROCEDURES



ATTACHMENT 4

EMERGENCY PROCEDURES



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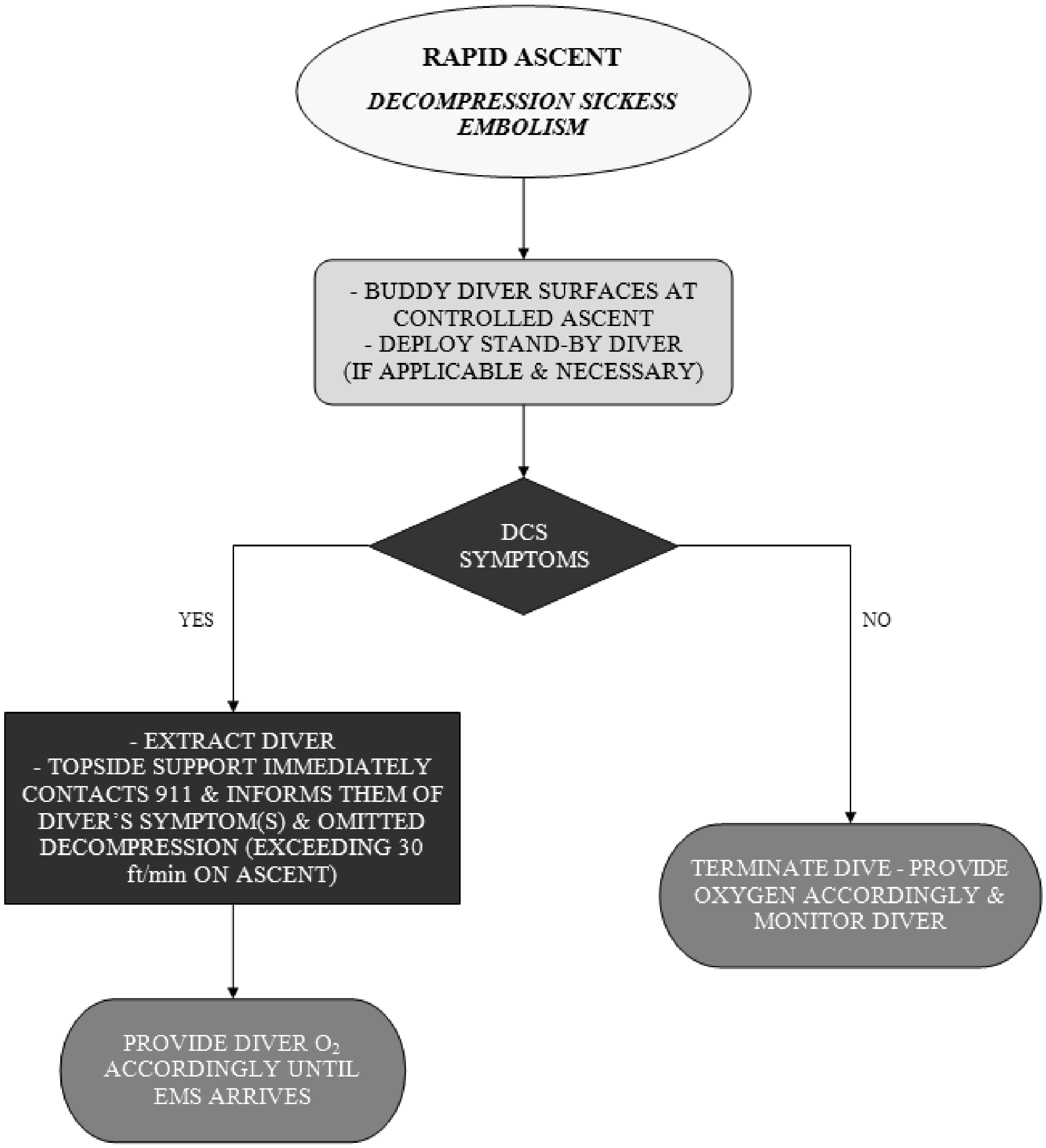

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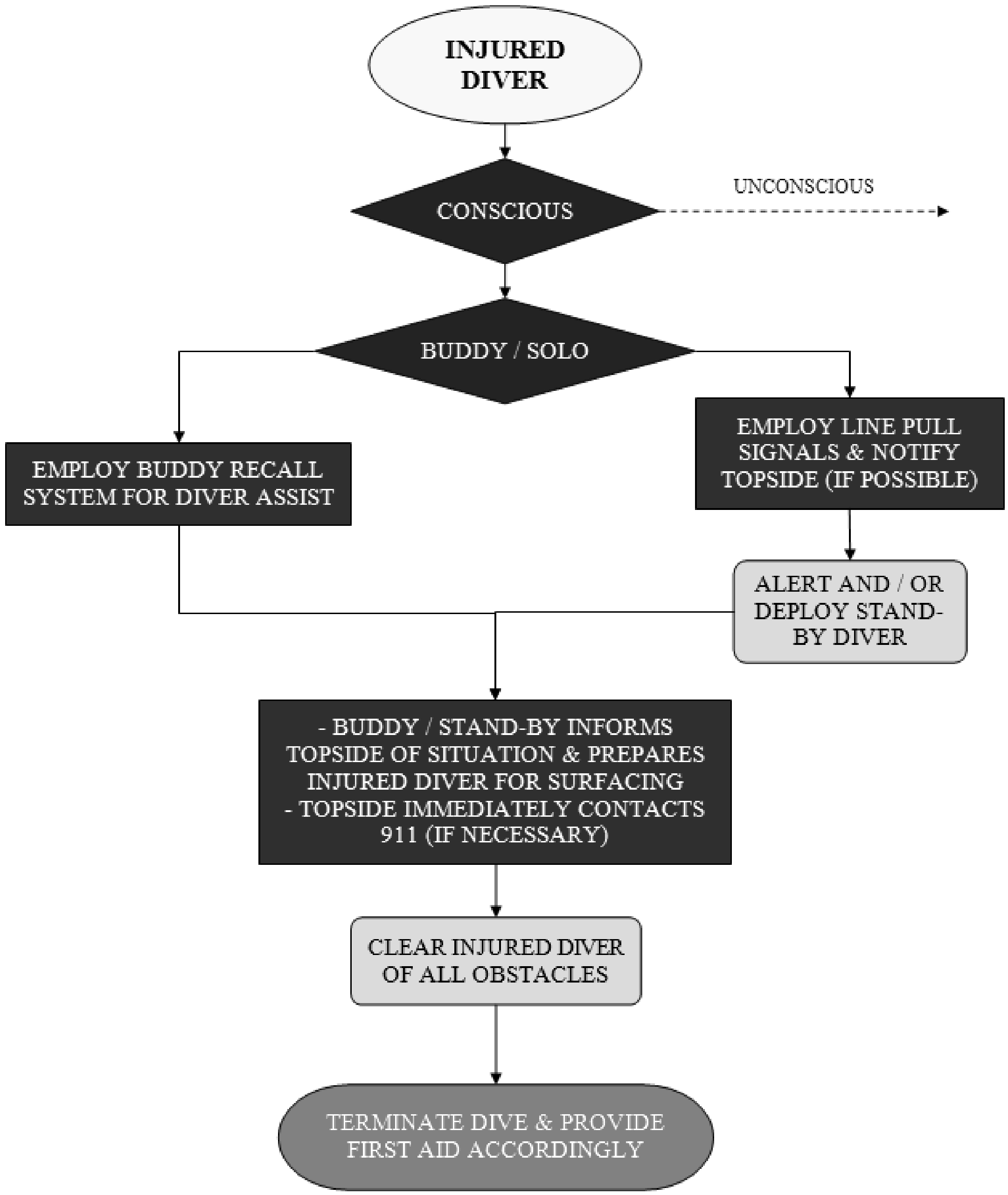
EMERGENCY PROCEDURES



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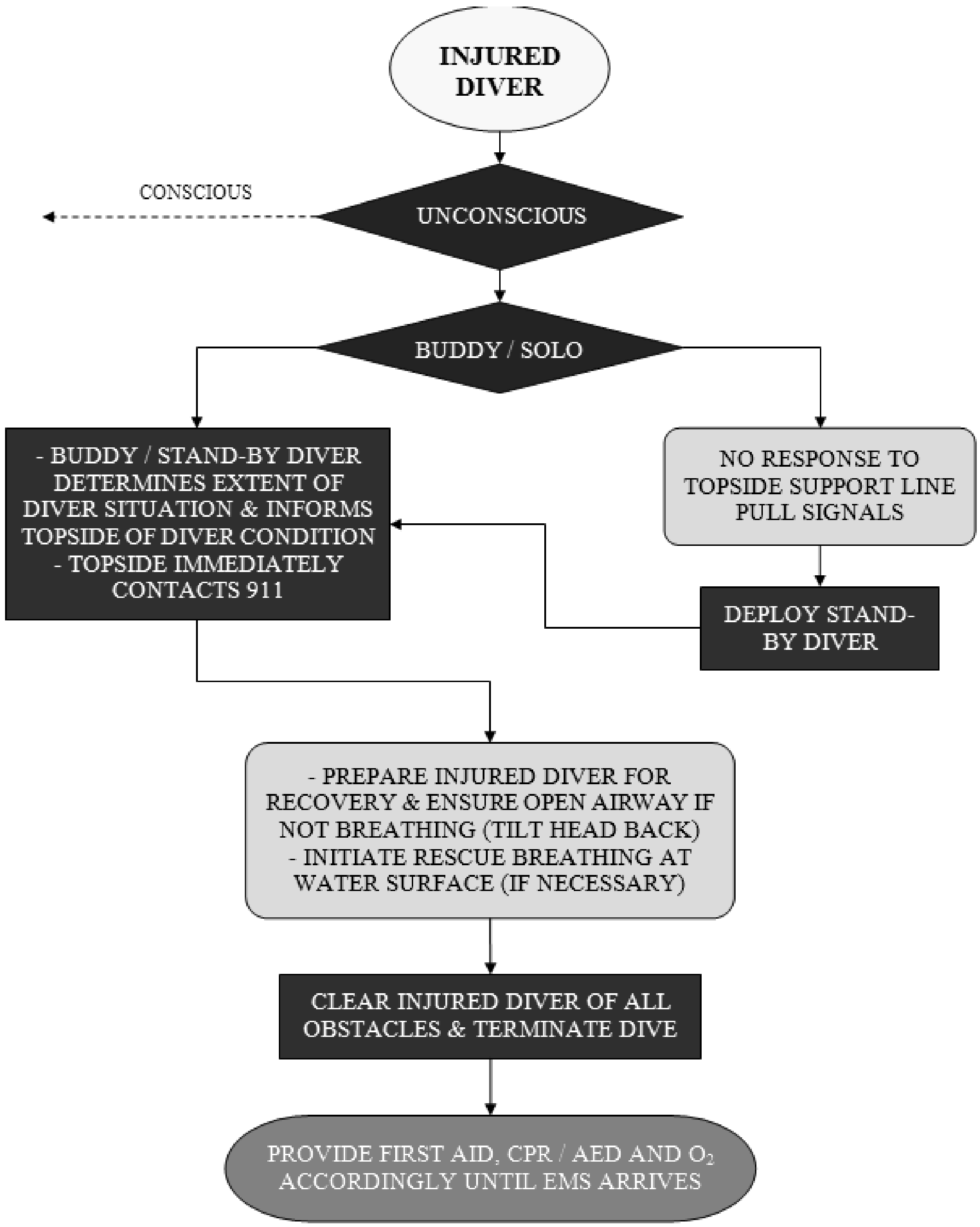
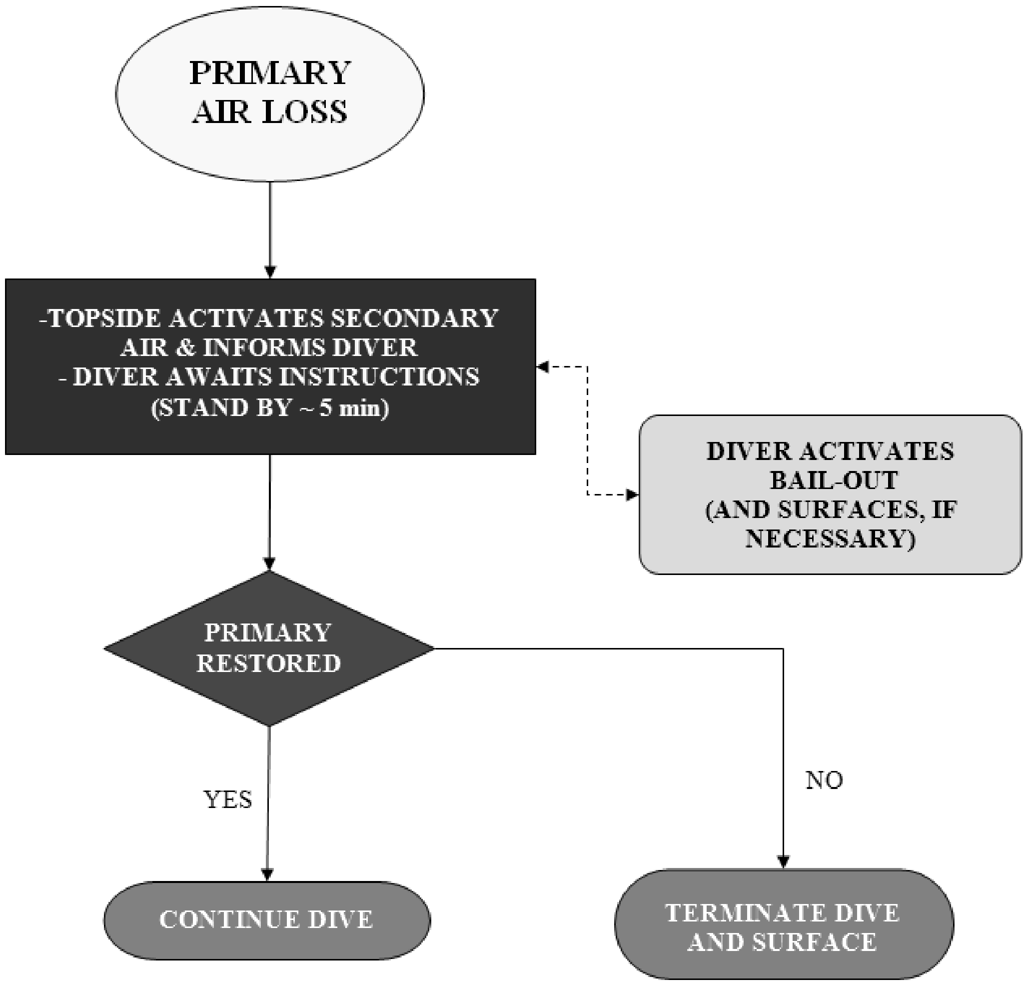


ATTACHMENT 4

EMERGENCY PROCEDURES

SURFACE SUPPLIED EMERGENCY PROCEDURES



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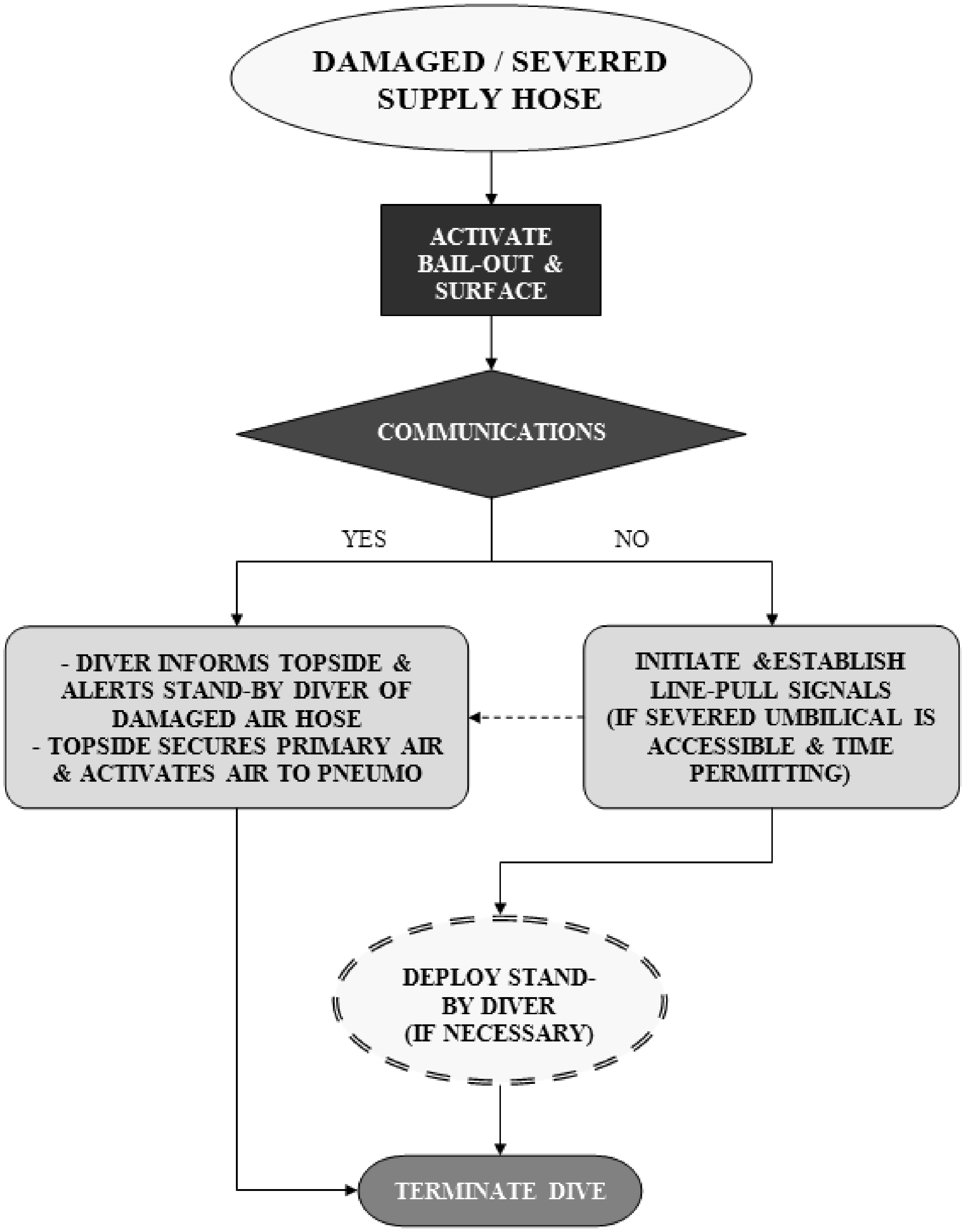
EMERGENCY PROCEDURES



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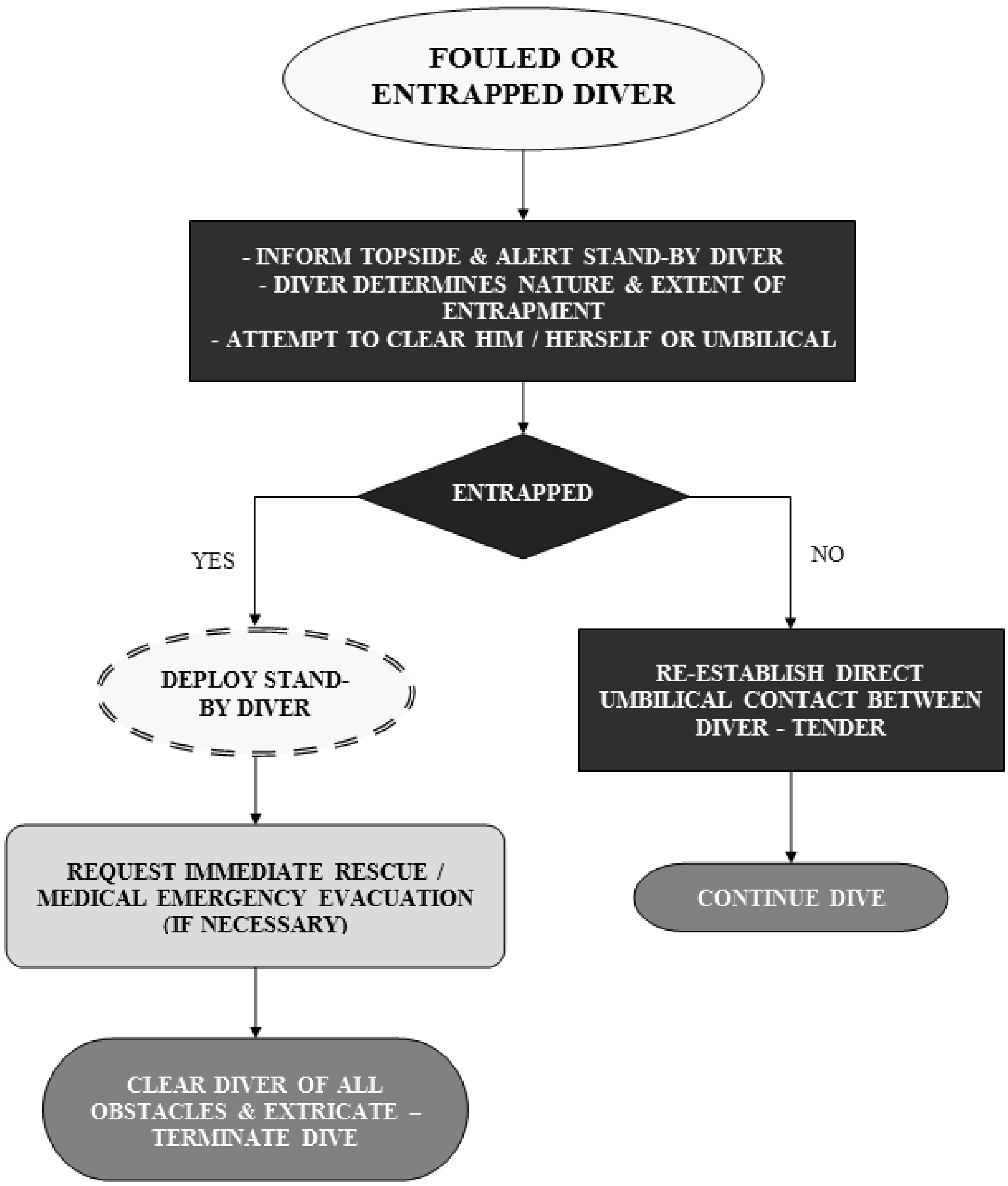
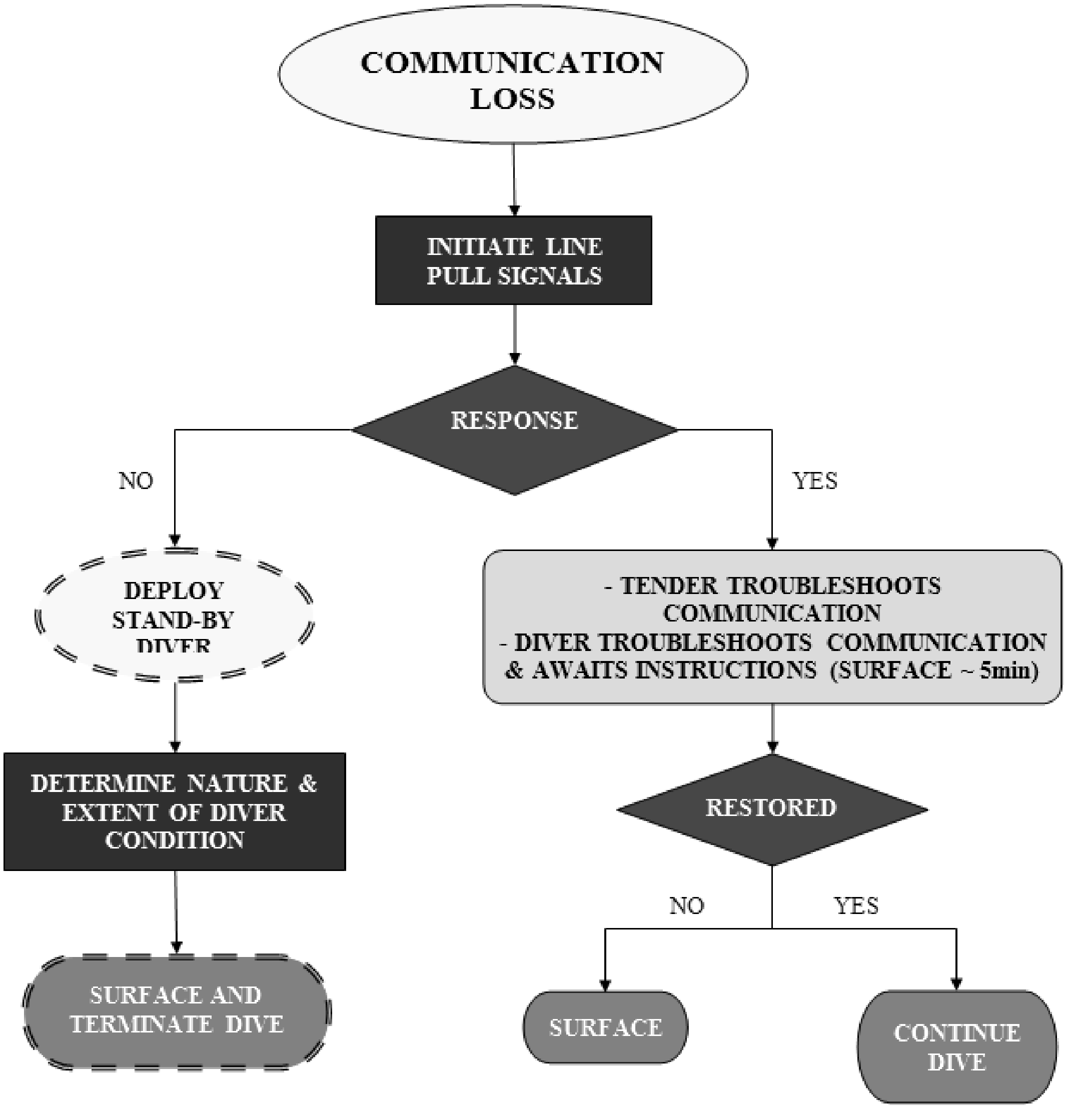
EMERGENCY PROCEDURES



ATTACHMENT 4
EMERGENCY PROCEDURES



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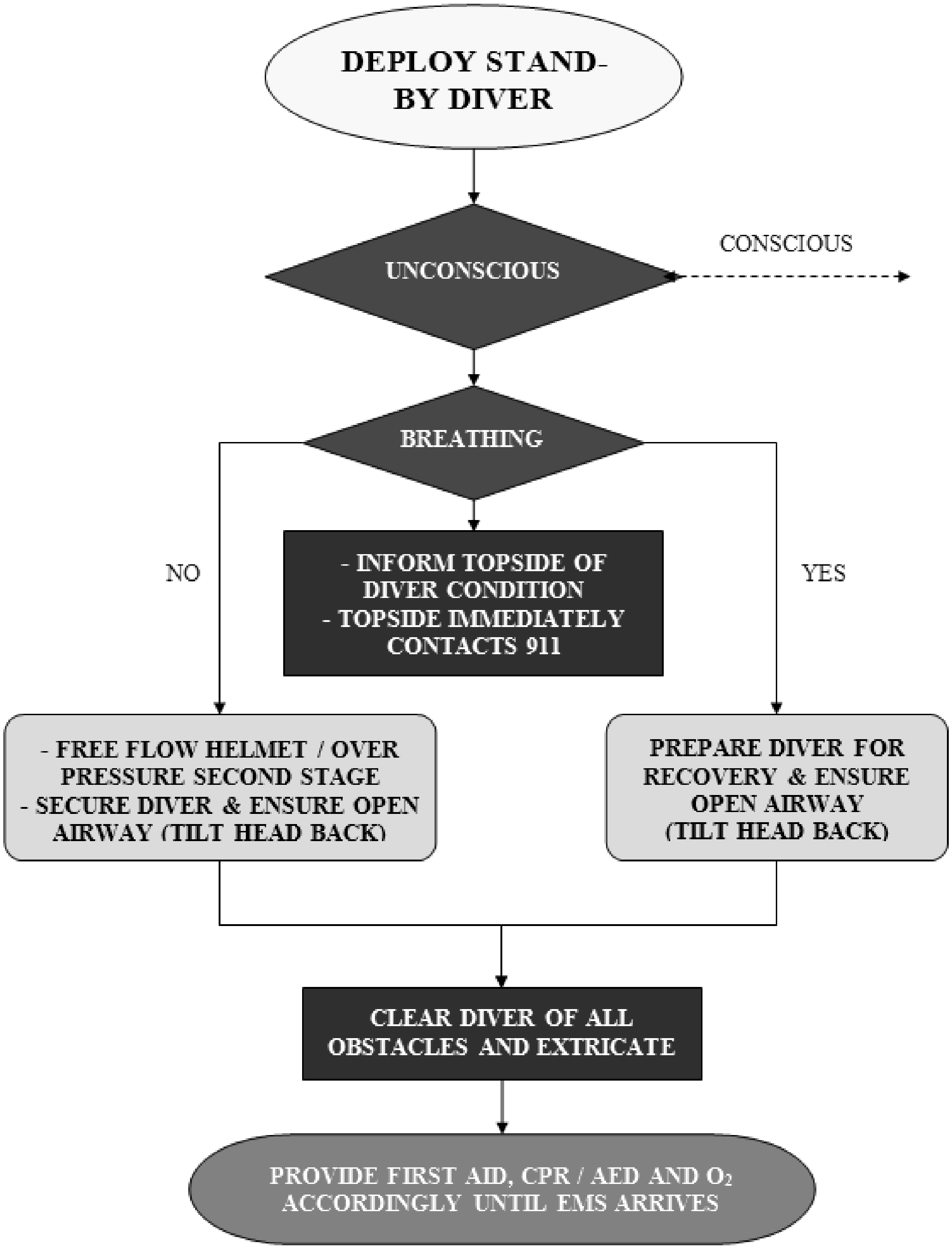

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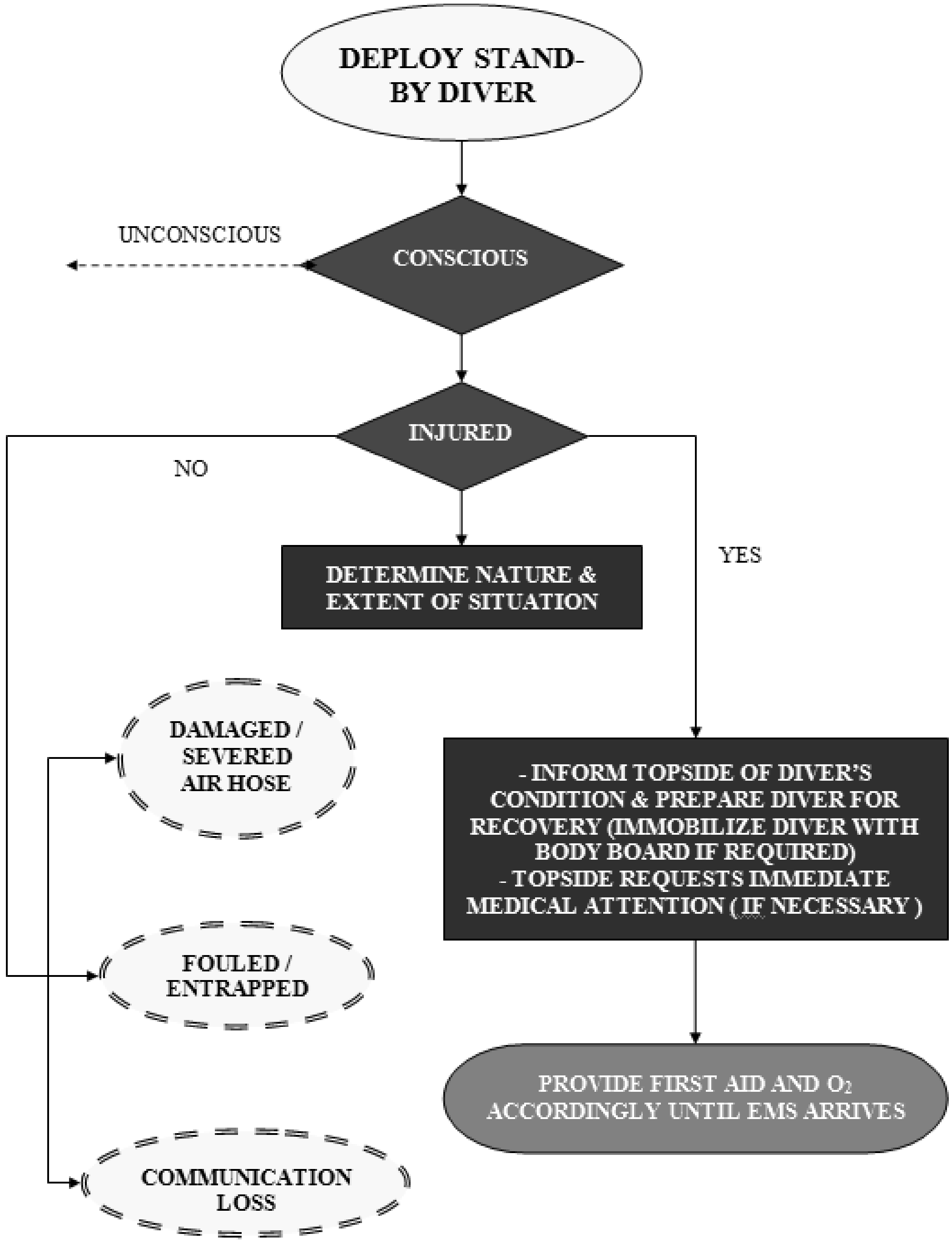
EMERGENCY PROCEDURES



ATTACHMENT 5

EMERGENCY PHONE NUMBERS CHECKLIST

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ATTACHMENT 5

EMERGENCY PHONE NUMBERS CHECKLIST

PROJECT NAME/NUMBER:____

RECOMPRESSION CHAMBER:

ADDRESS/ LAT-LONG ____

PHONE NUMBER: ____

POC: ____

RESPONSE TIME: ____

HOSPITAL:

ADDRESS/ LAT-LONG ____

PHONE NUMBER: ____

POC: ____

RESPONSE TIME: ____

AIR TRANSPORTATION:

ADDRESS/ LAT-LONG ____

PHONE NUMBER: ____

POC: ____

RESPONSE TIME: ____

SEA TRANSPORTATION:

ADDRESS/ LAT-LONG ____

PHONE NUMBER: ____

POC: ____

RESPONSE TIME: ____

ATTACHMENT 5

EMERGENCY PHONE NUMBERS CHECKLIST

PROJECT NAME/NUMBER:____

AMBULANCE:

ADDRESS/ LAT-LONG ____

PHONE NUMBER: ____

POC: ____

RESPONSE TIME: ____

PHYSICIAN:

ADDRESS/LAT-LONG ____

PHONE NUMBER: ____

POC: ____

RESPONSE TIME: ____

COMMUNICATIONS:

ADDRESS/ LAT-LONG ____

PHONE NUMBER: ____

POC: ____

RESPONSE TIME: ____

USCG RESCUE:

ADDRESS/ LAT-LONG ____

PHONE NUMBER: ____

POC: ____

RESPONSE TIME: ____

NOTE – THIS CHECKLIST WILL BE PROMINENTLY POSTED AT THE DIVE SITE AND BE PLACED IN ALL BOATS AND RESPONSE VEHICLES.

ATTACHMENT 6

WORKING DIVE LOG

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ATTACHMENT 6

WORKING DIVE LOG

1. All TMR dives will be recorded on this attachment during field operationseach dive day.

2. The information on these working Dive Logs will be then transferred/ recorded on the TMR Dive Smooth Log by the Dive Supervisor/ or designee and forwarded to the Project Managerfor the official project files. A copy will be further forwarded to the Chairman of the TMR Diving Review Board.

   For scientific divers, a copy will also be sent to the TMR Diving Safety Officer. The Chairman of the Diving Review Board will retain this log for 1 year, except where there has been an injury or incident of decompression sickness and then the record will be retained for 5 years.

3. Definitions:

   a. <u>Old Group</u> – Repetitive group designation from previous dive. Leave blank if this is the first dive.

   b. <u>Surface Interval</u> – The time, which a diver has spent on the surface following a dive. It begins as soon as the diver surfaces and ends as soon as the diver starts his/her next descent. Not required for first dive.

   c. <u>RNT – RESIDUAL NITROGEN TIME</u> – Time, in minutes, which must be added to the bottom time of a repetitive dive to compensate for the nitrogen still in solution in a diver's tissues from a previous dive.

   d. <u>Depth</u> – Depth of current dive.

   e. <u>Bottom Time</u> – The total elapsed time from when the divers leave the surface to thetime (rounded up to the next whole minute) they begin their ascent from the bottom.

   f. <u>Decompression time</u> – Decompression schedule/decompression time.

   g. <u>Equivalent Single Dive Time</u> – RNT plus actual bottom time.

   h. <u>New Group</u> – REPETITIVE GROUP DESIGNATION – A letter, which is used to relate directly to the amount of residual nitrogen remaining in a diver's body.

4. <u>RNT Exception Rule</u> – If performing a repetitive dive to the same depth or deeper, and the RNT is greater than the bottom time of the previous dive, use the bottom time of the previous dive as the RNT.

5. See Attachment 10 for the required U.S. Navy Dive Tables needed to complete these logs.

ATTACHMENT 6
WORKING DIVE LOG

PROJECT NAME/NUMBER:____**DATE:** ________________________

NAME	LS	RS	TBT	DEPTH	TDT	RNT	ESDT	T/S	REPET GROUP	SI
DIVE SUPERVISOR					STBY DIVER					

ATTACHMENT 7

DIVE SMOOTH LOG

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ATTACHMENT 7

DIVE SMOOTH LOG

PROJECT NAME/ NUMBER: ____

1. All TMR dives will be recorded on this attachment and be the final legal record concerning a diver's hyperbaric exposure during operations.

2. Upon completion of the project or weekly, all working Dive Logs from Attachment 6 will be recordedon this Dive Smooth Log by the Dive Supervisor/ Lead Diver and forwarded to the Project Managerfor the Project files and the Chairman Diving Review Board. For science divers, a copy will also besent to the TMR Diving Safety Officer. The Chairman of the Diving Review Board will retain thislog for 1 year, except where there has been an injury or incident of decompression sickness and then the record will be retained for 5 years.

3. Data field definitions:

    a. Date – Date of the diving operation.
    b. Project Name – Name of the Project that dive operations are supporting.
    c. Project Number – Associated Project number.
    d. Location – General Project Location.
    e. Platform – Platform from which the dive operations are conducted.
    f. Gas Source – Source of diver's breathing medium.
    g. Apparatus – The diving mode and equipment used during the operation.
    h. Dress – The exposure protection used by the diver(s).
    i. Project Location – The specific location in the project location that the dive is conducted.
    j. Air Temp – The ambient air temperature at the project dive site.
    k. Current – The observed or reported current at the dive site.
    l. Visibility – The observed underwater visibility reported by the diver(s) at depth.
    m. Altitude – The observed altitude recorded at the dive site.
    n. Water Temp – The observed underwater temperature reported by the diver(s) at depth.
    o. Wave Ht. – The observed wave height recorded at the dive site.
    p. Bottom Type – The observed bottom type reported by the diver(s) at depth.
    q. Tools Used – The tools used for the specific Project task during the dive.
    r. Divers Name – Self-explanatory.
    s. Left Surface (LS) – The recorded time that the diver(s) left the surface (begin descent)
    t. Left Bottom (LB) – the recorded time that the diver(s) left the bottom. (begin ascent)
    u. Total Bottom Time (TBT) – the recorded bottom time (From when diver LS to diver LB).
    v. Total Decompression Time (TDT) – The recorded time of ascent (to include

PROJECT NAME/ NUMBER: ____

anydecompression stops or delays) from when diver LB to diver RS.

w. Reach Surface (RS) – The recorded time that the diver(s) reach the surface.

x. Total Time of Dive (TTD) – The recorded time from when the diver(s) LS to when the diver(s) RS.

y. Depth – The deepest depth recorded of the reported dive.

z. Surface Interval (SI) – The time, that a diver has spent on the surface following a dive. It begins as soon as the diver surfaces and ends as soon as the diver starts his/her next descent. Not required for first dive.

aa. Residual Nitrogen Time (RNT) – Time, in minutes, which must be added to the bottom time of a repetitive dive to compensate for the nitrogen still in solution in a diver's tissues from a previous dive.

bb. Equivalent Single Dive Time (ESDT) – A diver's RNT time plus total bottom time. Used to measure remaining time and new schedule for repetitive dives

cc. Table and Schedule (T/S) – The Table and Schedule used to measure a diver's hyperbaric exposure for a recorded dive.

dd. Repetitive Group (RG) – Repetitive group designation from previous dive and used for repetitive and final dive calculations. Leave blank if this is the diver's first dive.

4. RNT Exception Rule – If performing a repetitive dive to the same depth or deeper, and the RNT is greater than the bottom time of the previous dive, use the bottom time of the previous dive as the RNT.

5. Repetitive Group Designation – A final letter designation, which is used to relate directly to the amount of residual nitrogen remaining in a diver's body after that dive.

6. Use the applicable U.S. Navy Dive Tables located in Attachment 10. These tables are required to complete this log.

TETRA TECH

DIVE LOG

Project

Date: ____________ Project Name: ______________________________ Location: ______________________________

Project Number: ______________________________

Equipment

Platform: ____________ Gas Source: ____________ Apparatus: ____________ Dress: ____________

Environment

Project Location: ____________ Altitude: ____________ Tools Used: ______________________________

Air Temp: ____________ Water Temp: ____________

Current: ____________ Wave Ht. ____________

Visibility: ____________ Bottom Type: ____________

Dive Data

Diver (Last, First MI)	LS	LB	TBT	TDT	RS	TTD	Depth	SI	RNT	ESDT	T/S	RG	NOTES

Dive Description

Purpose: ______________________________

Description: ______________________________

Approval

Signature: ______________________________ Date: ____________

Dive Supervisor: ______________________________

ATTACHMENT 8
USN DIVING LINE PULL AND HAND SIGNALS

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ATTACHMENT 8
USN Diving Line Pull and Hand Signals

From Tender to Diver		From Diver to Tender	
1 Pull	Are you all right? When diver is descending, 1 pull means STOP.	1 Pull	I am all right. When diver is descending, 1 pull means I am on the bottom.
2 Pulls	Leave surface; Go down.	2 Pulls	Give me slack.
3 Pulls	Standby to come up.	3 Pulls	Take up my slack.
4 Pulls	Come up.	4 Pulls	Haul me up.
7 Pulls	On/Off search signals.	7 Pulls	On/Off search signals.
1 Pull	Stop and search where you are at.	2-1 Pull	I understand, Talk to me.
2 Pulls	Move directly away from the tender if given slack; Move towards the tender if strain is taken.	3-2 Pulls	More air.
3 Pulls	Face umbilical, take a strain, and move RIGHT.	4-3 Pulls	Less air.
4 Pulls	Face umbilical, take a strain, and move LEFT.	1-2-3 Pulls	Send me a square mark.
2-1 Pull	I understand, talk to me.	2-1-2 Pulls	Send me a slate.
3-2 Pulls	Ventilate rig.	5 Pulls	Send me a line.
4-3 Pulls	Circulate rig.	5-5 Pulls	Reacquired anomaly *(for UXO tasking only).*

EMERGENCY—From Diver to Tender	
2-2-2 Pulls	I am fouled and need assistance ("I need you").
3-3-3 Pulls	I am fouled but can clear myself ("I need me").
4-4-4 Pulls	Haul me up immediately.

	Meaning/Signal	Comment
	**STOP** Clenched fist.	
	**SOMETHING IS WRONG** Hand flat, fingers together, palm out, thumb down then hand rocking back and forth on axis of forearm.	This is the opposite of Okay. The signal does not indicate an emergency.
	**I AM OKAY or ARE YOU OKAY?** Thumb and forefinger making a circle with three remaining fingers extended (if possible).	Divers wearing mittens may not be able to extend three remaining fingers distinctly. Short range use.
	**OKAY ON THE SURFACE (CLOSE)** Right hand raised overhead giving Okay signal with fingers. **OKAY ON THE SURFACE (DISTANT)** Both hands touching overhead with both arms bent at 45° angle.	Given when diver is close to pickup boat. Given when diver is at a distance from the pickup boat.
	**DISTRESS or HELP or PICK ME UP** Hand waving overhead (diver may also thrash hand in water).	Indicates immediate aid is required.
	**WHAT TIME? or WHAT DEPTH?** Diver points to either watch or depth gauge.	When indicating time, this signal is commonly used for bottom time remaining.
	**GO DOWN or GOING DOWN** Two fingers up, two fingers and thumb against palm.	
	**GO UP or GOING UP** Four fingers pointing up, thumb against palm.	
	**I'M OUT OF AIR** Hand slashing or chopping at throat. **I NEED TO BUDDY BREATHE** Fingers pointing to mouth or regulator.	Indicates signaler is out of air. Signaler's regulator may be in or out of mouth.

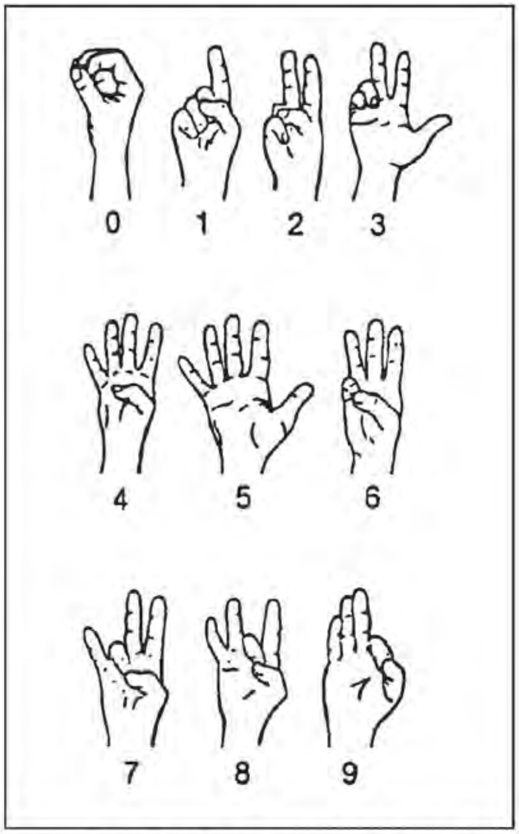
Figure 7-9. SCUBA Hand Signals (page 1 of 3).

ATTACHMENT 8
USN Diving Line Pull and Hand Signals

	Meaning/Signal	Comment
	**COME HERE** Hand to chest, repeated.	
	**ME or WATCH ME** Finger to chest, repeated.	
	**OVER, UNDER, or AROUND** Fingers together and arm moving in and over, under, or around movement.	Diver signals intention to move over, under, or around an object.
	**LEVEL OFF or HOW DEEP?** Fingers and thumb spread out and hand moving back and forth in a level position.	
	**GO THAT WAY** Fist clenched with thumb pointing up, down, right, or left.	Indicates which direction to swim.
	**WHICH DIRECTION?** Fingers clenched, thumb and hand rotating right and left.	
	**EAR TROUBLE** Diver pointing to either ear.	Divers should ascend a few feet. If problem continues, both divers must surface.
	**I'M COLD** Both arms crossed over chest.	
	**TAKE IT EASY OR SLOW DOWN** Hand extended, palm down, in short up-and-down motion.	
	**YOU LEAD, I'LL FOLLOW** Index fingers extended, one hand forward of the other.	

Figure 7-9. SCUBA Hand Signals (page 2 of 3).

ATTACHMENT 8
USN Diving Line Pull and Hand Signals



NIGHT DIVING SIGNALS
(Buddy at Distance)

When buddy is near, use regular hand signals in front of light.

Something is wrong.
I require assistance.
(Large, rapid up-and-down motions with arm extended.)

I am Okay.
Are you Okay?
(Large, slow circles with light.)

Figure 7-9. SCUBA Hand Signals (page 3 of 3).

ATTACHMENT 9

COLD WATER CONSIDERATIONS AND SAFETY PRECAUTIONS

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ATTACHMENT 9

COLD WATER CONSIDERATIONS AND SAFETY PRECAUTIONS

UNDER ICE DIVING

Diving under the ice requires extremely specialized training and equipment and will not be performed by TMR employees unless approved by the Diving Review Board.

COLD WATER DIVING

In addition to decompression, thermal problems arising from exposure to cold water pose the major consideration when planning operational dives and selecting equipment. The working diver commonly experiences heat loss during immersion and often expects to be uncomfortably chilled at the end of a dive. Bottom time limits may be determined by the diver's cold tolerance rather than by decompression considerations.

An individual thoroughly conditioned physically can be transported from warm climates into cold climates and immediately begin diving without harmful effects. However, individuals differ in how well suited they are for cold weather operations. At least half of the diving team should have previous experience in ice or cold water diving operations and should be well qualified to train the less experienced.

Personnel scheduled to go to Polar Regions should be instructed in cold weather physiology and the prevention of cold injuries. To prevent injury, any techniques that aid heat balance, protection, and basic metabolism should be used.

Cold water immersion may also cause excessive urination, severely dehydrating the diver. This in turn reduces performance and may increase the risk of developing decompression sickness. A diver who is dehydrated may appear normal in the water. However, exiting the water combined with warming of the skin may cause pooling of the blood in the extremities leading to fainting. This means that divers who have been in cold water for any period and who appear cold should be assisted from the water and sit or lie down and take fluids until they are sure they can stand without problems.

Vertigo is caused by cold water stimulating the balance mechanism of the inner ear.

In repetitive diving with cold exposure, the operation should be planned so that the diver is re-warmed to the point of sweating before diving again. If cold water exposures are severe and if more than a 30-minute duration, then consideration should be given to requiring an overnight rest between exposures. The diver must also have sufficient non-caffeine beverages to replace the excessive body fluid loss from cold water induced urination.

The support equipment required for ice and cold water diving must be carefully evaluated for effectiveness and suitability.

Maintaining proper body temperature is particularly difficult for a diver working underwater. The principal temperature control problem encountered by divers involves keeping the body warm. The high thermal conductivity of water, coupled with the normally cool-to-cold waters in which divers operate, can result in rapid and excessive heat loss. At extremely low temperatures or with prolonged immersion, body heat loss will reach a point at which death will occur. Appropriate dress can greatly reduce the effects of heat loss, and a diver with proper dress can work in very cold water for reasonable periods of time.

ATTACHMENT 9

COLD WATER CONSIDERATIONS AND SAFETY PRECAUTIONS

In very cold water, the wet suit is only a marginally effective thermal protective measure, and its use exposes the diver to hypothermia and restricts available bottom time. The use of alternative thermal protective equipment should be considered in these circumstances.

The variable volume dry suit and hot water suit are effective means of thermal protection for cold water diving. Wet suits made of incompressible material are now available. Such suits offer more protection at depth than standard wet suits of the same thickness. Prior to the use of variable volume dry suits and hot water suits in cold and ice-covered waters, divers must be trained in their use and be thoroughly familiar with the operation of these suits.

More weight must be used with a variable volume dry suit than with a wet suit due to the great positive buoyancy of a dry suit. Manufacturer's recommendations should be followed to select starting weight. The additional weight makes use of a weight vest or harness desirable. A shoulder harness is one method of preventing the heavy, awkward belts from slipping down during a dive. A few heavy hip hugger weights are better than several smaller weights.

Both single- and double-hose regulators are used for ice and cold water diving. The single-hose regulator is preferred for buddy breathing, is less bulky, and is easier to maintain than the double-hose; however, it is more subject to freeze-up than the double-hose regulator. Due to the serious nature of the freeze-up problems in single-hose regulators, they should not be allowed to free-flow or be purged for over five seconds at a time. Only regulators having a cold water conversion will be used for ice/cold water diving.

The single-hose regulator should be kept in a warm place before diving. It is important that the divers test the regulator in a warm place, then refrain from breathing it until submerging. When returning to the surface, the regulator should remain submerged, and the diver should refrain from breathing from the regulator until re-submerging. The diver's time on the surface should be kept to a minimum. Once under the water, chances of a freeze-up are reduced. However, if a regulator is allowed to free-flow at depth for as little as 5 seconds, freeze-up may occur. The diver should therefore avoid purging the second stage of the regulator when diving in cold water. If water needs to be purged from the mouthpiece, the diver should do so by exhaling into it.

Where water temperature is at or below 37ºF, a redundant SCUBA system (twin SCUBA bottles, each having a "K" valve and an approved cold water regulator) or twin SCUBA bottles with one common manifold and an approved cold water regulator (with octopus) may be used. When selecting the redundant SCUBA system, maximum depth and bottom time are greatly reduced because the extra SCUBA will be used for emergencies only.

Using surface supplied diving in cold water requires detailed operations planning and extensive logistical support. This includes thermal protection for an elaborate dive station and recompression chamber and hot water heating equipment. In addition, dive equipment may require cold climate modification. Because of logistical considerations, scuba is used in most ice diving situations. However, surface supplied diving may be required because of prolonged bottom times, depth requirements, and complex communications between topside and diver. When diving in cold water that is not ice covered, logistic and equipment support requirements are reduced; however, very cold water poses many of the same dangers to the surface-supplied diver as ice diving.

The diver's mask may show an increased tendency to fog in cold water. An anti-fog solution should be used to prevent this from occurring. Saliva will not prevent this fogging.

HYPOTHERMIA

When diving in cold water, hypothermia may predispose the diver to decompression sickness. Hypothermia is easily diagnosed. The hypothermic diver loses muscle strength, the ability to concentrate, and may become irrational or confused. The victim may shiver violently, or, with severe hypothermia, shivering may be replaced by muscle rigidity. Profound hypothermia may so depress the heartbeat and respiration that the victim appears dead. However, a diver should not be considered dead until the diver has been re-warmed and all resuscitation attempts have been proven to be unsuccessful.

Hypothermia demands immediate treatment and prompt evacuation to a medical facility. A hypothermic diver must not be allowed to walk, i.e., the diver should be transported in a horizontal position. Improper handling of the diver can cause dangerous rhythms of the heart and a drop in the body core temperature, known as after drop. The local/responding medical facility must be notified of the possibility of hypothermia PRIOR to the commencement of diving operations. Emergency re-warming and evacuation plans should be established with their recommendations.

Some of the signs and symptoms of hypothermia are shivering, mental confusion, and loss of memory, speech /sensory impairment, and hallucinations. At approximately 88ºF, all shivering stops, the victim will not recognize familiar people, followed by the victim experiencing muscle rigidity and loss of consciousness

ATTACHMENT 10

U.S. NAVY DIVE TABLES

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ATTACHMENT 10
U.S. NAVY DIVE TABLES

1. All TMR dive logs will use the tables in the attachment to complete the dive logs in Attachment 6 and 7 and when developing any TMR project Health and Safety Dive Plans.

2. **U.S. Navy No-Decompression Table (Table 9-7)** – This table gives the maximum time that can be spent at a given depth without the need for decompression stops during the subsequent ascent to the surface. This table is sometimes called the "no-stop" table. At depthsof 20 feet of seawater (FSW) and shallower, there is no limit on the amount of time that can be spent at depth. Deeper than 20 FSW, the time that can be spent is limited. For example, at 60 FSW, any dive longer than 63 minutes will require decompression stops.

The No-Decompression Table also provides the repetitive group designators for dives that fall within the no-decompression limits. Even though no decompression stops are required during ascent, the diver still surfaces with some residual nitrogen in his tissues. This residual nitrogen needs to be accounted for if a repetitive dive is planned. If a diver exceeds the limits given inthe No-Decompression Table, then the decompression stop requirement must be calculated using U.S Navy Standard Air Table (Table 9-9).

For each depth listed in the No-Decompression Table, the corresponding no decompressionlimit is indicated in the second column. This limit is the maximum bottom time that a diver mayspend at that depth and still return to the surface without taking decompression stops. To findthe no-decompression limit, enter the table at the depth equal to or next greater than the maximum depth of the dive.

Follow that row to the second column to obtain the no-decompression limit. The columns to the right of the no-decompression limit column contain the repetitive group designators for dives with bottom times equal to or shorter than the no-decompression limit. A repetitive groupdesignator must be assigned to a diver after every dive, even a no-decompression dive.

3. **Optional Shallow Water No-Decompression Table (Table 2A-1)** – This table contains an expanded version of Table 9-7 and Table 9-8 covering the depth range of 30–50 FSW in one-foot increments. In this depth range, a small change in the diver's maximum depth can makea substantial difference in the allowable no-decompression time. For example, at 35 FSW theno-decompression limit is 232 minutes; at 40 FSW it is only 163 minutes, more than an hour less. When the diver's maximum depth is accurately known at the beginning of the dive, for example in ballast tank dives, or when continuous depth recording is available, for example with a decompression computer, the expanded table can be used to maximize no- decompression time.

These optional tables are most suited to ship husbandry diving, but can be used in other shallow air diving applications as well.

4. **Residual Nitrogen Time Table for Repetitive Air Dives (Figure 9-8)** - The procedures for conducting a repetitive dive are summarized in this table. Upon completing the first dive, the diver is assigned a repetitive group designator from either the Air Decompression Table or theNo-Decompression Table. This designator tells the diver how much residual nitrogen he has upon surfacing from the first dive. A diver in Group A has the lowest amount of residual nitrogen; a diver in Group Z has the highest.

As nitrogen passes out of the diver's body during the surface interval, the repetitive group designation changes to a lower letter group to reflect the lower quantity of residual nitrogen.

The top half of the table allows the repetitive group designator to be determined at any time during the surface interval. The lower half of the table gives the Residual Nitrogen Time (RNT) corresponding to the repetitive group designator at the end of the surface interval and the depth of the repetitive dive. The residual nitrogen time is the time a diver would have had to spend at the depth of the repetitive dive to absorb the amount of nitrogen he has left over from the previous dive. The residual nitrogen time is added to the bottom time of the repetitive dive to obtain the Equivalent Single Dive Time (ESDT).

The decompression schedule for the repetitive dive is obtained by entering either the Air Decompression Table or the No-Decompression Table at the depth of the repetitive dive and the equivalent single dive time.

NOTE: When using the Optional Shallow Water No Decompression Tables above ensure the corresponding Residual Nitrogen Timetable for Repetitive Shallow Water Air Dives (Table 2A- 2) is used for your repetitive dive calculations.

5. **U.S Navy Standard Air Table (Table 9-9)** – This table combines three modes of decompression into one table. These modes are: (1) in-water decompression on air, (2) in- water decompression on air and oxygen, and (3) surface decompression on oxygen.

Refer to reference (b), Chapter 9, when using the Standard Air Tables in any of the above modes when developing HASPs where decompression diving profiles are anticipated.

These tables are to be available to the Dive Supervisor/ Lead Diver on TMR dive sites for emergency procedure in water decompression on planned no decompression dive plans

Table 9-7. *No-Decompression Limits and Repetitive Group Designators for No-Decompression Air Dives.*

Depth (fsw)	No-Stop Limit	Repetitive Group Designation															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
10	Unlimited	57	101	158	245	426	*										
15	Unlimited	36	60	88	121	163	217	297	449	*							
20	Unlimited	26	43	61	82	106	133	165	205	256	330	461	*				
25	1102	20	33	47	62	78	97	117	140	166	198	236	285	354	469	992	1102
30	371	17	27	38	50	62	76	91	107	125	145	167	193	223	260	307	371
35	232	14	23	32	42	52	63	74	87	100	115	131	148	168	190	215	232
40	163	12	20	27	36	44	53	63	73	84	95	108	121	135	151	163	
45	125	11	17	24	31	39	46	55	63	72	82	92	102	114	125		
50	92	9	15	21	28	34	41	48	56	63	71	80	89	92			
55	74	8	14	19	25	31	37	43	50	56	63	71	74				
60	63	7	12	17	22	28	33	39	45	51	57	63					
70	48	6	10	14	19	23	28	32	37	42	47	48					
80	39	5	9	12	16	20	24	28	32	36	39						
90	33	4	7	11	14	17	21	24	28	31	33						
100	25	4	6	9	12	15	18	21	25								
110	20	3	6	8	11	14	16	19	20								
120	15	3	5	7	10	12	15										
130	12	2	4	6	9	11	12										
140	10	2	4	6	8	10											
150	8		3	5	7	8											
160	7		3	5	6	7											
170	6			4	6												
180	6			4	5	6											
190	5			3	5												

* Highest repetitive group that can be achieved at this depth regardless of bottom time.

__Table 9-8.__ Residual Nitrogen Time Table for Repetitive Air Dives.

Locate the diver's repetitive group designation from his previous dive along the diagonal line above the table. Read horizontally to the interval in which the diver's surface interval lies.

Next, read vertically downward to the new repetitive group designation. Continue downward in this same column to the row that represents the depth of the repetitive dive. The time given at the intersection is residual nitrogen time, in minutes, to be applied to the repetitive dive.

* Dives following surface intervals longer than this are not repetitive dives. Use actual bottom times in the Air Decompression Tables to compute decompression for such dives.

Repetitive Group at Beginning of Surface Interval

Repetitive Group at Beginning of Surface Interval	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
A																:10 2:20 *
B															:10 1:16	1:17 3:36 *
C														:10 :55	:56 2:11	2:12 4:31 *
D													:10 :52	:53 1:47	1:48 3:03	3:04 5:23 *
E												:10 :52	:53 1:44	1:45 2:39	2:40 3:55	3:56 6:15 *
F											:10 :52	:53 1:44	1:45 2:37	2:38 3:31	3:32 4:48	4:49 7:08 *
G										:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:23	4:24 5:40	5:41 8:00 *
H									:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:16	5:17 6:32	6:33 8:52 *
I								:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:08	6:09 7:24	7:25 9:44 *
J							:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 7:00	7:01 8:16	8:17 10:36 *
K						:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:52	7:53 9:09	9:10 11:29 *
L					:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:44	8:45 10:01	10:02 12:21 *
M				:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:37	9:38 10:53	10:54 13:13 *
N			:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:34	9:35 10:29	10:30 11:45	11:46 14:05 *
O		:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:34	9:35 10:27	10:28 11:21	11:22 12:37	12:38 14:58 *
Z	:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:34	9:35 10:27	10:28 11:19	11:20 12:13	12:14 13:30	13:31 15:50 *

Repetitive Group at the End of the Surface Interval

Dive Depth	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
10	**	**	**	**	**	**	**	**	**	**	**	427	246	159	101	58
15	**	**	**	**	**	**	**	**	450	298	218	164	122	89	61	37
20	**	**	**	**	**	462	331	257	206	166	134	106	83	62	44	27
25	†	†	470	354	286	237	198	167	141	118	98	79	63	48	34	21
30	372	308	261	224	194	168	146	126	108	92	77	63	51	39	28	18
35	245	216	191	169	149	132	116	101	88	75	64	53	43	33	24	15
40	188	169	152	136	122	109	97	85	74	64	55	45	37	29	21	13
45	154	140	127	115	104	93	83	73	64	56	48	40	32	25	18	12
50	131	120	109	99	90	81	73	65	57	49	42	35	29	23	17	11
55	114	105	96	88	80	72	65	58	51	44	38	32	26	20	15	10
60	101	93	86	79	72	65	58	52	46	40	35	29	24	19	14	9
70	83	77	71	65	59	54	49	44	39	34	29	25	20	16	12	8
80	70	65	60	55	51	46	42	38	33	29	25	22	18	14	10	7
90	61	57	52	48	44	41	37	33	29	26	22	19	16	12	9	6
100	54	50	47	43	40	36	33	30	26	23	20	17	14	11	8	5
110	48	45	42	39	36	33	30	27	24	21	18	16	13	10	8	5
120	44	41	38	35	32	30	27	24	22	19	17	14	12	9	7	5
130	40	37	35	32	30	27	25	22	20	18	15	13	11	9	6	4
140	37	34	32	30	27	25	23	21	19	16	14	12	10	8	6	4
150	34	32	30	28	26	23	21	19	17	15	13	11	9	8	6	4
160	32	30	28	26	24	22	20	18	16	14	13	11	9	7	5	4
170	30	28	26	24	22	21	19	17	15	14	12	10	8	7	5	3
180	28	26	25	23	21	19	18	16	14	13	11	10	8	6	5	3
190	26	25	23	22	20	18	17	15	14	12	11	9	8	6	5	3

Residual Nitrogen Times (Minutes)

** Residual Nitrogen Time cannot be determined using this table (see paragraph 9-9.1 subparagraph 8 for instructions).

† Read vertically downward to the 30 fsw repetitive dive depth. Use the corresponding residual nitrogen times to compute the equivalent single dive time. Decompress using the 30 fsw air decompression table.

__Table 2A-1.__ No-Decompression Limits and Repetitive Group Designators for Shallow Water Air No-Decompression Dives.

Depth (fsw)	No-Stop Limit (min)	Repetitive Group Designation															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
30	371	17	27	38	50	62	76	91	107	125	145	167	193	223	260	307	371
31	334	16	26	37	48	60	73	87	102	119	138	158	182	209	242	282	334
32	304	15	25	35	46	58	70	83	98	114	131	150	172	197	226	261	304
33	281	15	24	34	45	56	67	80	94	109	125	143	163	186	212	243	281
34	256	14	23	33	43	54	65	77	90	104	120	137	155	176	200	228	256
35	232	14	23	32	42	52	63	74	87	100	115	131	148	168	190	215	232
36	212	14	22	31	40	50	61	72	84	97	110	125	142	160	180	204	212
37	197	13	21	30	39	49	59	69	81	93	106	120	136	153	172	193	197
38	184	13	21	29	38	47	57	67	78	90	102	116	131	147	164	184	
39	173	12	20	28	37	46	55	65	76	87	99	112	126	141	157	173	
40	163	12	20	27	36	44	53	63	73	84	95	108	121	135	151	163	
41	155	12	19	27	35	43	52	61	71	81	92	104	117	130	145	155	
42	147	11	19	26	34	42	50	59	69	79	89	101	113	126	140	147	
43	140	11	18	25	33	41	49	58	67	76	87	98	109	122	135	140	
44	134	11	18	25	32	40	48	56	65	74	84	95	106	118	130	134	
45	125	11	17	24	31	39	46	55	63	72	82	92	102	114	125		
46	116	10	17	23	30	38	45	53	61	70	79	89	99	110	116		
47	109	10	16	23	30	37	44	52	60	68	77	87	97	107	109		
48	102	10	16	22	29	36	43	51	58	67	75	84	94	102			
49	97	10	16	22	28	35	42	49	57	65	73	82	91	97			
50	92	9	15	21	28	34	41	48	56	63	71	80	89	92			

Table 2A-2. Residual Nitrogen Time Table for Repetitive Shallow Water Air Dives.

Locate the diver's repetitive group designation from his previous dive along the diagonal line above the table. Read horizontally to the interval in which the diver's surface interval lies.

Next, read vertically downward to the new repetitive group designation. Continue downward in this same column to the row that represents the depth of the repetitive dive. The time given at the intersection is residual nitrogen time, in minutes, to be applied to the repetitive dive.

* Dives following surface intervals longer than this are not repetitive dives. Use actual bottom times in the Air Decompression Tables to compute decompression for such dives.

Repetitive Group at Beginning of Surface Interval

Repetitive Group at Beginning of Surface Interval	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
A																:10 2:20 *
B															:10 1:16	1:17 3:36 *
C														:10 :55	:56 2:11	2:12 4:31 *
D													:10 :52	:53 1:47	1:48 3:03	3:04 5:23 *
E												:10 :52	:53 1:44	1:45 2:39	2:40 3:55	3:56 6:15 *
F											:10 :52	:53 1:44	1:45 2:37	2:38 3:31	3:32 4:48	4:49 7:08 *
G										:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:23	4:24 5:40	5:41 8:00 *
H									:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:16	5:17 6:32	6:33 8:52 *
I								:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:08	6:09 7:24	7:25 9:44 *
J							:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 7:00	7:01 8:16	8:17 10:36 *
K						:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:52	7:53 9:09	9:10 11:29 *
L					:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:44	8:45 10:01	10:02 12:21 *
M				:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:37	9:38 10:53	10:54 13:13 *
N			:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:34	9:35 10:29	10:30 11:45	11:46 14:05 *
O		:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:34	9:35 10:27	10:28 11:21	11:22 12:37	12:38 14:58 *
Z	:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:34	9:35 10:27	10:28 11:19	11:20 12:13	12:14 13:30	13:31 15:50 *

Repetitive Group at the End of the Surface Interval

Dive Depth	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
30	372	308	261	224	194	168	146	126	108	92	77	63	51	39	28	18
31	334	282	243	210	183	159	139	120	103	88	74	61	49	38	27	17
32	305	262	227	198	173	151	132	115	99	85	71	59	47	36	26	17
33	282	244	213	187	164	144	126	110	95	81	69	57	46	35	25	16
34	262	229	201	177	156	138	121	105	91	78	66	55	44	34	25	16
35	245	216	191	169	149	132	116	101	88	75	64	53	43	33	24	15
36	231	204	181	161	143	126	111	98	85	73	62	51	41	32	23	15
37	218	194	173	154	137	122	107	94	82	70	60	50	40	31	23	14
38	207	185	165	148	132	117	103	91	79	68	58	48	39	30	22	14
39	197	177	158	142	127	113	100	88	77	66	56	47	38	29	21	14
40	188	169	152	136	122	109	97	85	74	64	55	45	37	29	21	13
41	180	163	146	132	118	105	93	82	72	62	53	44	36	28	20	13
42	173	156	141	127	114	102	91	80	70	61	52	43	35	27	20	13
43	166	150	136	123	110	99	88	78	68	59	50	42	34	26	19	12
44	160	145	131	119	107	96	85	75	66	57	49	41	33	26	19	12
45	154	140	127	115	104	93	83	73	64	56	48	40	32	25	18	12
46	149	136	123	111	101	90	81	71	63	54	46	39	32	25	18	12
47	144	131	119	108	98	88	78	70	61	53	45	38	31	24	18	11
48	139	127	116	105	95	85	76	68	60	52	44	37	30	24	17	11
49	135	123	112	102	92	83	74	66	58	51	43	36	30	23	17	11
50	131	120	109	99	90	81	73	65	57	49	42	35	29	23	17	11

Residual Nitrogen Times (Minutes)

Table 9-9. *Air Decompression Table.*

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
30 FSW														
371	1:00	AIR									0	1:00	0	Z
		AIR/O_2									**0**	1:00		
380	0:20	AIR									5	6:00	0.5	Z
		AIR/O_2									**1**	2:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended														
420	0:20	AIR									22	23:00	0.5	Z
		AIR/O_2									**5**	6:00		
480	0:20	AIR									42	43:00	0.5	
		AIR/O_2									**9**	10:00		
540	0:20	AIR									71	72:00	1	
		AIR/O_2									**14**	15:00		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required														
600	0:20	AIR									92	93:00	1	
		AIR/O_2									**19**	20:00		
660	0:20	AIR									120	121:00	1	
		AIR/O_2									**22**	23:00		
720	0:20	AIR									158	159:00	1	
		AIR/O_2									**27**	28:00		
35 FSW														
232	1:10	AIR									0	1:10	0	Z
		AIR/O_2									**0**	1:10		
240	0:30	AIR									4	5:10	0.5	Z
		AIR/O_2									**2**	3:10		
In-Water Air/O_2 Decompression or SurDO_2 Recommended														
270	0:30	AIR									28	29:10	0.5	Z
		AIR/O_2									**7**	8:10		
300	0:30	AIR									53	54:10	0.5	Z
		AIR/O_2									**13**	14:10		
330	0:30	AIR									71	72:10	1	Z
		AIR/O_2									**18**	19:10		
360	0:30	AIR									88	89:10	1	
		AIR/O_2									**22**	23:10		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required														
420	0:30	AIR									134	135:10	1.5	
		AIR/O_2									**29**	30:10		
480	0:30	AIR									173	174:10	1.5	
		AIR/O_2									**38**	44:10		
540	0:30	AIR									228	229:10	2	
		AIR/O_2									**45**	51:10		
600	0:30	AIR									277	278:10	2	
		AIR/O_2									**53**	59:10		
660	0:30	AIR									314	315:10	2.5	
		AIR/O_2									**63**	69:10		
720	0:30	AIR									342	343:10	3	
		AIR/O_2									**71**	82:10		

Table 9-9. *Air Decompression Table (Continued).*

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
40 FSW														
163	1:20	AIR									0	1:20	0	O
		AIR/O_2									**0**	1:20		
170	0:40	AIR									6	7:20	0.5	O
		AIR/O_2									**2**	3:20		
180	0:40	AIR									14	15:20	0.5	Z
		AIR/O_2									**5**	6:20		
In-Water Air/O_2 Decompression or SurDO_2 Recommended														
190	0:40	AIR									21	22:20	0.5	Z
		AIR/O_2									**7**	8:20		
200	0:40	AIR									27	28:20	0.5	Z
		AIR/O_2									**9**	10:20		
210	0:40	AIR									39	40:20	0.5	Z
		AIR/O_2									**11**	12:20		
220	0:40	AIR									52	53:20	0.5	Z
		AIR/O_2									**12**	13:20		
230	0:40	AIR									64	65:20	1	Z
		AIR/O_2									**16**	17:20		
240	0:40	AIR									75	76:20	1	Z
		AIR/O_2									**19**	20:20		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required														
270	0:40	AIR									101	102:20	1	Z
		AIR/O_2									**26**	27:20		
300	0:40	AIR									128	129:20	1.5	
		AIR/O_2									**33**	34:20		
330	0:40	AIR									160	161:20	1.5	
		AIR/O_2									**38**	44:20		
360	0:40	AIR									184	185:20	2	
		AIR/O_2									**44**	50:20		
420	0:40	AIR									248	249:20	2.5	
		AIR/O_2									**56**	62:20		
480	0:40	AIR									321	322:20	2.5	
		AIR/O_2									**68**	79:20		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required														
540	0:40	AIR									372	373:20	3	
		AIR/O_2									**80**	91:20		
600	0:40	AIR									410	411:20	3.5	
		AIR/O_2									**93**	104:20		
660	0:40	AIR									439	440:20	4	
		AIR/O_2									**103**	119:20		
Exceptional Exposure: SurDO_2														
720	0:40	AIR									461	462:20	4.5	
		AIR/O_2									**112**	128:20		

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
45 FSW														
125	1:30	AIR									0	1:30	0	N
		AIR/O_2									**0**	1:30		
130	0:50	AIR									2	3:30	0.5	O
		AIR/O_2									**1**	2:30		
140	0:50	AIR									14	15:30	0.5	O
		AIR/O_2									**5**	6:30		
In-Water Air/O_2 Decompression or SurDO_2 Recommended ---														
150	0:50	AIR									25	26:30	0.5	Z
		AIR/O_2									**8**	9:30		
160	0:50	AIR									34	35:30	0.5	Z
		AIR/O_2									**11**	12:30		
170	0:50	AIR									41	42:30	1	Z
		AIR/O_2									**14**	15:30		
180	0:50	AIR									59	60:30	1	Z
		AIR/O_2									**17**	18:30		
190	0:50	AIR									75	76:30	1	Z
		AIR/O_2									**19**	20:30		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
200	0:50	AIR									89	90:30	1	Z
		AIR/O_2									**23**	24:30		
210	0:50	AIR									101	102:30	1	Z
		AIR/O_2									**27**	28:30		
220	0:50	AIR									112	113:30	1.5	Z
		AIR/O_2									**30**	31:30		
230	0:50	AIR									121	122:30	1.5	Z
		AIR/O_2									**33**	34:30		
240	0:50	AIR									130	131:30	1.5	Z
		AIR/O_2									**37**	43:30		
270	0:50	AIR									173	174:30	2	
		AIR/O_2									**45**	51:30		
300	0:50	AIR									206	207:30	2	
		AIR/O_2									**51**	57:30		
330	0:50	AIR									243	244:30	2.5	
		AIR/O_2									**61**	67:30		
360	0:50	AIR									288	289:30	3	
		AIR/O_2									**69**	80:30		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required--														
420	0:50	AIR									373	374:30	3.5	
		AIR/O_2									**84**	95:30		
480	0:50	AIR									431	432:30	4	
		AIR/O_2									**101**	117:30		
Exceptional Exposure: SurDO_2 --														
540	0:50	AIR									473	474:30	4.5	
		AIR/O_2									**117**	133:30		

Table 9-9. Air Decompression Table (Continued).

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
50 FSW														
92	1:40	AIR									0	1:40	0	M
		AIR/O_2									**0**	1:40		
95	1:00	AIR									2	3:40	0.5	M
		AIR/O_2									**1**	2:40		
100	1:00	AIR									4	5:40	0.5	N
		AIR/O_2									**2**	3:40		
110	1:00	AIR									8	9:40	0.5	O
		AIR/O_2									**4**	5:40		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
120	1:00	AIR									21	22:40	0.5	O
		AIR/O_2									**7**	8:40		
130	1:00	AIR									34	35:40	0.5	Z
		AIR/O_2									**12**	13:40		
140	1:00	AIR									45	46:40	1	Z
		AIR/O_2									**16**	17:40		
150	1:00	AIR									56	57:40	1	Z
		AIR/O_2									**19**	20:40		
160	1:00	AIR									78	79:40	1	Z
		AIR/O_2									**23**	24:40		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
170	1:00	AIR									96	97:40	1	Z
		AIR/O_2									**26**	27:40		
180	1:00	AIR									111	112:40	1.5	Z
		AIR/O_2									**30**	31:40		
190	1:00	AIR									125	126:40	1.5	Z
		AIR/O_2									**35**	36:40		
200	1:00	AIR									136	137:40	1.5	Z
		AIR/O_2									**39**	45:40		
210	1:00	AIR									147	148:40	2	
		AIR/O_2									**43**	49:40		
220	1:00	AIR									166	167:40	2	
		AIR/O_2									**47**	53:40		
230	1:00	AIR									183	184:40	2	
		AIR/O_2									**50**	56:40		
240	1:00	AIR									198	199:40	2	
		AIR/O_2									**53**	59:40		
270	1:00	AIR									236	237:40	2.5	
		AIR/O_2									**62**	68:40		
300	1:00	AIR									285	286:40	3	
		AIR/O_2									**74**	85:40		
Exceptional Exposure: In-Water Air/O_2 Decompression ------------- SurDO_2 Required--														
330	1:00	AIR									345	346:40	3.5	
		AIR/O_2									**83**	94:40		
360	1:00	AIR									393	394:40	3.5	
		AIR/O_2									**92**	103:40		
Exceptional Exposure: SurDO_2 ---														
420	1:00	AIR									464	465:40	4.5	
		AIR/O_2									**113**	129:40		

Table 9-9. *Air Decompression Table (Continued).*

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
55 FSW														
74	1:50	AIR									0	1:50	0	L
		AIR/O_2									**0**	1:50		
75	1:10	AIR									1	2:50	0.5	L
		AIR/O_2									**1**	2:50		
80	1:10	AIR									4	5:50	0.5	M
		AIR/O_2									**2**	3:50		
90	1:10	AIR									10	11:50	0.5	N
		AIR/O_2									**5**	6:50		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
100	1:10	AIR									17	18:50	0.5	O
		AIR/O_2									**8**	9:50		
110	1:10	AIR									34	35:50	0.5	O
		AIR/O_2									**12**	13:50		
120	1:10	AIR									48	49:50	1	Z
		AIR/O_2									**17**	18:50		
130	1:10	AIR									59	60:50	1	Z
		AIR/O_2									**22**	23:50		
140	1:10	AIR									84	85:50	1	Z
		AIR/O_2									**26**	27:50		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
150	1:10	AIR									105	106:50	1.5	Z
		AIR/O_2									**30**	31:50		
160	1:10	AIR									123	124:50	1.5	Z
		AIR/O_2									**34**	35:50		
170	1:10	AIR									138	139:50	1.5	Z
		AIR/O_2									**40**	46:50		
180	1:10	AIR									151	152:50	2	Z
		AIR/O_2									**45**	51:50		
190	1:10	AIR									169	170:50	2	
		AIR/O_2									**50**	56:50		
200	1:10	AIR									190	191:50	2	
		AIR/O_2									**54**	60:50		
210	1:10	AIR									208	209:50	2.5	
		AIR/O_2									**58**	64:50		
220	1:10	AIR									224	225:50	2.5	
		AIR/O_2									**62**	68:50		
230	1:10	AIR									239	240:50	2.5	
		AIR/O_2									**66**	77:50		
240	1:10	AIR									254	255:50	3	
		AIR/O_2									**69**	80:50		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required--														
270	1:10	AIR									313	314:50	3.5	
		AIR/O_2									**83**	94:50		
300	1:10	AIR									380	381:50	3.5	
		AIR/O_2									**94**	105:50		
330	1:10	AIR									432	433:50	4	
		AIR/O_2									**106**	122:50		
Exceptional Exposure: SurDO_2 --														
360	1:10	AIR									474	475:50	4.5	
		AIR/O_2									**118**	134:50		

Table 9-9. Air Decompression Table (Continued).

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop									Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
			100	90	80	70	60	50	40	30	20			
60 FSW														
63	2:00	AIR									0	2:00	0	K
		AIR/O_2									**0**	2:00		
65	1:20	AIR									2	4:00	0.5	L
		AIR/O_2									**1**	3:00		
70	1:20	AIR									7	9:00	0.5	L
		AIR/O_2									**4**	6:00		
80	1:20	AIR									14	16:00	0.5	N
		AIR/O_2									**7**	9:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
90	1:20	AIR									23	25:00	0.5	O
		AIR/O_2									**10**	12:00		
100	1:20	AIR									42	44:00	1	Z
		AIR/O_2									**15**	17:00		
110	1:20	AIR									57	59:00	1	Z
		AIR/O_2									**21**	23:00		
120	1:20	AIR									75	77:00	1	Z
		AIR/O_2									**26**	28:00		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
130	1:20	AIR									102	104:00	1.5	Z
		AIR/O_2									**31**	33:00		
140	1:20	AIR									124	126:00	1.5	Z
		AIR/O_2									**35**	37:00		
150	1:20	AIR									143	145:00	2	Z
		AIR/O_2									**41**	48:00		
160	1:20	AIR									158	160:00	2	Z
		AIR/O_2									**48**	55:00		
170	1:20	AIR									178	180:00	2	
		AIR/O_2									**53**	60:00		
180	1:20	AIR									201	203:00	2.5	
		AIR/O_2									**59**	66:00		
190	1:20	AIR									222	224:00	2.5	
		AIR/O_2									**64**	71:00		
200	1:20	AIR									240	242:00	2.5	
		AIR/O_2									**68**	80:00		
210	1:20	AIR									256	258:00	3	
		AIR/O_2									**73**	85:00		
220	1:20	AIR									278	280:00	3	
		AIR/O_2									**77**	89:00		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required---														
230	1:20	AIR									300	302:00	3.5	
		AIR/O_2									**82**	94:00		
240	1:20	AIR									321	323:00	3.5	
		AIR/O_2									**88**	100:00		
270	1:20	AIR									398	400:00	4	
		AIR/O_2									**102**	119:00		
Exceptional Exposure: SurDO_2 ---														
300	1:20	AIR									456	458:00	4.5	
		AIR/O_2									**115**	132:00		

Table 9-9. Air Decompression Table (Continued).
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	**DECOMPRESSION STOPS (FSW)** Stop times (min) include travel time, except first air and first O_2 stop									Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
			100	90	80	70	60	50	40	30	20			
70 FSW														
48	2:20	AIR									0	2:20	0	K
		AIR/O_2									**0**	2:20		
50	1:40	AIR									2	4:20	0.5	K
		AIR/O_2									**1**	3:20		
55	1:40	AIR									9	11:20	0.5	L
		AIR/O_2									**5**	7:20		
60	1:40	AIR									14	16:20	0.5	M
		AIR/O_2									**8**	10:20		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
70	1:40	AIR									24	26:20	0.5	N
		AIR/O_2									**13**	15:20		
80	1:40	AIR									44	46:20	1	O
		AIR/O_2									**17**	19:20		
90	1:40	AIR									64	66:20	1	Z
		AIR/O_2									**24**	26:20		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
100	1:40	AIR									88	90:20	1.5	Z
		AIR/O_2									**31**	33:20		
110	1:40	AIR									120	122:20	1.5	Z
		AIR/O_2									**38**	45:20		
120	1:40	AIR									145	147:20	2	Z
		AIR/O_2									**44**	51:20		
130	1:40	AIR									167	169:20	2	Z
		AIR/O_2									**51**	58:20		
140	1:40	AIR									189	191:20	2.5	
		AIR/O_2									**59**	66:20		
150	1:40	AIR									219	221:20	2.5	
		AIR/O_2									**66**	78:20		
160	1:20	AIR								1	244	247:00	3	
		AIR/O_2								**1**	**72**	85:00		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required---														
170	1:20	AIR								2	265	269:00	3	
		AIR/O_2								**1**	**78**	91:00		
180	1:20	AIR								4	289	295:00	3.5	
		AIR/O_2								**2**	**83**	97:00		
190	1:20	AIR								5	316	323:00	3.5	
		AIR/O_2								**3**	**88**	103:00		
200	1:20	AIR								9	345	356:00	4	
		AIR/O_2								**5**	**93**	115:00		
210	1:20	AIR								13	378	393:00	4	
		AIR/O_2								**7**	**98**	122:00		
Exceptional Exposure: SurDO_2 --														
240	1:20	AIR								25	454	481:00	5	
		AIR/O_2								**13**	**110**	140:00		

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop									Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
			100	90	80	70	60	50	40	30	20			
80 FSW														
39	2:40	AIR									0	2:40	0	J
		AIR/O_2									**0**	2:40		
40	2:00	AIR									1	3:40	0.5	J
		AIR/O_2									**1**	3:40		
45	2:00	AIR									10	12:40	0.5	K
		AIR/O_2									**5**	7:40		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
50	2:00	AIR									17	19:40	0.5	M
		AIR/O_2									**9**	11:40		
55	2:00	AIR									24	26:40	0.5	M
		AIR/O_2									**13**	15:40		
60	2:00	AIR									30	32:40	1	N
		AIR/O_2									**16**	18:40		
70	2:00	AIR									54	56:40	1	O
		AIR/O_2									**22**	24:40		
80	2:00	AIR									77	79:40	1.5	Z
		AIR/O_2									**30**	32:40		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
90	2:00	AIR									114	116:40	1.5	Z
		AIR/O_2									**39**	46:40		
100	1:40	AIR								1	147	150:20	2	Z
		AIR/O_2								**1**	**46**	54:20		
110	1:40	AIR								6	171	179:20	2	Z
		AIR/O_2								**3**	**51**	61:20		
120	1:40	AIR								10	200	212:20	2.5	
		AIR/O_2								**5**	**59**	71:20		
130	1:40	AIR								14	232	248:20	3	
		AIR/O_2								**7**	**67**	86:20		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required---														
140	1:40	AIR								17	258	277:20	3.5	
		AIR/O_2								**9**	**73**	94:20		
150	1:40	AIR								19	285	306:20	3.5	
		AIR/O_2								**10**	**80**	102:20		
160	1:40	AIR								21	318	341:20	4	
		AIR/O_2								**11**	**86**	114:20		
170	1:40	AIR								27	354	383:20	4	
		AIR/O_2								**14**	**90**	121:20		
Exceptional Exposure: SurDO_2 --														
180	1:40	AIR								33	391	426:20	4.5	
		AIR/O_2								**17**	**96**	130:20		
210	1:40	AIR								51	473	526:20	5	
		AIR/O_2								**26**	**110**	158:20		

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
90 FSW														
33	3:00	AIR									0	3:00	0	J
		AIR/O_2									**0**	3:00		
35	2:20	AIR									4	7:00	0.5	J
		AIR/O_2									**2**	5:00		
40	2:20	AIR									14	17:00	0.5	L
		AIR/O_2									**7**	10:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
45	2:20	AIR									23	26:00	0.5	M
		AIR/O_2									**12**	15:00		
50	2:20	AIR									31	34:00	1	N
		AIR/O_2									**17**	20:00		
55	2:20	AIR									39	42:00	1	O
		AIR/O_2									**21**	24:00		
60	2:20	AIR									56	59:00	1	O
		AIR/O_2									**24**	27:00		
70	2:20	AIR									83	86:00	1.5	Z
		AIR/O_2									**32**	35:00		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
80	2:00	AIR								5	125	132:40	2	Z
		AIR/O_2								**3**	**40**	50:40		
90	2:00	AIR								13	158	173:40	2	Z
		AIR/O_2								**7**	**46**	60:40		
100	2:00	AIR								19	185	206:40	2.5	
		AIR/O_2								**10**	**53**	70:40		
110	2:00	AIR								25	224	251:40	3	
		AIR/O_2								**13**	**61**	86:40		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required---														
120	1:40	AIR							2	28	256	288:20	3.5	
		AIR/O_2							2	**14**	**70**	98:40		
130	1:40	AIR							5	28	291	326:20	3.5	
		AIR/O_2							5	**14**	**79**	110:40		
140	1:40	AIR							8	28	330	368:20	4	
		AIR/O_2							8	**14**	**87**	126:40		
Exceptional Exposure: SurDO_2 --														
150	1:40	AIR							11	34	378	425:20	4.5	
		AIR/O_2							11	**17**	**94**	139:40		
160	1:40	AIR							13	40	418	473:20	4.5	
		AIR/O_2							13	**20**	**101**	151:40		
170	1:40	AIR							15	45	451	513:20	5	
		AIR/O_2							15	**23**	**106**	166:40		
180	1:40	AIR							16	51	479	548:20	5.5	
		AIR/O_2							16	**26**	**112**	176:40		
240	1:40	AIR							42	68	592	704:20	7.5	
		AIR/O_2							42	**34**	**159**	267:40		

Table 9-9. Air Decompression Table (Continued).

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
100 FSW														
25	3:20	AIR									0	3:20	0	H
		AIR/O_2									**0**	3:20		
30	2:40	AIR									3	6:20	0.5	J
		AIR/O_2									**2**	5:20		
35	2:40	AIR									15	18:20	0.5	L
		AIR/O_2									**8**	11:20		
In-Water Air/O_2 Decompression or $SurDO_2$ Recommended ---														
40	2:40	AIR									26	29:20	1	M
		AIR/O_2									**14**	17:20		
45	2:40	AIR									36	39:20	1	N
		AIR/O_2									**19**	22:20		
50	2:40	AIR									47	50:20	1	O
		AIR/O_2									**24**	27:20		
55	2:40	AIR									65	68:20	1.5	Z
		AIR/O_2									**28**	31:20		
60	2:40	AIR									81	84:20	1.5	Z
		AIR/O_2									**33**	36:20		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or $SurDO_2$ Required -----------														
70	2:20	AIR								11	124	138:00	2	Z
		AIR/O_2								**6**	**39**	53:00		
80	2:20	AIR								21	160	184:00	2.5	Z
		AIR/O_2								**11**	**45**	64:00		
90	2:00	AIR							2	28	196	228:40	2.5	
		AIR/O_2							2	**14**	**53**	82:00		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- $SurDO_2$ Required--														
100	2:00	AIR							9	28	241	280:40	3	
		AIR/O_2							9	**14**	**66**	102:00		
110	2:00	AIR							14	28	278	322:40	3.5	
		AIR/O_2							14	**14**	**76**	117:00		
120	2:00	AIR							19	28	324	373:40	4	
		AIR/O_2							19	**14**	**85**	136:00		
Exceptional Exposure: $SurDO_2$ --														
150	1:40	AIR						3	26	46	461	538:20	5	
		AIR/O_2						3	26	**23**	**109**	183:40		

Table 9-9. Air Decompression Table (Continued).

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
110 FSW														
20	3:40	AIR									0	3:40	0	H
		AIR/O_2									**0**	3:40		
25	3:00	AIR									5	8:40	0.5	I
		AIR/O_2									**3**	6:40		
30	3:00	AIR									14	17:40	0.5	K
		AIR/O_2									**7**	10:40		
In-Water Air/O_2 Decompression or SurDO_2 Recommended ----------														
35	3:00	AIR									27	30:40	1	M
		AIR/O_2									**14**	17:40		
40	3:00	AIR									39	42:40	1	N
		AIR/O_2									**20**	23:40		
45	3:00	AIR									50	53:40	1	O
		AIR/O_2									**26**	29:40		
50	3:00	AIR									71	74:40	1.5	Z
		AIR/O_2									**32**	35:40		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
55	2:40	AIR								5	85	93:20	1.5	Z
		AIR/O_2								**3**	**33**	44:20		
60	2:40	AIR								13	111	127:20	2	Z
		AIR/O_2								**7**	**36**	51:20		
70	2:40	AIR								26	155	184:20	2.5	Z
		AIR/O_2								**14**	**42**	64:20		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required----------														
80	2:20	AIR							9	28	200	240:00	2.5	
		AIR/O_2							9	**14**	**54**	90:20		
90	2:20	AIR							18	28	249	298:00	3.5	
		AIR/O_2							18	**14**	**68**	113:20		
100	2:20	AIR							25	28	295	351:00	3.5	
		AIR/O_2							25	**14**	**79**	131:20		
110	2:00	AIR						5	26	28	353	414:40	4	
		AIR/O_2						5	26	**14**	**91**	154:00		
Exceptional Exposure: SurDO_2 ----------														
120	2:00	AIR						10	26	35	413	486:40	4.5	
		AIR/O_2						10	26	**18**	**101**	173:00		
180	1:40	AIR					3	23	47	68	593	736:20	7.5	
		AIR/O_2					3	23	47	**34**	**159**	298:40		

***Table 9-9.** Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
120 FSW														
15	4:00	AIR									0	4:00	0	F
		AIR/O_2									**0**	4:00		
20	3:20	AIR									4	8:00	0.5	H
		AIR/O_2									**2**	6:00		
25	3:20	AIR									9	13:00	0.5	J
		AIR/O_2									**5**	9:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
30	3:20	AIR									24	28:00	0.5	L
		AIR/O_2									**13**	17:00		
35	3:20	AIR									38	42:00	1	N
		AIR/O_2									**20**	24:00		
40	3:00	AIR								2	49	54:40	1	O
		AIR/O_2								**1**	**26**	30:40		
45	3:00	AIR								3	71	77:40	1.5	Z
		AIR/O_2								**2**	**31**	36:40		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
50	3:00	AIR								10	85	98:40	1.5	Z
		AIR/O_2								**5**	**33**	46:40		
55	3:00	AIR								19	116	138:40	2	Z
		AIR/O_2								**10**	**35**	53:40		
60	3:00	AIR								27	142	172:40	2	Z
		AIR/O_2								**14**	**39**	61:40		
70	2:40	AIR							13	28	190	234:20	2.5	
		AIR/O_2							13	**14**	**51**	86:40		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required---														
80	2:40	AIR							24	28	246	301:20	3	
		AIR/O_2							24	**14**	**67**	118:40		
90	2:20	AIR						7	26	28	303	367:00	3.5	
		AIR/O_2						7	26	**14**	**80**	140:20		
100	2:20	AIR						15	25	28	372	443:00	4	
		AIR/O_2						15	25	**14**	**95**	167:20		
Exceptional Exposure: SurDO_2 ---														
110	2:20	AIR						21	25	38	433	520:00	5	
		AIR/O_2						21	25	**19**	**105**	188:20		
120	2:00	AIR					3	23	25	47	480	580:40	5.5	
		AIR/O_2					3	23	25	**24**	**113**	211:00		

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop									Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
			100	90	80	70	60	50	40	30	20			
130 FSW														
12	4:20	AIR									0	4:20	0	F
		AIR/O_2									**0**	4:20		
15	3:40	AIR									3	7:20	0.5	G
		AIR/O_2									**2**	6:20		
20	3:40	AIR									8	12:20	0.5	I
		AIR/O_2									**5**	9:20		
In-Water Air/O_2 Decompression or SurDO_2 Recommended ---														
25	3:40	AIR									17	21:20	0.5	K
		AIR/O_2									**9**	13:20		
30	3:20	AIR								2	32	38:00	1	M
		AIR/O_2								1	**17**	22:00		
35	3:20	AIR								5	44	53:00	1	O
		AIR/O_2								**3**	**23**	30:00		
40	3:20	AIR								6	66	76:00	1.5	Z
		AIR/O_2								**3**	**30**	37:00		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
45	3:00	AIR							1	11	84	99:40	1.5	Z
		AIR/O_2							1	**6**	**33**	49:00		
50	3:00	AIR							2	20	118	143:40	2	Z
		AIR/O_2							2	**10**	**36**	57:00		
55	3:00	AIR							4	28	146	181:40	2	Z
		AIR/O_2							4	**14**	**40**	67:00		
60	3:00	AIR							12	28	170	213:40	2.5	Z
		AIR/O_2							12	**14**	**46**	81:00		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required---														
70	2:40	AIR						1	26	28	235	293:20	3	
		AIR/O_2						1	26	**14**	**63**	117:40		
80	2:40	AIR						12	26	28	297	366:20	3.5	
		AIR/O_2						12	26	**14**	**79**	144:40		
90	2:40	AIR						22	25	28	375	453:20	4	
		AIR/O_2						22	25	**14**	**95**	174:40		
Exceptional Exposure: SurDO_2 ---														
100	2:20	AIR					6	23	26	38	444	540:00	5	
		AIR/O_2					6	23	26	**20**	**106**	204:20		
120	2:20	AIR					17	24	27	57	534	662:00	6	
		AIR/O_2					17	24	27	**29**	**130**	255:20		
180	2:00	AIR				13	21	45	57	94	658	890:40	9	
		AIR/O_2				13	21	45	57	**46**	**198**	418:00		

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
140 FSW														
10	4:40	AIR									0	4:40	0	E
		AIR/O_2									**0**	4:40		
15	4:00	AIR									5	9:40	0.5	H
		AIR/O_2									**3**	7:40		
20	4:00	AIR									13	17:40	0.5	J
		AIR/O_2									**7**	11:40		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
25	3:40	AIR								3	24	31:20	1	L
		AIR/O_2								**2**	**12**	18:20		
30	3:40	AIR								7	37	48:20	1	N
		AIR/O_2								**4**	**19**	27:20		
35	3:20	AIR							2	7	58	71:00	1.5	O
		AIR/O_2							2	**4**	**26**	36:20		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
40	3:20	AIR							4	7	82	97:00	1.5	Z
		AIR/O_2							4	**4**	**33**	50:20		
45	3:20	AIR							5	18	114	141:00	2	Z
		AIR/O_2							5	**9**	**36**	59:20		
50	3:20	AIR							8	27	145	184:00	2	Z
		AIR/O_2							8	**14**	**39**	70:20		
55	3:00	AIR						1	15	29	171	219:40	2.5	Z
		AIR/O_2						1	15	**15**	**45**	85:00		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required---														
60	3:00	AIR						2	23	28	209	265:40	3	
		AIR/O_2						2	23	**14**	**56**	109:00		
70	3:00	AIR						14	25	29	276	347:40	3.5	
		AIR/O_2						14	25	**15**	**74**	142:00		
80	2:40	AIR					2	24	25	29	362	445:20	4	
		AIR/O_2					2	24	25	**15**	**91**	175:40		
Exceptional Exposure: SurDO_2 ---														
90	2:40	AIR					12	23	26	38	443	545:20	5	
		AIR/O_2					12	23	26	**19**	**107**	210:40		

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop									Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
			100	90	80	70	60	50	40	30	20			
150 FSW														
8	5:00	AIR									0	5:00	0	E
		AIR/O_2									**0**	5:00		
10	4:20	AIR									2	7:00	0.5	F
		AIR/O_2									**1**	6:00		
15	4:20	AIR									8	13:00	0.5	H
		AIR/O_2									**5**	10:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended ---														
20	4:00	AIR								2	15	21:40	0.5	K
		AIR/O_2								1	**8**	13:40		
25	4:00	AIR								7	29	40:40	1	M
		AIR/O_2								**4**	**14**	22:40		
30	3:40	AIR							4	7	45	60:20	1.5	O
		AIR/O_2							4	**4**	**22**	34:40		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
35	3:40	AIR							6	7	74	91:20	1.5	Z
		AIR/O_2							6	**4**	**30**	44:40		
40	3:20	AIR						2	6	14	106	132:00	2	Z
		AIR/O_2						2	6	**7**	**35**	59:20		
45	3:20	AIR						3	8	24	142	181:00	2	Z
		AIR/O_2						3	8	**12**	**40**	72:20		
50	3:20	AIR						4	14	28	170	220:00	2.5	Z
		AIR/O_2						4	14	**14**	**46**	87:20		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------ SurDO_2 Required---														
55	3:20	AIR						7	21	28	212	272:00	3	
		AIR/O_2						7	21	**14**	**57**	113:20		
60	3:20	AIR						11	26	28	248	317:00	3	
		AIR/O_2						11	26	**14**	**67**	132:20		
70	3:00	AIR					3	24	25	28	330	413:40	4	
		AIR/O_2					3	24	25	**14**	**85**	170:00		
Exceptional Exposure: SurDO_2 --														
80	3:00	AIR					15	23	26	35	430	532:40	4.5	
		AIR/O_2					15	23	26	**18**	**104**	205:00		
90	2:40	AIR				3	22	23	26	47	496	620:20	5.5	
		AIR/O_2				3	22	23	26	**24**	**118**	239:40		
120	2:20	AIR			3	20	22	23	50	75	608	804:00	8	
		AIR/O_2			3	20	22	23	50	**37**	**168**	356:20		
180	2:00	AIR		2	19	20	42	48	79	121	694	1027:40	10.5	
		AIR/O_2		2	19	20	42	48	79	**58**	**222**	538:00		

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop									Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
			100	90	80	70	60	50	40	30	20			
160 FSW														
7	5:20	AIR									0	5:20	0	E
		AIR/O_2									**0**	5:20		
10	4:40	AIR									4	9:20	0.5	F
		AIR/O_2									**2**	7:20		
15	4:20	AIR								2	10	17:00	0.5	I
		AIR/O_2								**1**	**6**	12:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
20	4:00	AIR							1	4	19	28:40	0.5	L
		AIR/O_2							1	**2**	**10**	18:00		
25	4:00	AIR							4	7	35	50:40	1	N
		AIR/O_2							4	**4**	**17**	30:00		
30	3:40	AIR						2	6	7	62	81:20	1.5	Z
		AIR/O_2						2	6	**4**	**26**	42:40		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
35	3:40	AIR						4	6	8	89	111:20	1.5	Z
		AIR/O_2						4	6	**4**	**34**	57:40		
40	3:40	AIR						6	6	21	134	171:20	2	Z
		AIR/O_2						6	6	**11**	**38**	70:40		
45	3:20	AIR					2	5	11	28	166	216:00	2.5	Z
		AIR/O_2					2	5	11	**14**	**45**	86:20		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required--														
50	3:20	AIR					2	8	19	28	207	268:00	3	
		AIR/O_2					2	8	19	**15**	**55**	113:20		
55	3:20	AIR					3	11	26	28	248	320:00	3	
		AIR/O_2					3	11	26	**14**	**67**	135:20		
60	3:20	AIR					6	17	25	29	291	372:00	3.5	
		AIR/O_2					6	17	25	**15**	**77**	154:20		
Exceptional Exposure: SurDO_2 ---														
70	3:20	AIR					15	23	26	29	399	496:00	4.5	
		AIR/O_2					15	23	26	**15**	**99**	197:20		
80	3:00	AIR				6	21	24	25	44	482	605:40	5.5	
		AIR/O_2				6	21	24	25	**23**	**114**	237:00		

Table 9-9. *Air Decompression Table (Continued).*

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop									Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
			100	90	80	70	60	50	40	30	20			
170 FSW														
6	5:40	AIR									0	5:40	0	D
		AIR/O_2									**0**	5:40		
10	5:00	AIR									6	11:40	0.5	G
		AIR/O_2									**3**	8:40		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
15	4:40	AIR								3	13	21:20	0.5	J
		AIR/O_2								2	**6**	13:20		
20	4:20	AIR							3	6	24	38:00	1	M
		AIR/O_2							3	**3**	**12**	23:20		
25	4:00	AIR						1	7	7	41	60:40	1	O
		AIR/O_2						1	7	**4**	**20**	37:00		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
30	4:00	AIR						5	7	7	77	100:40	1.5	Z
		AIR/O_2						5	7	**3**	**30**	50:00		
35	3:40	AIR					2	6	6	15	120	153:20	2	Z
		AIR/O_2					2	6	6	**8**	**37**	68:40		
40	3:40	AIR					4	6	9	25	158	206:20	2.5	Z
		AIR/O_2					4	6	9	**12**	**44**	84:40		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required---														
45	3:40	AIR					5	7	16	28	197	257:20	2.5	Z
		AIR/O_2					5	7	16	**14**	**53**	109:40		
50	3:20	AIR				1	5	11	23	28	244	316:00	3	
		AIR/O_2				1	5	11	23	**14**	**66**	134:20		
55	3:20	AIR				2	7	16	26	28	289	372:00	3.5	
		AIR/O_2				2	7	16	26	**14**	**77**	156:20		
60	3:20	AIR				2	11	21	26	28	344	436:00	4	
		AIR/O_2				2	11	21	26	**14**	**88**	181:20		
Exceptional Exposure: SurDO_2 ---														
70	3:20	AIR				7	19	24	25	39	454	572:00	5	
		AIR/O_2				7	19	24	25	**20**	**109**	228:20		
80	3:20	AIR				17	22	23	26	53	525	670:00	6	
		AIR/O_2				17	22	23	26	**27**	**128**	267:20		
90	3:00	AIR			8	19	22	23	37	66	574	752:40	7	
		AIR/O_2			8	19	22	23	37	**33**	**148**	319:00		
120	2:40	AIR		9	19	20	22	42	60	94	659	928:20	9	
		AIR/O_2		9	19	20	22	42	60	**46**	**198**	454:40		
180	2:20	AIR	10	18	19	40	43	70	97	156	703	1159:00	11.5	
		AIR/O_2	10	18	19	40	43	70	97	**74**	**229**	648:00		

Table 9-9. Air Decompression Table (Continued).

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop									Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
			100	90	80	70	60	50	40	30	20			
180 FSW														
6	6:00	AIR									0	6:00	0	E
		AIR/O_2									**0**	6:00		
10	5:20	AIR									8	14:00	0.5	G
		AIR/O_2									**4**	10:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
15	4:40	AIR							2	3	14	24:20	0.5	K
		AIR/O_2							2	**2**	**7**	16:40		
20	4:20	AIR						1	5	7	29	47:00	1	M
		AIR/O_2						1	5	**3**	**15**	29:20		
25	4:20	AIR						5	6	7	57	80:00	1.5	O
		AIR/O_2						5	6	**4**	**24**	44:20		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
30	4:00	AIR					3	6	6	7	95	121:40	1.5	Z
		AIR/O_2					3	6	6	**4**	**34**	63:00		
35	3:40	AIR				1	5	6	6	22	144	188:20	2	Z
		AIR/O_2				1	5	6	6	**11**	**41**	79:40		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required---														
40	3:40	AIR				2	6	5	13	28	178	236:20	2.5	
		AIR/O_2				2	6	5	13	**14**	**48**	97:40		
45	3:40	AIR				4	5	10	20	28	235	306:20	3	
		AIR/O_2				4	5	10	20	**14**	**63**	130:40		
50	3:40	AIR				4	8	13	25	29	277	360:20	3.5	
		AIR/O_2				4	8	13	25	**15**	**75**	154:40		
55	3:40	AIR				5	11	19	26	28	336	429:20	4	
		AIR/O_2				5	11	19	26	**14**	**87**	181:40		
Exceptional Exposure: SurDO_2 ---														
60	3:20	AIR			1	8	13	23	25	31	406	511:00	4.5	
		AIR/O_2			1	8	13	23	25	**16**	**100**	205:20		
70	3:20	AIR			4	12	21	24	25	48	499	637:00	5.5	
		AIR/O_2			4	12	21	24	25	**24**	**119**	253:20		

Table 9-9. *Air Decompression Table (Continued).*

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
190 FSW														
5	6:20	AIR									0	6:20	0	D
		AIR/O_2									**0**	6:20		
10	5:20	AIR								2	8	16:00	0.5	H
		AIR/O_2								1	**4**	11:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended ---														
15	4:40	AIR						1	3	3	16	28:20	0.5	K
		AIR/O_2						1	3	**2**	**8**	19:40		
20	4:20	AIR					1	2	6	7	34	55:00	1	N
		AIR/O_2					1	2	6	**4**	**17**	35:20		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
25	4:20	AIR					2	6	7	7	72	99:00	1.5	Z
		AIR/O_2					2	6	7	**3**	**28**	51:20		
30	4:00	AIR				1	6	5	7	13	122	158:40	2	Z
		AIR/O_2				1	6	5	7	**7**	**38**	74:00		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required--														
35	4:00	AIR				4	5	6	8	26	165	218:40	2.5	Z
		AIR/O_2				4	5	6	8	**13**	**45**	91:00		
40	3:40	AIR			1	5	5	8	17	28	217	285:20	3	
		AIR/O_2			1	5	5	8	17	**15**	**58**	123:40		
45	3:40	AIR			2	5	6	12	24	29	264	346:20	3.5	
		AIR/O_2			2	5	6	12	24	**15**	**71**	149:40		
50	3:40	AIR			3	5	10	17	26	28	324	417:20	4	
		AIR/O_2			3	5	10	17	26	**14**	**85**	179:40		
Exceptional Exposure: SurDO2 --														
55	3:40	AIR			4	8	10	24	25	30	397	502:20	4.5	
		AIR/O_2			4	8	10	24	25	**15**	**99**	204:40		
60	3:40	AIR			5	10	16	24	25	40	454	578:20	5	
		AIR/O_2			5	10	16	24	25	**20**	**109**	233:40		
90	3:20	AIR		11	19	20	21	28	51	83	626	863:00	8.5	
		AIR/O_2		11	19	20	21	28	51	**41**	**178**	408:20		
120	3:00	AIR	15	17	19	20	37	46	79	113	691	1040:40	10.5	
		AIR/O_2	15	17	19	20	37	46	79	**55**	**219**	551:00		

Table 9-9. Air Decompression Table (Continued).

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
200 FSW														
Exceptional Exposure --														
5	6:40	AIR									0	6:40	0	E
		AIR/O_2									**0**	6:40		
10	5:40	AIR								3	8	17:20	0.5	H
		AIR/O_2								**2**	**4**	12:20		
15	5:00	AIR						2	3	5	19	34:40	0.5	L
		AIR/O_2						2	3	**3**	**9**	23:00		
20	4:40	AIR					2	4	6	7	43	67:20	1	O
		AIR/O_2					2	4	6	**4**	**20**	41:40		
25	4:20	AIR				1	5	6	6	7	85	115:00	1.5	Z
		AIR/O_2				1	5	6	6	**4**	**32**	64:20		
30	4:20	AIR				4	6	5	7	19	145	191:00	2	Z
		AIR/O_2				4	6	5	7	**10**	**42**	84:20		
35	4:00	AIR			2	5	5	6	13	28	188	251:40	2.5	
		AIR/O_2			2	5	5	6	13	**14**	**51**	106:00		
40	4:00	AIR			4	5	5	11	21	28	249	327:40	3.5	
		AIR/O_2			4	5	5	11	21	**14**	**68**	143:00		
45	3:40	AIR		1	4	5	10	14	25	28	306	397:20	3.5	
		AIR/O_2		1	4	5	10	14	25	**14**	**81**	168:40		
50	3:40	AIR		2	4	8	10	21	26	28	382	485:20	4.5	
		AIR/O_2		2	4	8	10	21	26	**14**	**97**	201:40		
210 FSW														
Exceptional Exposure --														
4	7:00	AIR									0	7:00	0	D
		AIR/O_2									**0**	7:00		
5	6:20	AIR									2	9:00	0.5	E
		AIR/O_2									**1**	8:00		
10	5:40	AIR							2	3	9	20:20	0.5	I
		AIR/O_2							2	**2**	**4**	14:40		
15	5:00	AIR					1	3	3	6	24	42:40	1	M
		AIR/O_2					1	3	3	**3**	**12**	28:00		
20	4:40	AIR				1	3	5	6	7	57	84:20	1	O
		AIR/O_2				1	3	5	6	**4**	**23**	47:40		
25	4:40	AIR				3	6	5	7	8	110	144:20	2	Z
		AIR/O_2				3	6	5	7	**4**	**38**	73:40		
30	4:20	AIR			2	5	6	6	6	26	163	219:00	2.5	Z
		AIR/O_2			2	5	6	6	6	**13**	**45**	93:20		
35	4:00	AIR		1	4	5	6	7	18	28	223	296:40	3	
		AIR/O_2		1	4	5	6	7	18	**14**	**60**	130:00		
40	4:00	AIR		2	5	5	7	11	26	28	278	366:40	3.5	
		AIR/O_2		2	5	5	7	11	26	**14**	**76**	161:00		
45	4:00	AIR		4	4	6	11	18	26	28	355	456:40	4	
		AIR/O_2		4	4	6	11	18	26	**14**	**91**	194:00		
50	3:40	AIR	1	4	5	10	12	23	26	36	432	553:20	5	
		AIR/O_2	1	4	5	10	12	23	26	**18**	**105**	223:40		

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

220 FSW

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 130	120	110	100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
Exceptional Exposure																	
4	7:20	AIR												0	7:20	0	E
		AIR/O_2												**0**	7:20		
5	6:40	AIR												3	10:20	0.5	E
		AIR/O_2												**2**	9:20		
10	6:00	AIR										3	4	10	23:40	0.5	J
		AIR/O_2										3	**2**	**5**	17:00		
15	5:20	AIR								3	2	4	7	28	50:00	1	N
		AIR/O_2								3	2	4	**4**	**14**	33:20		
20	5:00	AIR							2	4	6	6	7	70	100:40	1.5	Z
		AIR/O_2							2	4	6	6	**4**	**26**	54:00		
25	4:40	AIR						1	5	6	6	6	14	133	176:20	2	Z
		AIR/O_2						1	5	6	6	6	**7**	**41**	82:40		
30	4:20	AIR					1	4	5	6	6	10	28	183	248:00	2.5	
		AIR/O_2					1	4	5	6	6	10	**14**	**50**	106:20		
35	4:20	AIR					3	5	5	5	10	22	28	251	334:00	3.5	
		AIR/O_2					3	5	5	5	10	22	**14**	**68**	147:20		
40	4:00	AIR				1	4	5	5	9	15	26	28	319	416:40	4	
		AIR/O_2				1	4	5	5	9	15	26	**14**	**84**	183:00		

250 FSW

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	130	120	110	100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
Exceptional Exposure																	
4	7:40	AIR												4	12:20	0.5	F
		AIR/O_2												**2**	10:20		
5	7:40	AIR												7	15:20	0.5	G
		AIR/O_2												**4**	12:20		
10	6:20	AIR								2	2	4	3	15	33:00	0.5	L
		AIR/O_2								2	2	4	**2**	**7**	24:20		
15	5:40	AIR						2	2	3	4	6	7	53	83:20	1	O
		AIR/O_2						2	2	3	4	6	**4**	**22**	49:40		
20	5:20	AIR					2	2	4	6	6	6	11	125	168:00	2	Z
		AIR/O_2					2	2	4	6	6	6	**6**	**39**	82:20		
25	5:00	AIR				1	4	4	5	6	6	10	28	189	258:40	2.5	
		AIR/O_2				1	4	4	5	6	6	10	**14**	**51**	112:00		
30	4:40	AIR			1	4	4	4	5	6	9	25	28	267	358:20	3.5	
		AIR/O_2			1	4	4	4	5	6	9	25	**15**	**72**	160:40		
35	4:40	AIR			3	4	4	5	5	10	19	26	28	363	472:20	4	
		AIR/O_2			3	4	4	5	5	10	19	26	**14**	**93**	203:40		

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop												Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
			130	120	110	100	90	80	70	60	50	40	30	20			

300 FSW

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	130	120	110	100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
Exceptional Exposure --																	
4	9:00	AIR											3	7	19:40	0.5	G
		AIR/O_2											**2**	**4**	15:40		
5	8:40	AIR										3	3	8	23:20	0.5	I
		AIR/O_2										3	**2**	**4**	18:40		
10	7:20	AIR						2	3	2	3	4	7	35	64:00	1	N
		AIR/O_2						2	3	2	3	4	**4**	**18**	44:20		
15	6:20	AIR			1	2	2	3	3	5	6	7	11	125	172:00	2	Z
		AIR/O_2			1	2	2	3	3	5	6	7	**6**	**39**	86:20		
20	6:00	AIR		2	2	2	4	5	5	5	6	16	28	219	300:40	3	
		AIR/O_2		2	2	2	4	5	5	5	6	16	**14**	**59**	137:00		
25	5:40	AIR	1	3	4	4	4	5	5	5	18	26	28	324	433:20	4	
		AIR/O_2	1	3	4	4	4	5	5	5	18	26	**14**	**85**	195:40		

ATTACHMENT 11

EQUIPMENT CHECKLISTS

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ATTACHMENT 11

EQUIPMENT CHECKLISTS

PROJECT NAME: ______________________________________ DATE: ______________________

GENERAL DIVE EQUIPMENT LOADOUT

General Dive Equipment

Item	Quantity	Inspected for operation and loaded
DIVE FLAG (CIVILIAN AND CODE ALPHA)		
LOST DIVER BUOY		
TENDING LINES AND HARNESSES		
HANDHELD GPS		
BUDDY LINES		
DIVE SYSTEM(S)		
AIR SUPPLY/ BOTTLES		
CELLULAR PHONE (ON AND CHARGED)		
VHF RADIO		
DRINKING WATER		
PERSONAL DIVE GEAR		
DIVE OPS WORK PLAN		
DIVE SAFE PRACTICES MANUAL		
U.S. NAVY DIVE MANUAL		
EMERGENCY CONTACT LIST (POSTED)		
REQUIRED LINES, BUOYS, ANCHORS		

ATTACHMENT 11

EQUIPMENT CHECKLISTS

PROJECT NAME: ______________________________ DATE: ____________________

GENERAL DIVE EQUIPMENT LOADOUT

Medical Equipment

Item	Quantity	Inspected for operation and loaded	
FIRST AID KIT/ TRAUMA KIT			
EMERGENCY OXYGEN SYSTEM		**PSIG**	**PSIG**
STRETCHER OR BACKBOARD			

Tools, UXO Related Equipment, Explosive Materials

Item	Quantity	Inspected for operation and loaded

______________________________ ______________________________
Loadout Checked (Name) Signature

______________________________ ______________________________
Diving Supervisor Name Diving Supervisor Signature

ATTACHMENT 11

EQUIPMENT CHECKLISTS

BOAT PRE-OPERATION CHECKLIST

Project Description:	**Date:**
Project Location:	**Job#:**

Step No.	**Description**	**Check Completed (Initials)**
1	**Inspect exterior of vessel** ☐ Inspect for visible damage ☐ Boat registration ☐ POL leaks ☐ Hull plugs in place ☐ Maintenance issues	
2	**Inspect propulsion system** ☐ a. Engine (propeller, oil, fuel level and extra fuel on board, hours since last maintenance, functional, and adequately secured to vessel) ☐ b. Steering system (functional, forward/reverse gears) ☐ c. Batteries (charged, water in cells, contacts clean)	
3	**Inspect all communication equipment** ☐ a. Perform VHF radio check with a base station ☐ b. Perform cellular phone check with a base station ☐ c. Perform dive communication check with radio and dive hats ☐ d. Have spare batteries charged and within reach of all comm. equip.	
4	**Inspect electrical systems and all other communication equipment** Ensure the following are on board and in work order ☐ a. Dive flags (Alpha and Recreational) and pole ☐ b. Sound signaling device (vessel horn, hand horn, whistle) ☐ c. Flares (rocket/parachute, hand held, smoke) ☐ d. Water dye canister, flash light, signaling mirror, EPIRB, and strobe lights for PFDs ☐ e. Deck and Navigation lighting (port, starboard, fore/aft, search, and cabin) ☐ f. Bilge pump	
5	**Inspect mooring systems** ☐ a. Anchor secured to line/chain and functional ☐ b. Line/chain in working order and ready for use ☐ c. Fenders secure and ready for use ☐ d. Extra line available for use	
6	**Ensure navigational equipment is functioning** ☐ a. GPS (locked on 4 satellites, correct datum, power source) ☐ b. Compass and binoculars ☐ c. Charts / maps	
7	**Place copies of the following in cabin near helm** ☐ a. Emergency procedures plan ☐ b. Safe diving practices and operations manual ☐ c. Air decompression tables	

ATTACHMENT 11

EQUIPMENT CHECKLISTS

BOAT PRE-OPERATION CHECKLIST

Step No.	Description	Check Completed (Initials)
8	**Inspect lifesaving equipment** ☐ a. Ensure 1 PFD per person and 1 throw ring (USCG approved, in working order and properly fitted with strobe, whistle and knife attached) ☐ b. First aid kit (stocked, non-expired contents), First aid book, back board ☐ c. Fire extinguisher (charged, current inspection, accessible)	
9	**Inspect toolbox** ☐ a. Spare parts for engine and other vessel systems ☐ b. Tools (clean and in working order) for repairing vessel systems and dive equipment	
10	**Alternate propulsion systems** ☐ a. Hand paddles (2) ☐ b. Spare outboard engine (complete, working, with spare fuel source)	
11	**Personal comfort equipment** ☐ a. Water ☐ b. Food ☐ c. Sunscreen/motion sickness medicine ☐ d. Clothing as required by conditions/locations (hard hat, sunglasses, ballcap, extreme weather, steel toed boots, change of clothes)	

NOTES:

1. File completed checklist in daily job log.
2. Record any maintenance issues in vessel log and report to Project Manager.
3. Complete dive boat safety checklist after completing this checklist.

ATTACHMENT 11

EQUIPMENT CHECKLISTS

SCUBA EQUIPMENT INSPECTION

Cylinders				FFMs/ Regulators/ Gauges		Buoyancy Compensators	
Primary		Emergency Bail-Out					
Pre-Dive	Post Dive	Pre-Dive	Post Dive	Pre-Dive	Post Dive	Pre-Dive	Post Dive
Serial # Inspect	Clean and Charge (PSIG)	Serial # Inspect	Clean and Charge (PSIG)	Serial # Inspect /Test	Clean and Inspect	Serial # Inspect /Test	Clean/Inspect

Notes:

1. Fill-in and initial each block prior to and after each dive. Place PSI level in block as indicated.
2. Ensure cylinders are gauged at minimum 90% capacity (2700 PSI) following charge. (NOTE: Gauge after bottles are cool).

Specific Pre-Dive Procedures:

FFM
- Inspect – Nose pad/ one-way/ comms/ purge/ ABV/ seal/ straps/ test breathe

Specific Post Dive Procedures:

Cylinders
- Rinse cylinders with fresh water.
- Leak check cylinders during charging.

Buoyancy Compensators
- Rinse with fresh water and clean BC.
- Inspect BC inflation and dump valves.
- Empty any water in BC, Inflate and leave overnight for drying and leak check

Masks / Regulators / Gauges
- Rinse with fresh water and sterilize masks and regulators (Note: see DOP concerning COVID-19 protocols).
- Inspect mask, regulator and hoses.
- Rinse & inspect gauges.

Diving Supervisor Name ____________________

Diving Supervisor Signature ____________________

ATTACHMENT 11

EQUIPMENT CHECKLISTS

SCUBA CHECKLIST

ALL ITEMS WILL BE CHECKED IN APPROPRIATE BLOCKS AS FOLLOWS:

1. **ALL PERSONNEL MUST WEAR SAFETY GLASSES WHEN WORKING WITH HP AIR**
2. **Initial for each completed and satisfactory check.**
3. **When completed, person completing the checks will sign as appropriate (blocks 1 thru 4) and then turn in to the Diving Supervisor for his checks, review and signature.**

Set Number	Diver Signature	Dive Supervisor Signature

Initial	Procedure	Remarks
Air Cylinders		
	Cylinders – inspect for current hydro and visual	
	O ring and valve – inspect condition	
	Pressure – adequate for days operations	
	Bail-Out Bottles - *Repeat above steps	
Buoyancy Compensator (BC)		
	Straps / Buckles / Harness – inspect condition and adjust for fit	
	Air bladder – leak check	
	Cylinder and bail-out – mount securely	
	Inflator fitting and hose – inspect condition	
	Dump valves – check for proper function	
Regulator(s)		
	Hoses / Connectors – inspect condition	
	1st and 2nd stages – inspect condition	
	Cylinder yoke assembly – secure	
	Bail-out regulator(s) – repeat above checks	
	Regulator assemblies – attach to cylinders	
	Inflation whip – attach to BC	
	Valves – open / leak check cylinder O ring	
	Pressure gauge – reading properly	
	Dive Computer – inspect, check batt, function	
	BC inflation – check proper function	
	Primary regulator / bail-out regulator - test	
	Fittings - Check for leaks	
	FFM – Nose pad/ one-way valves / comms/ pp/ ABV**/** seal/straps	
Notes:		

ATTACHMENT 11

EQUIPMENT CHECKLISTS

SCUBA CHECKLIST

ALL ITEMS WILL BE CHECKED IN APPROPRIATE BLOCKS AS FOLLOWS:

1. **ALL PERSONNEL MUST WEAR SAFETY GLASSES WHEN WORKING WITH HP AIR**
2. **Initial for each completed and satisfactory check.**
3. **When completed, person completing the checks will sign as appropriate (blocks 1 THRU 3) and then turn in to the Diving Supervisor for checks, review, and signature.**

Mask/ Type	Serial No.	Diver Signature	Dive Supervisor Signature
1.			
2.			
3.			
4.			
5.			

Initial	Procedure	Remarks
	Check SADS float inflation level	
	Check SADS for holes, tears, or air bladder leaks.	
	Check Umbilical condition and correctly secured to SADS float assembly.	
	Ensure SADS air bottles (primary and EGS are properly secured to SADS float assembly).	
	Attach Primary and EGS regulators to bottles	
	Check divers harness assembly (Configure as required)	
	Connect FFM to primary LP hose (replace second stage)	
	Inspect Full Face Mask (FFM) - Nose pad/ one-way/ comms/ pp/ ABV (if installed)/ seal / straps	
	Open main bottle slowly; record pressure	PSIG: (min 90% @ 2700 psig)
	Open EGS bottle slowly; record pressure	PSIG: (min 90% @ 2700 psig)
	Check air to FFM; test breathe	
	Check air to EGS; test breathe	
	Check comms – DV to/from SUPE (during in water checks)	

Notes:

ATTACHMENT 11

EQUIPMENT CHECKLISTS

SCUBA CHECKLIST

ALL ITEMS WILL BE CHECKED IN APPROPRIATE BLOCKS AS FOLLOWS:

1. **ALL PERSONNEL MUST WEAR SAFETY GLASSES WHEN WORKING WITH HP AIR**
2. **Initial for each completed and satisfactory check.**
3. **When completed, person completing the checks will sign as appropriate (blocks 1 or 2) and then turn in to the Diving Supervisor for checks, review, and signature.**

Mask/ Type	Serial No.	Diver Signature	Dive Supervisor Signature
1.			
2.			
3.			
4.			
5.			

Initial	Procedure	Remarks
	Secure primary and EGS air; bleed down system	
	Disconnect FFM	
	Check FFM for damage	
	Check SADS for holes, tears, or air bladder leaks.	
	Check umbilical condition and still correctly secured to SADS float assembly.	
	Remove primary and EGS first stages from bottles	
	Inspect harness	
	Cap all open fittings on umbilical	** Use dummy plugs/ tape connector.*
	Disinfect FFM and EGS 2nd stage with disinfectant solution/ wipes	***Note**: See DOP for COVID-19 protocols*
	Wash all components with soap and water. Hang dry.	
	Stow SADS system	

Notes:

ATTACHMENT 11

EQUIPMENT CHECKLISTS

PRE-DIVE: SSA SYSTEM

PROJECT NAME/NUMBER:_________________________________DATE:___________________
TENDER/DIVER: ____

<u>NOTE:</u> ALL ITEMS WILL BE CHECKED IN APPROPRIATE BLOCKS AS FOLLOWS:

1. **An initial for each completed and satisfactory check.**
2. **An N/A for each item not applicable to the Dive Helmet being pre-dove.**
3. **An "R" for any repairs made. A brief description in the remarks section. If more space required use the "notes" section for continuation.**
4. **When completed, person completing the checks will sign as appropriate and then turn in to the Diving Supervisor for his checks, review, and signature.**

Helmet/Mask Type	Serial No.	Checked By:	Signature	Dive Supe Signature
1.				
2.				

	Procedure	Remarks					
1	Ensure HP Air Bottles secured; Check cylinder pressures; Record cylinder pressures	#1:	#2:	#3:	#4:	#5:	#6:
2	Ensure ACS on solid surface and secured						
3	Inspect ACS condition						
4	Check Umbilical condition and secured						
5	Ensure all ACS valves are SECURED (closed);regulator valve low pressure (*all the way counterclockwise*)						
6	Attach HP whips to bottles						
7	Open bottles slowly; record HP Supply Pressure	PSIG #1:			PSIG #2:		
8	Attach Divers supply/ pneumo hoses/ comm wires and mic to ACS						
9	Open 1 HP supply (slowly)						
10	Set required OB pressure on ACS	OB PSIG:					

	Procedure	1	2	Remarks
11	Test non-return valve (suck and blow)			
12	Check helmet for damage / deterioration			
13	Check neck dam seal (lube if required)			
14	Check oral nasal mask			
15	Check side block assembly – ensure secure			
16	Check 2nd stage regulator			
17	Check inhalation diaphragm			
18	Check exhaust valve			
19	Check neck dam for damage			
20	Check neck dam assembly			
21	Check locking mechanism			
22	Check to ensure flow restrictor in place			*Mandatory if inflator hose used for dry suit
23	Ensure flow restrictor plug in place or stowed in safe place			*If inflator hose not used.
24	Check 1st stage assembly			
25	Check HP and LP hoses			

ATTACHMENT 11

EQUIPMENT CHECKLISTS

PRE-DIVE: SSA SYSTEM

	Procedure	1	2	Remarks	
26	Check face plate secure and not damaged *(DO NOT use screwdriver)*				
27	Check harness assembly				
28	Check bailout bottle PSIG *(90% or 2700 minimum)*			PSIG 1:	PSIG 2:
29	Check air spread OPs completed				
30	Remove hose plugs; blow down system				
31	Connect hoses; snoop all fittings				
32	Adjust dial-a-breath				
33	Check free-flow				
34	Check purge				
35	Check EGS valve				
36	Check communications OK				

Notes:

ATTACHMENT 11

EQUIPMENT CHECKLISTS

POST-DIVE: SSA SYSTEM

PROJECT NAME/NUMBER:__________________________________DATE:___________________
TENDER/DIVER: ____

NOTE: ALL ITEMS WILL BE CHECKED IN APPROPRIATE BLOCKS AS FOLLOWS:

1. **An initial for each completed and satisfactory check.**
2. **An N/A for each item not applicable to the Dive Helmet being pre-dove.**
3. **An “R” for any repairs made. A brief description in the remarks section. If more space required use the “notes” section for continuation.**
4. **When completed, person completing the checks will sign as appropriate (blocks 1 or 2) and then turn in to the DivingSupervisor for his checks, review and signature.**

Helmet/Mask Type	Serial No.	Checked By:	Signature	Dive Supe Signature
1.				
2.				

	Procedure	1	2	Remarks
1	Secure ACS			
2	Bleed and disconnect hoses			
3	Make sure flow restrictor remains on helmet when using dry suit inflator whip			
4	Install flow restrictor plug			
5	Disconnect comms: 2-wire or MM plug			
6	Cap helmet and umbilical fittings			
7	Check helmet for damage			
8	Check neck dam O-ring for damage (lube)			
9	Check neck dam assembly for damage			
10	Check locking mechanisms for damage			
11	Remove head liner			
12	Check oral nasal mask			
13	Check side block assembly - secured			
14	Check 2nd stage regulator			
15	Check inhalation diaphragm			
16	Check LP and HP hoses (1st stage)			
17	Check face plate secure and not damaged *(DO NOT use screwdriver)*			
18	Wash with soap and water. Then dry.			
19	Disinfect using COVID-19 protocols outlined in DOP			
20	Open all valves – back of ¼ turn			
21	Remove covers from ear speakers / comms pod			
Notes:				
Number of dives:				

ATTACHMENT 11

EQUIPMENT CHECKLISTS

PRE-DIVE: SURFACE SUPPLIED AIR w/ FFM

PROJECT NAME/NUMBER:_________________________________DATE:___________________

TENDER/DIVER: ____

ALL ITEMS WILL BE CHECKED IN APPROPRIATE BLOCKS AS FOLLOWS:

1. **ALL PERSONNEL MUST WEAR SAFETY GLASSES WHEN WORKING WITH HP AIR**
2. **Initial for each completed and satisfactory check.**
3. **When completed, person completing the checks will sign as appropriate (blocks 1 THRU 3) and then turn in to the Diving Supervisor for his checks, review and signature.**

Mask/ Type	Serial No.	Diver Signature	Dive Supervisor Signature
1.			
2.			
3.			

Initial	Procedure	Remarks					
	Ensure HP Air Bottles secured; Check cylinder pressures; Record cylinder pressures	#1:	#2:	#3:	#4:	#5:	#6:
	Ensure ACS on solid surface and secured						
	Inspect ACS condition						
	Check Umbilical condition and secured						
	Ensure all ACS valves are SECURED (closed); regulator valve low pressure (*all the way counterclockwise*)						
	Attach HP whips to bottles						
	Open bottles slowly; record HP Supply Pressure	1 HP PSIG:				2 HP PSIG:	
	Attach Divers supply/ pneumo hoses/ comm wires and mic to ACS						
	Open 1 HP supply (slowly)						
	Set required OB pressure on ACS	OB PSIG:				* *Initial set @ 135 PSIG*	
	Check harness assembly						
	Check bailout bottle PSIG (90% @ min 2700)	PSIG DVR:				PSIG STBY:	
	Attach bailout first stage to pony bottle				* *Attach QD (first stage to KM block)*		
	Check KM Manifold Block (*Suck and blow*)						
	Blow down diver's umbilical's						
	Connect umbilical hose to KM blocks						
	Connect comms (Hi-use connector)			* *Secure dummy plugs/ tape connector*			
	Inspect Full Face Mask (FFM) - Nose pad/ one-way/ comms/ pp/ ABV/ seal / straps						
	Connect FFM to Block						
	Air to Masks						
	Check air to FFM; purge mask						
	Check comms – DV to console; DV to DV						
	Check pneumo for both umbilical's						
	Check all air spread OPs completed						

Notes:

ATTACHMENT 11

EQUIPMENT CHECKLISTS

POST-DIVE: SURFACE SUPPLIED AIR w/ FFM

PROJECT NAME/NUMBER:__________________________________DATE:___________________
TENDER/DIVER: ____

ALL ITEMS WILL BE CHECKED IN APPROPRIATE BLOCKS AS FOLLOWS:

1. **ALL PERSONNEL MUST WEAR SAFETY GLASSES WHEN WORKING WITH HP AIR**
2. **Initial for each completed and satisfactory check.**
3. **When completed, person completing the checks will sign as appropriate (blocks 1 or 2) and then turn in to the Diving Supervisor for his checks, review and signature.**

Mask/ Type	Serial No.	Diver Signature	Dive Supervisor Signature
1.			
2.			
3.			

Initial	Procedure	Remarks
	Secure HP air; bleed down all HP whips and umbilical's	
	Disconnect FFM air / comms	
	Check FFM for damage/ post dive	
	Disinfect with antibacterial wipes	*Note: See DOP for COVID-19 protocols.*
	Wash with soap and water. Then dry.	
	Bleed down EGS; Disconnect QD	
	Remove B/O first stage from pony	
	Bleed and disconnect hoses from KM block, inspect block and harness	
	Cap all fittings on block and umbilical	** Use dummy plugs/ tape connector.*
	Remove umbilicals from ACS/ stow	
	Cap all fittings on umbilical and ACS	
	Remove mic from ACS/ stow	
	Ensure all air system fittings capped and valves are secured; regulator valve backed out; ACS power OFF	
	Place ACS on charge or stow	

Notes:

Status:	Approved	**Approved By:**	M.W.D.ll Mark W. Dollar, President
Version Date:	09/08/2021	**Title:**	HSE 1-10, Boating
Revision #:	Rev. 2	**Original Issue Date:**	03/31/2020
Category:	Procedure	**Sections:**	Safety
Reference Driver:	CFR 33/EM 385-1-1	**Document Type:**	Procedure
Keyword Index:	Boating/Health, Safety and Environmental	**Document Owner:**	Scot Wilson

1.0 PURPOSE AND SCOPE

The purpose of this procedure is to establish the minimum requirements for boating safety. This procedure applies to all Tetra Tech Munitions Response (TMR) project sites and activities, including subcontractor activities.

2.0 DEFINITIONS

Definitions are provided to understand their intent as they pertain to a procedure and projects requiring quality program planning.

A Master List of Definitions is located in the Corporate Reference Library on the intranet (https://tetratechinc.sharepoint.com/sites/OU-TMR). In addition, the following definitions are specific to this procedure.

Inshore/Nearshore- For the purposes of TMR boating operations, inshore operations typically consist of the use of a boat less than 26 feet (Class A or Class I) that will not operate more than 1 mile from the nearest land.

Offshore- For the purposes of TMR boating operations, offshore operations typically consist of the use of a boat greater than 26 feet (Class II, Class III, or greater) that will operate more than 1 mile from the nearest land.

Boat – Any powered or non-powered watercraft utilized for the transport of personnel on a body of water.

Class	**Description**
Class A	Less than 16 feet (4.8 meters) length overall
Class I	16 feet (4.8 meters) to less than 26 feet (8 meters) length overall
Class II	26 feet (8 meters) to less than 40 feet (12 meters) length overall
Class III	40 to 65 feet (12 to 20 meters) length overall
Small Research Vessel (SRV)	Greater than 65 feet (20 meters) length overall but less than 300 gross tons
Diving Support Vessel (DSV)	Greater than 65 feet (20 meters) length overall but less than 300 gross tons

3.0 PROCEDURE

3.1 Responsibilities

3.1.1 Line Management

Project manager (PM) is responsible for coordinating with the dive program safety officer to implement the requirements of this procedure. The PM shall provide the necessary management support and allocate enough project resources to enable project personnel to operate boats in a safe manner.

Site managers (SMs) and supervisors are responsible for implementation of this boating safety program in the field.

3.1.2 HSE Personnel

The Health, Safety, and Environmental (HSE) director shall ensure that the requirements of this program are incorporated into site HSE plans.

3.1.3 Boat Captain

The captain of the boat is responsible for the overall health and safety of those on the boat. The boat captain shall ensure that all persons on the boat are given a safety orientation regarding emergency procedures. The boat captain shall also ensure that safety requirements in the applicable safety plan governing the work, such as the use of personal protective equipment, are implemented. The captain is also responsible for the inspection of the boat being used and for having the proper safety equipment, in good working order, on the boat. The captain of the boat will have the final say concerning safety, specifically concerning that of the personnel and craft during operations.

3.2 General Requirements

3.2.1 Boating Towing and Launching

Those TMR personnel who will tow a boat on a trailer to the launching site will be experienced in this capacity and be responsible for reviewing the Boat Pre-Operation Checklist prior to departure. This person will ensure that the boat is not loaded with project equipment, which will overload the bearings and axle weight capacity. Overweight equipment should be carried in another vehicle or the towing vehicle.

The PM must designate a person experienced in towing a boat, launching, or piloting a vessel. This person must have attended a nationally recognized boating safety class (i.e., United States Coast Guard [USCG] Auxiliary or Power Squad). Pre-launch checks will be done before the boat is backed into the water. This includes checking the engine oil and/or fuel mixtures in the tanks. Any mixing of fuel and oil will be done in a separate Underwriters Laboratory (UL) approved flammable liquid storage container prior to filling the vessel tanks. This will ensure the gas/oil mixture is correct.

Whenever possible, perform fuel mixing and transfer in an environmentally safe area where spills can be easily cleaned.

To launch the vessel, back part of the way down the boat ramp, remove the rear tie down straps to the trailer, ensure the boat plug is installed, and continue backing into the water's edge. Place the fenders/bumpers on the side that will be in contact with the pier, to prevent damage. Ensure that the bow and stern lines are being handled by personnel on the pier as the vessel is backed further into the water—until the vessel is floating freely. An alternative plan is to have the coxswain in the boat lower the engine and start it when the rear is in the water and floating free from the trailer. Carefully back the boat with the engine clear of the trailer. Pull the truck and trailer forward and park and secure. Secure the bow and stern lines to the dock and load additional equipment. Lower the engine/out drive, if applicable, and start the engine. Once warm, check all indicators and gauges to ensure that the motor is working properly.

For vessel recovery, reverse the process listed above. Back the truck and trailer down the ramp and place the truck in park with the emergency brake on. Keep the bow winch connected to the vessel until the vessel is out of the water and onto the trailer. Raise the motor/outdrive and secure in the up position. Once the vessel is trailered, remove additional equipment as necessary to reduce weight; and secure the vessel to the trailer with bow and stern straps and the safety chain near the winch. The vessel is not to be towed with a person in the vessel.

3.2.2 Boat Operators

Only designated TMR personnel who meet appropriate Federal, State or local training requirements shall operate a boat during a project. These requirements are a valid USCG license for vessels over 40 feet (12 meters) or any USCG recognized training such as the USCG Auxiliary Boating Skills and Seamanship Training for vessels less than 40 feet (12 meters).

Boat operators must possess basic knowledge to troubleshoot common mechanical problems that can occur on the boat. The boat operator shall be responsible for all personnel's safety on board the boat and for the integrity of all boat and safety equipment.

Each designated boat operator shall give a safety briefing to boat occupants prior to leaving shore. **Boats are to be occupied during use by not less than one qualified operator plus one additional person.** If the "additional person" is not a qualified operator, a basic safety and operations demonstration will be conducted before launching.

3.3 Logbook

Boat captains shall maintain a logbook for each vessel. The logbook will be used to note weather, tides, maintenance issues, equipment status, and to record completion of the safety orientation given to each day's passengers. Captains will make notes of any additional observations regarding the boat and its safe operation. This logbook will be kept with the vessel.

3.4 Float Plan

A Float Plan shall be filled out by the boat captain, unexploded ordnance (UXO) safety officer (UXOSO) or field operations lead (FOL) for all trips made by boat using the USCG Float Plan (Attachment 2). The UXOSO or FOL shall always be aware of the location of all project boats and designated use personnel. If several boats and crews are involved in the work or are traveling to remote areas, each designated boat operator shall file a written USCG Float Plan or equivalent with the UXOSO or SM/FOL. This plan can be filed electronically, via email or text message, if necessary. The Float Plan shall include the following:

- The names of the boat operator and passengers.
- A description and registration numbers of the boat.
- Radio call sign or cellular telephone number if boat is so equipped.
- A trip itinerary with expected time and location of return.
- Steps the UXOSO or SM/FOL will take to initiate a search response if the expected time of return is exceeded.

A Float Plan shall be prepared by each designated boat operator and approved by the PM, UXOSO, and/or qualified person prior to the activity. For boats that are operated with one crew, the Float Plan shall be developed that ensures the boat returns to the dock in no more than 12 hours.

3.5 Boat Registration and Numbering

The UXOSO or SM/FOL shall ensure that all project boats meet USCG or state boat registration and numbering requirements. The USCG requires that all motorized boats be numbered in the state of principal use. Many states also require that certain non-motorized boats be numbered (sailboats, rafts, and dinghies). A valid certificate or number showing the numbers issued to the boat is required to be on board the boat whenever the boat is in use. Boat registration numbers are required to be painted or permanently attached to the outside of each side of the forward half of the boat. Boat registration must be updated annually or as required by the registering state.

3.6 USCG -Approved Equipment

All TMR project boats will meet or exceed USCG requirements for safety equipment. These requirements are summarized below for small craft (less than 40 feet or 12 meters in length). The UXOSO or SM/FOL shall consult with the HSE director if larger craft are required.

3.6.1 Flame Arresters

All gasoline engines, except outboard motors, installed in a boat must have an approved flame arrestor (backfire preventer) fitted to the carburetor/intake.

3.6.2 Sound Signaling Devices

Although not required for small craft, all TMR boats shall carry at least one air horn or similar sound-signaling device.

3.6.3 Personal Flotation Devices

All TMR personnel and passengers shall always wear an approved personal flotation device (PFD) when operating or being transported in a boat. A positively buoyant wet suit may be substituted for a PFD. PFDs shall be Type III or higher (capable of turning its wearer in a vertical or slightly backward position in the water). Automatic inflating PFDs can be used providing that they are approved in the HSE Plan, and Activity Hazards Analysis addresses its use. For persons less than 90 pounds, a child PDF must be used. PDFs shall be inspected, maintained, and stored in accordance with the manufacturer's instruction. In addition, each boat up to 26 feet (8 meters) in length shall be equipped with at least one Type IV PFD ring buoy, 24 inches (6 meters) in diameter with 90 feet (27 meters) of buoyant line attached, designed to be thrown to a person in the water, grasped and held by the user until rescued.

A buoyant boat cushion equipped with straps and a float ring are two common examples of additional types of life rings that can qualify as a Type IV PFD and help in a rescue.

For boat operations in cold water environments, immersion/exposure suits will be required for each person on board based on the location of boat operations listed below.

AREA OF OPERATION	VSL TYPE	DEVICE
Seaward of the Boundary Line, north of 32ºN, or south of 32ºS, and Lake Superior.	Documented	Immersion Suit/Exposure Suit
Coastal Waters on the West Coast of the U.S. north of Pt. Reyes, CA; Beyond coastal waters, cold waters; and Lake Superior	All	Immersion Suit/Exposure Suit

3.6.4 Fire Extinguishers

Each boat used by TMR personnel less than 26 feet (8 meters) shall carry at least one Type 1-A:10-B:C fire extinguisher (for use in gasoline, oil, and grease fires) approved by UL. Motorboats or skiffs over 26 feet (8 meters) will have a minimum of two 1-A:10BC fire extinguishers available. Larger craft will have additional requirements. Each fire extinguisher shall be inspected by the UXOSO or SM/FOL at least once every week to ensure that it is sufficiently charged and that the nozzles are free and clear. Discharged fire extinguishers shall be replaced or recharged immediately. The number and sizes of extinguishers required will depend on the vessel size and applicable regulations.

3.6.5 Navigation Lights

All TMR project boats shall be equipped with navigation lights. These lights shall always be utilized when operating between sunset and sunrise. Navigational lighting shall meet all USCG requirements. Boats shall be operated at reduced speeds at night and when visibility is reduced.

3.6.6 Visual Distress Signals

All TMR boats shall carry a selection of pyrotechnic and non-pyrotechnic visual distress signals. Pyrotechnic visual distress signals include red flares, orange smoke (day use only), and aerial red meteor or parachute flares. No pyrotechnic visual distress signals include an orange distress flag (day use only) and a flashlight or other electric distress light (night use only). No single signaling device is ideal under all conditions and for all purposes. Pyrotechnic visual distress signals shall not be used past the expiration date.

3.6.7 Pollution Control

The Refuse Act of 1899 prohibits the throwing, discharging, or depositing of any refuse matter of any kind (including trash, garbage, oil, and other liquid pollutants) into the waters of the United States (U.S.). The Federal Water Pollution Control Act prohibits the discharge of oil or hazardous substances in quantities that may be harmful into U.S. navigable waters. No person may intentionally drain oil or oily wastes from any source into the bilge of any vessel. Vessels 26 feet (8 meters) and greater in length, with machinery spaces, must display a placard fixed in a conspicuous place in the machinery spaces, or at the bilge pump control station stating the rules of the Federal Water Pollution Control Act governing the discharge of oil or oily waste to the water (see Reference No. 3). Pumping of bilge water without using an oily-water separator should be undertaken with caution. Any vessels equipped with toilet facilities must be equipped with a USCG-approved marine sanitation device and shall observe all no-discharge areas shown on National Oceanic and Atmospheric Administration (NOAA) charts.

TMR employees shall report any significant oil spills to water to the HSE director who must report the spill to the USCG or other applicable regulatory agency. The procedure for incident reporting and investigation shall be followed when reporting the spill. (See Tetra Tech Safety Manual, DCN 02-02, Incident Reporting & Investigation Program)

3.7 Weather

A daily weather check shall be conducted prior to any boating operation. If severe weather is forecast, work should be delayed or cancelled. All HSE plans covering boating operations shall address the hazards that weather poses to boating operations, and specific actions to be taken to avoid these hazards. The field supervisor in consultation with the boat captain, site safety and health officer and PM shall establish maximum sea state or go/no-go criteria, ensuring compliance with the applicable project safety plans, prior to the beginning of operations.

3.8 Load Capacity

Boats less than 20 feet shall not be loaded (passengers and gear) beyond the weight capacity printed on the USCG capacity plate attached to the stern. For boats without capacity plates, the licensed captain/trained operator shall evaluate the safe loading of crew, cargo, and equipment on a trip-by-trip basis. Several factors must be considered when loading a boat: distribute the load evenly; keep the load low; do not stand up in a small boat or canoe; and do not overload the boat.

3.9 Tool Kit

All TMR motorized boats shall carry a tool kit with enough tools for the boat operator to troubleshoot common mechanical problems such as fouled spark plugs, flooded carburetor, electrical shorts, etc. Boats operated in remote areas shall also carry appropriate spare parts (e.g., propellers, shear pins, patch kits, air pumps). The tool kit shall be maintained by the boat operator, with supplies replaced immediately upon use.

3.10 Survival Kit/Ditch Bag

All TMR boats utilized in remote areas shall carry a survival kit. The survival kit shall contain, at a minimum: a first aid kit; high-energy canned or preserved foods; drinking water; blankets; a heat source; signaling devices; waterproof matches; and other items as necessary to ensure survival for a minimum of 24 hours for the entire crew. For offshore work, a “ditch bag” consisting of an Emergency Position-Indicating Radio Beacon (EPIRB); handheld very high frequency (submersible) signaling devices – visual and audible; and/or strobe light or light stick may be required. The ditch bag should be waterproof, float and preferably be high visibility in color. Survival suits may be required by the HSE plans for operations in cold environments.

3.11 Communications

All TMR boats operated in remote areas shall carry a two-way radio or cellular telephone that enables communication back to the field camp or other pre-established location. Exceptions to this requirement must be negotiated with the HSE director. Additional communication and locating methods may be utilized such as SPOT Messenger, global positioning system, EPIRB, and satellite telephones.

3.12 Boating Accident Report

The USCG requires filing a boating accident report within 24 hours of an accident (death, disappearance overboard, medical treatment beyond first aid, property damage > $2000, or if the boat is destroyed).

TMR personnel involved in a boating accident shall follow the procedure outlined in HSE plans and Tetra Tech's Safety Manual, Incident Reporting and Investigation Program (DCN 02-02), for accident and injury reporting. This procedure will provide for proper notification of the USCG.

3.13 Good Housekeeping

TMR personnel using a boat shall properly stow and secure all gear and equipment against unexpected shifts when underway. Decks and open spaces must be kept clear and free from clutter and trash to minimize slip, trip, and fall hazards.

3.14 Fuel Management

TMR personnel shall utilize the "one-third rule" in boating fuel management. Use one-third of the fuel to get to the destination, one-third to return, and keep one-third in reserve.

3.15 Training

Boat operators shall be trained on, and pass the test of, a nationally recognized boating safety organization such as the USCG Auxiliary or Power Squadron. All operators and passengers shall be trained on the requirements of this program. Training records shall be maintained in accordance with the Tetra Tech Safety Manual, DCN 01-04, Recordkeeping and Reporting Requirements.

3.16 Operations

Operations of motorboats/skiffs can be hazardous to personnel considering other boaters, weather conditions, the task assigned, and the condition of the boat/skiff you are operating. Ensure Boat Pre-Operation Checklist is completed before departing the launch area. The boat captain or designee must utilize and fill out the checklist each day the vessel is used (use is defined as being launched from the trailer or departing the dock or moorage) and submit it to the UXOSO or FOL. This checklist can be filed electronically, via email or text message, if necessary.

When operating in restricted waters, near shipping channels, in rough fast flowing water, or near obstacles that could damage or capsize the boat, plan for emergency rescue in case the boat motor fails, or you become incapacitated from operating the boat and you are in personal danger. Consideration would be for a second motor or a safety boat operating in the area or other rescue capability available.

4.0 REFERENCES

CFR Title 33, Navigation and Navigable Waters, Chapter I - Coast Guard, Department of Homeland Security (Parts 1-199), Subchapter S, Boating Safety (Parts 173-199), Retrieved from https://www.gpo.gov/fdsys/granule/CFR-2010-title33-vol2/CFR-2010-title33-vol2-chapI-subchapS

USACE EM 385-1-1 (November 30, 2014), Safety and Health Requirements Manual. Retrieved from https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_385-1-1.pdf

Title 33 USC. Chapter 9 Protection of Navigable Waters and of Harbor and River Improvements. Subchapter I - In General. 407 - Deposit of refuse in navigable waters generally. (pp. 46). Retrieved from https://www.gpo.gov/fdsys/pkg/USCODE-2011-title33/pdf/USCODE-2011-title33-chap9-subchapI.pdf

Tetra Tech Safety Manual, Incident Reporting and Investigation Program, DCN 02-02.[1]

Tetra Tech Safety Manual, Recordkeeping and Reporting Requirements, DCN 01-04.[2]

U.S Department of Homeland Security. United States Coast Guard Auxiliary (2015 v.10.2). USCG Float Plan. Retrieved from http://www.floatplancentral.org

DOC NOAA. Office of Marine & Aviation Operations. NOAA Small Boat Standards and Procedures Manual (April 30, 2018, 4.1 Edition), Retrieved from https://www.omao.noaa.gov/sites/default/files/documents/2018%200430%20SBS%26PM%204.1.pdf.

5.0 RECORDS

Records associated with the awareness and recognition programs will be retained in the appropriate project or office files.

6.0 GUIDELINES

HSE-25 Boat Pre-Operation Checklist

HSE-26 Float Plan Template

7.0 APPLICABLE ISO17025 CLAUSES

None.

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[1] https://tetratechinc.sharepoint.com/:b:/r/sites/Health-Safety/Health%20%20Safety%20Manual/02_General%20Health%20and%20Safety%20Programs/DCN%2002-02%20Incident%20Reporting%20and%20Investigation%20Program.pdf

[2] https://tetratechinc.sharepoint.com/:b:/r/sites/Health-Safety/Health%20%20Safety%20Manual/01_Health%20and%20Safety%20Program%20Administration/DCN%2001-04%20Recordkeeping%20and%20Reporting%20Requirements.pdf

APPENDIX D

FIELD INSPECTION FORMS

DAILY BRIEFING/STAFF & VISITOR SIGN-IN SHEET
SAFETY INSPECTION REPORT

PART I: Daily Safety Briefing/Staff & Visitor Sign-In Sheet **Report #**

Date:	**Office/Project Name/Location:**
Shift/Department:	**Contract/Task Order:**
Weather:	
1. Awareness: (e.g., special EHS concerns, chemical or physical hazards, recent incidents, etc.)	
2. Other Issues: (ESQ Plan changes, action items, attendee comments, etc._	
3. Medical Support Available: **Hospital:** **Urgent/Routine Care:**	
Ordnance Training Presented by:	

Attendees

By signing in below, I certify that I understand the hazards and risk controls associated with each task I am to perform. I understand the permit requirements applicable to the work being performed and am aware that all tasks must be assessed. I am also aware of my obligation to "stop work." Furthermore, I am physically and mentally fit for duty and am not under the influence of any type of medication, drugs, or alcohol that could affect my ability to work safety. I am aware of my responsibility to bring any injury, illness, or other safety issue to the attention of the UXOSO.

By signing out below, I certify that I am uninjured unless I have already informed the TL, PM, or UXOSO.

PRINT NAME	SIGNATURE	COMPANY	TIME IN	TIME OUT

PART I: Daily Safety Briefing/Staff & Visitor Sign-In Sheet (continued)

PRINT NAME	SIGNATURE	COMPANY	TIME IN	TIME OUT

VI. SIGNATURES:	I certify all personnel were present, accounted for, and participated in the Daily Safety Briefing.
UXOSO Name (Print)	Signature

DAILY BRIEFING/STAFF & VISITOR SIGN-IN SHEET
SAFETY INSPECTION REPORT

PART II: Safety Inspection Report

DATE:	**TIME:**	**REPORT NO.:**
CONTRACT NO.:	**TASK ORDER NO.:**	
SITE NAME AND LOCATION:		
WEATHER CONDITONS:		
Temperature:	Humidity:	
Conditions (circle one): Sunny Partly Sunny Cloudy Partly Cloudy Rain Snow		

I. WORK CONDUCTED:

II. **INSPECTION POINTS**

Item Description	Pass	Item Description	Pass
1. Personal Protection (PPE)	Y / N	9. Site Communications	Y / N
2. Work Processes	Y / N	10. House Keeping	Y / N
3. Site Control	Y / N	11. Heavy Equipment	Y / N
4. First Aid Kit(s)/Eyewash	Y / N	12. Refueling Operations	Y / N
5. Fire Extinguisher(s)	Y / N	13. Other: (list)	Y / N
6. Site Vehicles	Y / N	14. Other: (list)	Y / N
7. Safety and Health Monitoring Equipment	Y / N	15. Other: (list)	Y / N
8. Power Tools	Y / N	16. Other: (list)	Y / N

III. SIGNIFICANT EVENTS:

IV. DEFICIENCIES and CORRECTIVE ACTIONS: (If required)

V. REINSPECTION RESULTS: (If Required)

VI. SIGNATURES:

Contractor's Verification: On behalf of the Contractor, I certify this report is complete and correct, and all materials used, and work performed during this reporting period are in compliance with the contract plans and specifications to the best of my knowledge, except as may be noted above.

UXOSO Name (Print)	Signature

VEHICLE INSPECTION CHECKLIST

Reset Form

Project:	
Manufacturer:	Model:
License Number:	Team Number:
Date Period: /	Mileage start/end: /

Equipment Checklist (Check all that apply and provide description of corrections needed)

Item	Status	Corrective Action
Steering	Pass ☐ Fail ☐ NA ☐	
Service Brakes	Pass ☐ Fail ☐ NA ☐	
Emergency Brake	Pass ☐ Fail ☐ NA ☐	
Transmission	Pass ☐ Fail ☐ NA ☐	
Warning Gauges	Pass ☐ Fail ☐ NA ☐	
Leaks	Pass ☐ Fail ☐ NA ☐	
Lights	Pass ☐ Fail ☐ NA ☐	
Mirrors	Pass ☐ Fail ☐ NA ☐	
Fluids	Pass ☐ Fail ☐ NA ☐	
Seat and Seat Belts	Pass ☐ Fail ☐ NA ☐	
Tires/Tread	Pass ☐ Fail ☐ NA ☐	
Regular Horn	Pass ☐ Fail ☐ NA ☐	
Back Up Alarm	Pass ☐ Fail ☐ NA ☐	
Hand Hold/Running Boards	Pass ☐ Fail ☐ NA ☐	
Fire Extinguisher	Pass ☐ Fail ☐ NA ☐	
Emergency Kit	Pass ☐ Fail ☐ NA ☐	
Other:	Pass ☐ Fail ☐ NA ☐	
Other:	Pass ☐ Fail ☐ NA ☐	

Remarks:

NOTE: If the vehicle requires attention or there is something missing, you are required to contact your Responsible Manager before operating vehicle. *Please initial appropriate box.*

Sun	Mon	Tue	Wed	Thu	Fri	Sat

Approvals

Operator's Signature:		Date:
Supervisor's Signature: *(Repairs or adjustments Completed)*		Date:
Safety Review by Signature:		Date:

	Tetra Tech Munitions Response **DOCUMENTATION OF HAZWOPER FIELD EXPERIENCEFIELD**	Revision Date: 04/15/2019 Document Control Number: FORM HSE-08

Employee Name: ____________________ Office: ______________________________

Employee No.: ______________________ Date of Employment: ____________________

FIELD EXPERIENCE RECORD					
Level D	Site	Activity	Supervisor	Date	Hours
Level C	Site	Activity	Supervisor	Date	Hours
Level B	Site	Activity	Supervisor	Date	Hours
Level A	Site	Activity	Supervisor	Date	Hours

	Tetra Tech Munitions Response **DOCUMENTATION OF HAZWOPER FIELD EXPERIENCEFIELD**	Revision Date: 04/15/2019
		Document Control Number:
		FORM HSE-08

This is to certify that ______________________ has completed the field training requirements for hazardous waste field work in accordance with Title 29 of the *Code of Federal Regulations*, Part 1910.120, and is certified to work at hazardous waste sites in Level _____ and lower levels of protection.

____
Printed Employee Name

____ ________________________
Employee Signature Date

____
Printed Health and Safety Manager

____ ________________________
Health and Safety Manager Signature Date

TETRA TECH

WEEKLY CHECKLIST AND ACTION ITEM REPORT

Resset Form

Project/Location:	Inspector/s:	Time/Date: /
TOPIC	**OBSERVATIONS**	**FINDING (Yes/No or N/A)**

This inspection checklist is meant to capture the health, safety, and environment (HSE) inspection items that are appropriate for the particular project being inspected based on the scope of work and relevant project plans (e.g., safety plan, Environmental Protection Plan, Waste Management Plan, at a minimum). Additional relevant plans may include a Stormwater Pollution Prevention Plan (SWPPP) or Spill Prevention, Controls, and Countermeasures Plan (SPCC). This checklist should be completed by a qualified inspector who is familiar with the project plans and scope of work. Not all elements will be applicable to every project. If not applicable, indicate "N/A."

Weather Conditions at time of Inspection ____.

WORK CONDITIONS		YES	NO	NA
1. Housekeeping		☐	☐	☐
2. Walking/Working Surfaces		☐	☐	☐
3. Aisles and Passageways		☐	☐	☐
4. Platforms		☐	☐	☐
5. Ladders		☐	☐	☐
6. Stairs, Guardrails, Toe Boards		☐	☐	☐
7. Exits/Egress		☐	☐	☐
8. Roadways		☐	☐	☐
9. Lighting		☐	☐	☐
10. Noise Exposure		☐	☐	☐
11. Ergonomics		☐	☐	☐
12. Site Perimeter and Control Zones Identified		☐	☐	☐
EQUIPMENT		**YES**	**NO**	**NA**
13. Hand/Portable Tool Condition, Storage, and Use		☐	☐	☐
14. Machine, Conditions/Guarding		☐	☐	☐
15. Mobile/Heavy Equipment a. Physical inspection of equipment b. Review of daily inspection reports c. Review of equipment deficiency corrections logs/records		☐	☐	☐

TETRA TECH

WEEKLY CHECKLIST AND ACTION ITEM REPORT

Project/Location:	Inspector/s:	Time/Date: /
TOPIC	**OBSERVATIONS**	**FINDING (Yes/No or N/A)**

This inspection checklist is meant to capture the health, safety, and environment (HSE) inspection items that are appropriate for the particular project being inspected based on the scope of work and relevant project plans (e.g., safety plan, Environmental Protection Plan, Waste Management Plan, at a minimum). Additional relevant plans may include a Stormwater Pollution Prevention Plan (SWPPP) or Spill Prevention, Controls, and Countermeasures Plan (SPCC). This checklist should be completed by a qualified inspector who is familiar with the project plans and scope of work. Not all elements will be applicable to every project. If not applicable, indicate "N/A."

MATERIAL-HANDLING EQUIPMENT		YES	NO	NA
16. Hoisting and Rigging		☐	☐	☐
17. Lifting Aids Used When Possible		☐	☐	☐
18. Proper Lifting Techniques Used		☐	☐	☐
ELECTRICAL SAFETY		**YES**	**NO**	**NA**
19. Power Cords		☐	☐	☐
20. GFCI		☐	☐	☐
21. Generators		☐	☐	☐
22. Breaker Box Access/Clearance		☐	☐	☐
HAZARDOUS MATERIALS		**YES**	**NO**	**NA**
23. Hazardous Materials Inventory Current		☐	☐	☐
24. Safety Data Sheets (SDS)		☐	☐	☐
25. Labeling		☐	☐	☐
26. Signs/Postings/Color Coding		☐	☐	☐
27. Proper Storage and Segregation of Hazardous Materials		☐	☐	☐
28. Compressed Gas Storage and Use		☐	☐	☐
EMERGENCY SYSTEMS		**YES**	**NO**	**NA**
29. Emergency Phone Numbers Posted		☐	☐	☐
30. Evacuation Routes, Rally Points Shown on Site Map		☐	☐	☐
31. Fire Extinguishers Inspected Monthly		☐	☐	☐
32. Eyewashes and Showers Periodically Inspected, Units Flushed, and Fluids Periodically Changed		☐	☐	☐

TETRA TECH

WEEKLY CHECKLIST AND ACTION ITEM REPORT

Project/Location:	Inspector/s:	Time/Date: /
TOPIC	**OBSERVATIONS**	**FINDING (Yes/No or N/A)**

This inspection checklist is meant to capture the health, safety, and environment (HSE) inspection items that are appropriate for the particular project being inspected based on the scope of work and relevant project plans (e.g., safety plan, Environmental Protection Plan, Waste Management Plan, at a minimum). Additional relevant plans may include a Stormwater Pollution Prevention Plan (SWPPP) or Spill Prevention, Controls, and Countermeasures Plan (SPCC). This checklist should be completed by a qualified inspector who is familiar with the project plans and scope of work. Not all elements will be applicable to every project. If not applicable, indicate "N/A."

Topic	Observations	Yes	No	NA
33. First Aid Kits/Stations		☐	☐	☐
34. Bloodborne Pathogen Kits		☐	☐	☐
35. Emergency Rescue Equipment		☐	☐	☐
PROTECTIVE EQUIPMENT		**YES**	**NO**	**NA**
36. PPE Used, Stored, and Maintained in Accordance with Project EHS Plan		☐	☐	☐
37. Respirator Use, Storage, and Maintenance		☐	☐	☐
SPILL PREVENTION AND PREPAREDNESS		**YES**	**NO**	**NA**
38. Are Petroleum Products Stored in Containers or Tanks as Specified in Project-Specific Plans?		☐	☐	☐
39. Outside of Containers or Tanks (as Applicable) Show No Signs of Deterioration, Leaks, or Discharges at Seams, Gaskets, Piping, Pumps, Valves, Rivets, or Bolts.		☐	☐	☐
40. Appropriate Containment Materials are Available and Accessible, Including: Drip Pans, Dikes, Berms, Retaining Walls, Curbing, Other Barriers, Spill Diversion Ponds, Retention Ponds, or Integrated Secondary Containment Structures.		☐	☐	☐
41. Spill Control and Response Materials are Available, Including: Designated Spill Response Kits, Drip Pans, Sorbent Materials, Oil Retention Booms (Floating or Sorbent), Sand Bags/Temporary Curbing Devices, Fuel Recovery Pumps/Collection Hoses, Fuel Recovery Tank Trucks, and Tools.		☐	☐	☐
42. Is There Any Evidence of a Sheen or Discoloration on the Ground? Are Hazardous Materials Stored Properly in a Manner that Minimizes Potential For Spills?		☐	☐	☐
43. Emergency Contact Lists are Current and Posted.		☐	☐	☐

TETRA TECH

WEEKLY CHECKLIST AND ACTION ITEM REPORT

Project/Location:	Inspector/s:	Time/Date: /

TOPIC	OBSERVATIONS	FINDING (Yes/No or N/A)		
This inspection checklist is meant to capture the health, safety, and environment (HSE) inspection items that are appropriate for the particular project being inspected based on the scope of work and relevant project plans (e.g., safety plan, Environmental Protection Plan, Waste Management Plan, at a minimum). Additional relevant plans may include a Stormwater Pollution Prevention Plan (SWPPP) or Spill Prevention, Controls, and Countermeasures Plan (SPCC). This checklist should be completed by a qualified inspector who is familiar with the project plans and scope of work. Not all elements will be applicable to every project. If not applicable, indicate "N/A."				
44. Workers Have Received Spill Prevention Response Training.		☐	☐	☐
45. Does the Project Have a Spill Response, Controls, and Countermeasures (SPCC) Plan? If Yes, are Inspections being Performed and Documented as Required in the Plan? Has the Plan Been Updated as Required?		☐	☐	☐
STORMWATER POLLUTION PREVENTION AND EROSION CONTROLS		**YES**	**NO**	**NA**
46. Are Site Activities that Cause Land Disturbance being Performed (Grading, Excavating, Clearing and Grubbing, Demolition and Foundation Removal, Etc?		☐	☐	☐
47. Are Surface Waters Present on or Adjacent to the Site that Could Be Impacted By Runoff from the Site? Is There Any Evidence of Runoff from The Project Site to These Areas?		☐	☐	☐
48. Are There Storm Drains, Catch Basins or Other Conveyances that Collect Stormwater? Are There Activities Occurring that Could Cause Oil, Contaminants, or Sediments to Enter These Conveyances? If Yes, Are There Measures In Place Or Needed to Protect Stormwater Quality?		☐	☐	☐
49. Does The Project Have a Total Land Disturbance = or > 1 Acre or is the Project Part of a Larger or Common Plan of Development That Could Exceed 1 Acre of Disturbance? If Yes, Confirm the Stormwater Pollution Prevention Plan is in Place. If No, Check the Environmental Protection Plan for Requirements or Indicate N/A (E.G., if the Project Does Not Involve Land-Disturbing Activities)		☐	☐	☐
50. Are There Signs of Erosion on Recently Disturbed Soils (Channelization, Rivulets, Siltation Runoff, Etc.)? Can the Erosion Lead to Sediment or Runoff to Surface Water or Conveyances? If Yes, are		☐	☐	☐

TETRA TECH

WEEKLY CHECKLIST AND ACTION ITEM REPORT

Project/Location:	Inspector/s:	Time/Date: /

TOPIC	OBSERVATIONS	FINDING (Yes/No or N/A)		
This inspection checklist is meant to capture the health, safety, and environment (HSE) inspection items that are appropriate for the particular project being inspected based on the scope of work and relevant project plans (e.g., safety plan, Environmental Protection Plan, Waste Management Plan, at a minimum). Additional relevant plans may include a Stormwater Pollution Prevention Plan (SWPPP) or Spill Prevention, Controls, and Countermeasures Plan (SPCC). This checklist should be completed by a qualified inspector who is familiar with the project plans and scope of work. Not all elements will be applicable to every project. If not applicable, indicate "N/A."				
Erosion Control BMPs Necessary or Recommended?				
51. Are BMPs Being Implemented per the Environmental Project Plans or (if Prepared) SWPPP)? For Instance, Preventative Maintenance, Good Housekeeping Practices, Proper Waste Storage and Storage of Hazardous Materials, Structural BMPs, Etc.?		☐	☐	☐
52. If the Project Has a Stormwater Pollution Prevention Plan (SWPPP), are Inspections being Performed and Documented as Required in the Plan?		☐	☐	☐
53. Fugitive Dust – Appropriate BMPs are Instituted for Fugitive Dust Emissions.		☐	☐	☐
OTHER CONDITIONS OR WORK PRACTICES		**YES**	**NO**	**NA**
54. Are all required postings placed within the site? (deficiency log, OSHA 300A, etc.)		☐	☐	☐
55.		☐	☐	☐
56.		☐	☐	☐
57.		☐	☐	☐

Reviewed by: ______________________________ ____________________

Signature Date

File the Weekly Inspection Checklist with the Site Safety and Health Officer (SSHO)
Additionally, send a copy to the Project Manager and Safety and Health Director
IF A STOP WORK IS REQUIRED, NOTIFY THE DIRECTOR OF SAFETY

TETRA TECH

WEEKLY CHECKLIST AND ACTION ITEM REPORT

Project/Location:	Inspector/s:		Time/Date: /
ACTION ITEM	**RESPONSIBLE PARTY**	**SCHEDULE (DAY(S)/WEEK(S) TO COMPLETE)**	**DATE COMPLETED**
1.			/
2.			/
3.			/
4.			/
5.			/
6.			/
7.			/
8.			/
9.			/
10.			/
11.			/

BOAT PRE-OPERATION CHECKLIST

Project Description:	Date:
Project Location:	Job#:

Step No.	Description	Check Completed (Initials)
1	**Inspect exterior of vessel** ☐ Inspect for visible damage ☐ State registration numbers ☐ POL leaks ☐ Hull plugs in place ☐ Maintenance issues	
2	**Inspect propulsion system** ☐ a. Engine (propeller, oil, fuel level and extra fuel on board, hours since last maintenance, functional, and adequately secured to vessel) ☐ b. Steering system (functional, forward/reverse gears) ☐ c. Batteries (charged, water in cells, contacts clean)	
3	**Inspect all communication equipment** ☐ a. Perform VHF radio check with a base station ☐ b. Perform cellular phone check with a base station ☐ c. Perform dive communication check with radio and dive hats ☐ d. Have spare batteries charged and within reach of all comm. equip.	
4	**Inspect electrical systems and all other communication equipment** Ensure the following are on board and in work order ☐ a. Dive flags (Alpha and Recreational) and pole ☐ b. Sound signaling device (vessel horn, hand horn, whistle) ☐ c. Flares (rocket/parachute, hand held, smoke) ☐ d. Water dye canister, flash light, signaling mirror, EPIRB, and strobe lights for PFDs ☐ e. Deck and Navigation lighting (port, starboard, fore/aft, search, and cabin) ☐ f. Bilge pump	
5	**Inspect mooring systems** ☐ a. Anchor secured to line/chain and functional ☐ b. Line/chain in working order and ready for use ☐ c. Fenders secure and ready for use ☐ d. Extra line available for use	
6	**Ensure navigational equipment is functioning** ☐ a. GPS (locked on 4 satellites, correct datum, power source) ☐ b. Compass and binoculars ☐ c. Charts / maps	
7	**Place copies of the following in cabin near helm** ☐ a. Emergency procedures plan ☐ b. Safe diving practices and operations manual ☐ c. Air decompression tables	

BOAT PRE-OPERATION CHECKLIST

Step No.	Description	Check Completed (Initials)
8	**Inspect lifesaving equipment** ☐ a. Ensure 1 PFD per person and 1 throw ring (USCG approved, in working order and properly fitted with strobe, whistle and knife attached) ☐ b. 1st aid kit (stocked, non-expired contents), 1st aid book, back board ☐ c. Fire extinguisher (charged, current inspection, accessible)	
9	**Inspect tool box** ☐ a. Spare parts for engine and other vessel systems ☐ b. Tools (clean and in working order) for repairing vessel systems and dive equipment	
10	**Alternate propulsion systems** ☐ a. Hand paddles (2) ☐ b. Spare outboard engine (complete, working, with spare fuel source)	
11	**Personal comfort equipment** ☐ a. Water ☐ b. Food ☐ c. Sunscreen/motion sickness medicine ☐ d. Clothing as required by conditions/locations (hard hat, sun glasses, ball cap, extreme weather, steel toed boots, change of clothes)	

NOTES:

1. File completed checklist in daily job log.
2. Record any maintenance issues in vessel log and report to Project Manager.
3. Complete dive boat safety checklist after completing this checklist.

TETRA TECH

FLOAT PLAN

Date:

PROJECT:

	PRIMARY BOAT	SAFETY & SECURITY - TRANS	LOGISTICS BOAT	LOGISTICS BOAT	LOGISTICS BOAT	LOGISTICS BOAT
NAME OF VESSEL OPERATOR:						
NAME OF VESSEL/S:						
REGISTRATION #:						
VESSEL/S DESCRIPTION:						

COMMUNICATIONS

Project Supplied Radios
Marine Band Monitor Channel 16
Cell Phones

PERSONNEL ON BOARD

Name	Company	Name	Company	Name	Company

SURVIVAL/ EMERGENCY EQUIPMENT:

ITEMS	QTY	ITEMS	QTY	ITEMS	QTY
Life Jackets/PFD		Smoke Signal			
Medical Kit		Emergency Paddles			
Anchor/Tackle		Audible Signal Device			
Flares/Visual Distress		Throwable Rescue Ring			
EPIRB		Potable Water			
GPS		Emergency Beacon			
Nav/Anchor Lights		Binoculars			
Mooring Lines		Fire Extinguisher			
Deck Lights		Flashlights			
Tool Kit		Spare Batteries			

Date:
DEPARTURE Time and Location:
DESTINATION and Time of arrival:
EXPECTED RETURN Time and Location:
ADDITIONAL INFORMATION:

Captain Signature: ______________________________

Supervisor Signature: ______________________________

APPENDIX E

MEDICAL DATA SHEET

TETRA TECH

Medical Data Sheet

This Medical Data Sheet must be completed by on-site personnel and kept in the command post during the conduct of site operations. This data sheet will accompany any personnel when medical assistance is needed or if transport to hospital facilities is required.

Project ______________________________

Name ______________ Home Telephone________

Address ______________________________

Age ________ Height____________ Weight ________

Person to notify in the event of an emergency: Name:____________________

Phone: ______________

Drug or other Allergies: ______________________________

Particular Sensitivities: ______________________________

Do You Wear Contacts? ________________________

What medications are you presently using? ____________________

____

Name, Address, and Phone Number of personal physician: ______________

____

____

Note: Health Insurance Portability and Accountability Act (HIPAA) Requirements

HIPAA regulates the disclosure of Protected Health Information (PHI) by the entity collecting that information. PHI is any information about health status (such as that you may report on this Medical Data Sheet), provision of health care, or other information. HIPAA also requires Tetra Tech Munitions Response (TMR) to ensure the confidentiality of PHI. This Act can affect the ability of the Medical Data Sheet to contain and convey information you would want a Doctor to know if you were incapacitated. So, before you complete the Medical Data Sheet understand that this form will not be maintained in a secure location. It will be maintained in a file box or binder accessible to other members of the field crew so that they can accompany an injured party to the hospital.

DO NOT include information that you do not wish others to know, only information that may be pertinent in an emergency situation or treatment.

________________ ________________ ____________

Name (Print clearly) Signature Date

APPENDIX F

HAZARDOUS MATERIAL INVENTORY AND SAFETY DATA SHEETS

(Preliminary and generic list and associated SDSs, to be updated
with Tetra Tech and subcontractor inventory before mobilization)

Product or Material Name [1/]	**Primary Hazards**	**Quantity Maintained On-site**	**Total Quantity Required (*estimated*)**	**Operation(s) Material Used For**	**Container Size and Type**	**Location Stored***
Gasoline, unleaded (supplier and grade may vary)	Flammable liquid, vapors	Up to 10 gallons	Up to 50 gallons	Refueling and operation of small gasoline-powered equipment	5-gallon UL-listed metal fuel containers	Flammable storage locker in a designated flammable material storage area
Motor oil or two-cycle oil (supplier and grade may vary)	Petroleum product, non-flammable	1 quart to 1 gallon	Up to 2 gallons	Routine maintenance and upkeep of small gasoline-powered equipment	Pint to quart size in manufacturer's container (as purchased)	Maintenance supply area or flammable storage locker away from flammable materials

Notes:
* Material will only be stored on-site during active work tasks. Only the minimum quantity required for immediate use will be stored.
[1/] SDS will be obtained and added to inventory when the product manufacturer and exact product specifications become known.

APPENDIX G

QUALIFICATIONS

Board of Certified Safety Professionals

Upon the recommendation of the
Board of Certified Safety Professionals,
by virtue of the authority vested in it,
has conferred on

Jeffrey Allen Streib

the credential of

Certified Safety Professional

and has granted the title as evidence of meeting the qualifications and passing the required examination so long as this credential is not suspended or revoked and is renewed annually and meets all recertification requirements.

CSP®

BOARD OF CERTIFIED SAFETY PROFESSIONALS

February 3, 2018
DATE ISSUED

CSP-34027
CERTIFICATION NUMBER

BOARD PRESIDENT SIGNATURE

BOARD SECRETARY SIGNATURE

IHMM
INSTITUTE OF HAZARDOUS MATERIALS MANAGEMENT

THIS CERTIFIES THAT

JEFFREY STREIB

HAS SUCCESSFULLY MET ALL THE REQUIREMENTS OF EDUCATION, EXPERIENCE AND EXAMINATION, AND IS HEREBY DESIGNATED A

CERTIFIED HAZARDOUS MATERIALS MANAGER®
CHMM®

March 6, 2021 DATE OF CERTIFICATION	27711 CREDENTIAL NUMBER
March 31, 2026 CERTIFICATION EXPIRES	EUGENE A. GUILFORD, JR. EXECUTIVE DIRECTOR

VALID SO LONG AS THIS CREDENTIAL IS RENEWED ACCORDING TO SCHEDULE AND IS NOT OTHERWISE REVOKED.

Accredited by the American National Standards Institute and the Council of Engineering and Scientific Specialty Boards

The Board for Global EHS Credentialing® (BGC®)

through its vested authority, hereby confirms that

Jeffrey Allen Streib

has met all requirements of education, experience, and examination set forth through the BGC's American Board of Industrial Hygiene®'s (ABIH®) credentialing division for initial certification in the Comprehensive Practice of Industrial Hygiene and is thereby conferred the credential of

Certified Industrial Hygienist® (CIH®)

The aforenamed individual is given all rights, privileges, and responsibilities as both a diplomate of the BGC and holder of the CIH credential, provided that the credential is not suspended or revoked, and it is renewed annually. Moreover, the holder must meet all recertification requirements, including the obligation to practice ethically as prescribed by the BGC.

american board of industrial hygiene

BOARD FOR GLOBAL EHS CREDENTIALING INCORPORATED SEAL 1960 PENNSYLVANIA BGC

Credential Number:	12095 CP
Award Date:	June 27, 2020
Expiration Date:	December 1, 2025

Cynthia Hanko

Cynthia Hanko, CIH
Chair of the Board of Directors

Ulric K. Chung, MCS, PhD
Chief Executive Officer and Secretary

OSHA Occupational Safety and Health Administration

This card acknowledges that the recipient has successfully completed a 30-hour Occupational Safety and Health Training Course in
Construction Safety and Health

Patrick L Oberley

RICK GLEASON, CIH, CSP
(Trainer name – print or type)

3/12/2017
(Course end date)

SITE SAFETY AND HEALTH PLAN

ATTACHMENT 1

FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

Prepared for:
USACE Baltimore District

Contract Number: W912DR-21-D-0002
Task Order: W912DR22F0121

Prepared by:

Tetra Tech, Inc.
4801 University Square
Suite 24
Huntsville, AL 35816

October 2022

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This Site Safety and Health Plan (SSHP) contains safety procedures and requirements are implemented during the performance of the Military Munitions Investigation for Nashua River Former Fort Devens in Devens, Massachusetts. This SSHP is a companion to the Accident Prevention Plan (APP), which is the primary safety plan document and applies to all work conducted by Tetra Tech and its subcontractors. Essentially equivalent or additional health and safety procedures and practices may be approved by Tetra Tech and implemented by its subcontractors where necessary. All subcontractors are required to follow the Tetra Tech health and safety programs and procedures, including the APP and this SSHP. Changes and/or additional subcontractor programs and procedures must be approved by the Tetra Tech Safety and Health Manager (SHM), who is a Certified Industrial Hygienist (CIH) and Certified Safety Professional (CSP). The Tetra Tech SHM will review and provide written concurrence of the APP (that includes this SSHP as an attachment) and any relevant subcontractor programs and procedures before fieldwork initiation. The APP/SSHP (including any subsequent changes to an approved plan) will be submitted to the Contracting Officer's Representative (COR) for acceptance before work starting.

As specified in U.S. Army Corps of Engineers (USACE) Engineer Manual (EM) 385-1-1, Section 33.B.01, where applicable, this SSHP references the appropriate section of the APP where the required information (and/or supplemental information) can be found, rather than including requirements that are duplicative in both documents.

1.2 APPLICABLE STANDARDS, REGULATIONS AND GUIDANCE DOCUMENTS

Adherence to applicable portions of federal, local, national consensus organization, and corporate health and safety standards, regulations, and guidance manuals are required during field activities. These include, but are not limited to, the following:

- 29 Code of Federal Regulations (CFR), Part 1910, Occupational Safety and Health Standards, General Industry
- 29 CFR, Part 1926, Occupational Safety and Health Standards, Construction Industry
- 29 CFR, 1910.120, Hazardous Waste Operations and Emergency Response
- Tetra Tech Corporate Health and Safety Procedures and Guidelines
- Tetra Tech Project Rules Handbook (Tetra Tech, 2019)
- USACE Safety and Health Requirements Manual, EM 385-1-1 (USACE, 2014)
- Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists, the most current publication

For this project, adherence to the Department of Defense and other munitions-related safety requirements and guidelines, as referenced in the MR-QAPP and Explosives Siting Plan (ESP), also is required.

2.0 SITE DESCRIPTION AND CONTAMINATION CHARACTERIZATION

2.1 SITE DESCRIPTION

Addressed with Section 2.4 of the APP are the site description and history.

2.2 CONTAMINATION CHARACTERIZATION

2.2.1 Munitions and Explosives of Concern and Explosives Contamination

Munitions and explosives of concern (MEC), material potentially presenting an explosive hazard (MPPEH), and munitions debris may be found on-site, including discarded military munitions. Therefore, a potential explosive hazard safety risk exists at the site. UXO safety procedures and a description of the training required for workers at sites potentially containing MEC and procedures to be followed during MEC-/MPPEH-related tasks performed under the supervision of the Senior UXO Supervisor (SUXOS)/Dive Supervisor (DS) are discussed in detail within the Work Plan. Activity hazard analyses (AHAs) have been prepared for MEC-/MPPEH-related tasks and are included in Appendix A of the APP.

2.2.2 Chemical and Biological Warfare Material Contamination

Chemical warfare materiel or biological warfare material is not expected to be encountered at this site. However, if Tetra Tech identifies or suspects unknown liquid-filled munitions, Tetra Tech will evacuate the area in an upwind direction to a safe location and await further instruction. The UXO Safety Officer (UXOSO) will notify the COR for assistance and guidance. While awaiting support, Tetra Tech will deploy a team consisting of at least two UXO personnel to secure the area, thereby preventing unauthorized access. The personnel will position themselves as far upwind as possible while still maintaining the observation and security of the area. Once the site is secured, Tetra Tech personnel will continue to secure the site until relieved by security. Confirmation of chemical and/or biological warfare material will require that site operations be discontinued until the potential for future exposure can be assessed and the APP/SSHP and Work Plan are modified.

2.2.3 Hazardous Substance Contamination

Hazardous substances are those materials that can threaten human health and the environment if the substances have been improperly disposed of or uncontrollably released into the environment. Currently, two potential routes for chemical exposure to site personnel are anticipated: 1) exposure to explosive filler should MEC/MPPEH be found broken open, and 2) materials being brought on-site and/or used for the execution of this contract (e.g., fuels). Personnel will be vigilant at conducting an ongoing operational hazard assessment and addressing changing conditions at the time of recognition. Safety Data Sheets will be maintained for hazardous materials used on-site. Personnel will be trained in Hazard Communication requirements for the chemicals and hazardous materials in the workplace, and an inventory of chemicals/hazardous materials will be maintained.

3.0 ACTIVITY HAZARD ANALYSIS

Section 2.5 of the APP lists the major activities, tasks, and definable features of work (DFW) for each task/operation performed during this project. Please refer to Appendix A of the APP where the preliminary AHAs are located.

4.0 STAFF ORGANIZATION, QUALIFICATIONS, AND RESPONSIBILITIES

Section 4.2 of the APP identifies the key contacts and responsibilities for the Tetra Tech organization as they relate to safety on this project, including the Corporate SHM, who is a CIH and CSP, the Project Manager (PM), SUXOS/DS, and the UXOSO, as well as general site workers, subcontractors, Competent Persons (CPs), and suppliers/vendors.

A project organization chart showing the relationship among the above team members, client representatives, including government representatives, such as the COR and subcontractors (as applicable), is included in the APP.

5.0 TRAINING

Included within Section 5.0 of the APP are the general and project-specific training requirements for workers on this project. Additional training requirements (and certifications when required) apply to operators of heavy equipment and CPs; these requirements are addressed in applicable APP sections.

6.0 PERSONAL PROTECTIVE EQUIPMENT

PPE for site workers is selected and used based on existing and potential hazards, 29 CFR Section 1910.120 requirements, and the hazard assessment. The following PPE will be provided, used, and maintained in a sanitary and reliable condition:

- Protection for eyes, face, head, and extremities
- Protective clothing
- Protective shields and barriers

PPE is required as a last option when hazards cannot be controlled through engineering or administrative processes.

Tetra Tech is not responsible for providing any PPE, as described herein, to subcontractor employees. Subcontractor employees working on the project must arrive on-site with their individually assigned PPE, as required for the project and described in the APP/SSHP and associated AHAs.

The SHM has reviewed the applicable work plans and other available information and evaluated each major work activity to determine the appropriate PPE level needed for the work. This evaluation includes consideration of potential hazards present, work operations to be performed, potential routes of exposure, concentrations of contaminants present or reasonably expected, characteristics, capabilities, limitations of PPE, and any hazards that the PPE may create exacerbate (e.g., heat stress).

The initial and basic level of PPE required on the project site, as identified in 29 CFR 1910.132, includes: 1) safety glasses with side shields (including the appropriate lens tint), 2) dry suit or wetsuit; 3) standard work clothes (long pants, shirt (e.g., tee-shirt), 4) work gloves (as appropriate per the hazard assessment), 5) ear muffs when working around power tools or other sources of noise, and 7) weather-appropriate clothing.

During tasks where workers may have hand contact with MPPEH that is broken open and contains exposed filler (if encountered), workers will wear disposable nitrile gloves under work gloves.

The reasons to downgrade the level of protection are listed below:

- New information indicating that the situation is less hazardous than was originally thought
- Change in site condition that decreases the hazard
- Change in work task that will reduce contact with hazardous materials

The UXOSO will oversee the PPE program's implementation on-site and ensure workers are trained in specific PPE, including proper donning/doffing and disposal.

Used PPE will be managed based on requirements identified in the MR-QAPP, which considers the contaminants, concentration of contaminants that are or may have been in contact with the PPE, and applicable federal (base) regulations/instructions. The UXOSO will contract the SHM any time PPE is modified from the plan or initial AHA. The UXOSO and SHM will also review additional tasks not included in the AHA matrix.

7.0 MEDICAL SURVEILLANCE

Tetra Tech requires that site workers involved in specific tasks participate in a medical surveillance program (MSP) that meets the requirements of 29 CFR Part 1910.120(f) and 29 CFR Part 1926.65(f). The medical surveillance program, managed by the Tetra Tech medical consultant, who is certified by the American Board of Preventive Medicine-Occupational Medicine, will be instituted for the following employees:

- Employees who are, or who may be, exposed to contaminant-related safety and occupational health hazards (including hazardous substances or health hazards) at or above the permissible exposure limits (PELs), or, if there is no PEL, above the published exposure levels for these substances, without regard to the use of respirators, for 30 days or more a year.
- Employees who wear a respirator for 30 days or more a year, or as required in 29 CFR Part 1910.134.
- Employees who are injured, become ill, or develop signs or symptoms due to possible overexposure involving hazardous substances or health hazards from an emergency response or hazardous waste operation.

Medical examinations of personnel as required by the MSP shall be conducted by or under the supervision of a licensed physician board-certified in occupational medicine or has had extensive experience in recognizing, evaluating, and treating occupational diseases. The Tetra Tech MSP is managed by:

Dr. William Nassetta, MD
10059 N. Reiger Rd
Baton Rouge, LA 70809

Dr. Nassetta is certified by the American Board of Preventive Medicine (ABPM).

A certification of employee participation in the MSP (both Tetra Tech and subcontractor personnel, as applicable) will be appended to this SSHP before beginning work (placeholder is included as Appendix A of the SSHP) when and as personnel are designated. The certification will be maintained up to date by the UXOSO for all personnel required to be under medical surveillance. Individual certifications will be made available to the government-designated authority (GDA) upon request. Individual certifications will include the employee's name, date of the last examination, and the name of the examining physician(s).

Employees who are expected to participate in on-site activities where they are potentially exposed to health or safety hazards will be required to complete a baseline physical examination.

Workers who must enter an EZ and/or who meet the criteria listed above must provide the UXOSO with a written opinion from a licensed physician attesting to the employee's fitness for duty at a hazardous waste site. A physician's written opinion of the employee's ability to wear a respirator is also required when there is a reasonable possibility that a respirator may be required for site work. The physician's written opinion must be dated within the previous 12-month period, or an alternative period of time as determined by the physician, for continued work. The required physician's written opinion will be made available, upon request, to the GDA.

Tetra Tech will maintain all medical records in accordance with 29 CFR 1910.1020. At no time will the UXOSO maintain a copy of any actual medical records. These records are maintained by the Tetra Tech medical consultant, CORE Occupational Medicine, or subcontractor's equivalent medical consultant.

Tetra Tech has a Drug-Free Workplace Program. All Tetra Tech personnel, craft, and subcontractors on this project are subject to drug and alcohol testing at any time. Supervisors, managers, and the UXOSO are to determine their workers' fitness, including assessing whether their workers may be under the influence of any alcohol or drugs, including over-the-counter and prescription medications.

8.0 EXPOSURE MONITORING/AIR SAMPLING PROGRAM

The Exposure Control and Monitoring Plan is included in Section 8.6 of the APP.

The Health Hazard Control Plan is included in Section 8.12 of the APP. There is no established exposure sampling plan required at this time. If work activities necessitate that air monitoring, other than as stated in Section 8.12.1, is required (e.g., discovery of contamination in soil, etc.), the SHM will be contacted to develop an exposure assessment and sampling/monitoring plan. Observations will be used by the UXOSO, with input by the SHM, to determine if the PPE provided adequate protection and evaluate worker exposure to site-related contaminants and hazardous substances during the work activities and materials management and disposal phase of this project.

9.0 HEAT AND COLD STRESS

A Heat Stress Management Plan (HSMP) is included in Section 8.19 of the APP. A Cold Stress Management Plan (CSMP) is addressed in Section 8.20 of the APP. Both the HSMP and CSMP comply with Section 06.J of EM 385-1-1.

10.0 STANDARD OPERATING PROCEDURES, ENGINEERING CONTROLS, AND WORK PRACTICES

This section identifies (or provides a reference to) the standard operating procedures (SOPs), engineering controls, and work practices that must be followed for this project, as applicable.

The order of precedence on any project is as follows:

a. All laws and regulations

b. The contract (including EM 385-1-1 and other referenced and contract-required manuals or instructions)

c. This site-specific APP and SSHP and any referenced SOPs (which may be part of the Work Plan)

d. The Tetra Tech Corporate Records Library (CRL) documents

e. The Project Orientation, Rules, and Safety Guidelines Handbook (addressed in abbreviated form in Section 10.1 below)

10.1 SITE RULES/PROHIBITIONS

Unless otherwise addressed specifically in this APP/SSHP and/or the referenced SOPs in the project Work Plan (when applicable), Tetra Tech employees are directed to follow the applicable requirements identified in the *Project Orientation Rules Safety Guidelines Handbook*, *Part I* (Project Orientation and Rules) *and II* (Environmental, Health, and Safety Guidelines (Tetra Tech 2019). A copy of this handbook can be found in the Tetra Tech CRL under "Manuals" and/or a copy will be available on site.

All workers have a responsibility to ensure that all project activities proceed efficiently and safely. The following describes the basic site rules and prohibitions that Tetra Tech expects Tetra Tech and subcontractor employees to follow during this project, in addition to those specified elsewhere:

1. Attend each day's work briefing and other safety training as scheduled.
2. Comply with all work plans and procedures and identify any changes in the plan immediately to your supervisor.
3. Inform your medical care physician if you are taking prescribed medication. The medical consultant will determine whether you can safely work on site while taking the medication.
4. Wear the PPE specified in the APP/SSHP and AHAs.
5. If you are required to wear a respirator, remove facial hair (beards, long sideburns, or mustaches) that may interfere with the respirator mask's satisfactory fit.
6. Become familiar with the on-site hazards, work zones, PPE requirements, and decontamination methods.
7. Immediately report any incident, accident, injury, safety hazard, or symptoms of possible exposure, no matter how minor, to your supervisor or safety representative. If you cannot obtain resolution at the project level, notify the SHM at the phone number indicated on a

project emergency contact list (Table 8-2 in the APP) that is found on every project site, or call the Compliance Hotline at 1-800-886-2577.

8. Stop work if an imminent danger situation exists.
9. Follow proper decontamination procedures.
10. Do not eat, drink, chew tobacco or gum, smoke, or engage in any other such activity that may increase the possibility of personal contamination.
11. Do not use lighters or matches in work zones.
12. Obey all authorized safety signs and demarcations. Do not place or remove these items except as authorized by the project safety lead.
13. Do not enter a confined space without the permit and proper training and follow all permit requirements as issued. Full compliance with the Tetra Tech procedure is required.
14. Follow lockout/tagout procedures when working on equipment that has moving parts or hazardous energy sources. Install and remove locks and tags only following procedure and only when authorized.
15. Check with your supervisor before starting any hot work operation (welding or cutting operations). If you are working in an area that requires a hot work permit, follow all permit requirements as issued.
16. Use the buddy system when performing operations in hazardous areas, when working with hazardous contaminants, when physical capabilities may become stressed (heat/cold stress), or when working in proximity of operating machinery or equipment.
17. Follow the work/rest regimens and other practices required by the heat and cold stress procedures.
18. Do not operate equipment unless you are properly trained and authorized to do so in a manner consistent with the owner/operator's manual.
19. Do not operate motor vehicles without a valid driver’s license or operate a Government Services Administration vehicle without a U.S. Government Motor Vehicle Operator's I-16 identification card.
20. Comply with site security requirements and carry any issued identification card or badge required for the project. Do not enter restricted areas unless authorized to do so.
21. Use vehicle or equipment seat belts any time the vehicle or equipment is in operation.
22. Use ladders and scaffolds that are solidly constructed and in good working condition and that have been properly secured and inspected by a CP before use. Remove defective ladders or scaffolds from service, tag as “Defective—Do Not Use,” and have them repaired or disposed of by competent personnel.
23. Inspect equipment and hand or portable manual and power tools before use. Remove defective tools and equipment from service and either dispose of them or have them properly repaired.

24. Always use ground-fault circuit interrupters for cord-and-plug equipment used outdoors or in damp locations. Keep electrical cords out of walkways and out of accumulations of water unless protected and rated for such service. Inspect cords daily. Ground electrical generators while they are in use.
25. Do not improperly use, mishandle, or tamper with health and safety equipment and samples.
26. Do not engage in horseplay of any kind. Do not run or jump from equipment, except as necessary in an emergency.
27. Do not bring, keep, or use alcoholic beverages, controlled substances, or unauthorized weapons on site. The following are prohibited:
    - Illegal drugs (under federal regulations), illegal look-alike, designer drugs, and drug paraphernalia
    - Controlled substances, such as medications, when usage is abused
    - Valid medications, when not kept in marked prescription bottles
    - Alcoholic beverages
    - Unauthorized firearms, weapons, and ammunition
    - Unauthorized explosives
    - Stolen property or contraband
    - Unauthorized cameras or photographic equipment
    - Unauthorized recording devices
28. Do not bring pets on project premises.
29. Become familiar with the Emergency Response Plan or Emergency Action Plan (as applicable) so that you can respond properly in an emergency.
30. Become familiar with the locations and types of emergency equipment, such as fire extinguishers, emergency showers, spill response equipment, eyewash, and air horns.
31. Practice contamination avoidance techniques.
32. Obtain help to lift or move bulky or heavy objects and any object weighing more than 50 pounds.
33. Keep work, storage, and access areas orderly and free of debris.
34. Implement, adhere to, and follow established rules, guidelines, procedures, plans, etc., as specified.
35. Stop work and ask questions of your supervisor when you are uncertain about a procedure or equipment use.
36. Perform all tasks in a safe and approved manner.

37. Participate in the evaluation or investigation of any accident or incident when you are requested to do so.
38. Do not bring visitors or children on project premises without the expressed written permission from the PM, construction supervisor, or their designee.

In the event additional or different health and safety rules or requirements must be followed, or when a situation may arise for which a project rule or requirement may become inappropriate, the project safety lead, after careful evaluation, may authorize a variance to the rule or requirement. Variances will also require the approval of the PM. When a variance is granted, it will be allowed to continue only so long as the conditions for which it was evaluated continue to occur.

10.2 WORK PERMIT REQUIREMENTS

Specific work permit requirements (Tetra Tech and client, as appropriate) are addressed within appropriate sections of the APP or Work Plan when applicable, as follows:

- Hot work permit (not anticipated to be required)
- Dig permit
- Confined space permit (not anticipated to be required)
- Hazardous Energy Control (lockout/tagout) permit

10.3 MATERIAL HANDLING PROCEDURES

Specific material handling procedures and standard operating procedures are contained in the Work Plan and AHAs where required.

10.4 DRUM/CONTAINER/TANK HANDLING PROCEDURES

Specific material handling procedures for containers are contained in the MR-QAPP where required and referenced in the AHAs for these tasks as appropriate.

10.5 COMPREHENSIVE AHA OF TREATMENT TECHNOLOGIES EMPLOYED AT THE SITE

Not applicable.

11.0 SITE CONTROL MEASURES

11.1 GENERAL MEASURES

Site control measures are addressed in Section 8.12.2 of the APP. Site control measures will be used in conjunction with engineering controls and basic or specific decontamination and hygiene procedures during the project to prevent/control the potential spread of contaminants by personnel or equipment into previously unaffected areas of the site, break areas, and personal or site vehicles, and to prevent exposures to workers where chemical hazards and other workplace hazards exist. Dust will be controlled primarily through the implementation of dust suppression methods. Additionally, tasks that generate excessive amounts of will be modified or avoided to reduce dust emissions.

11.2 SITE ACCESS

Project site access will be via existing access roads and trails whenever possible. Due to the location and current uses of the project site, security needs will be assessed upon arrival and as an ongoing initiative. Maintenance and enforcement of MEC/MPPEH EZs are addressed in the MR-QAPP.

12.0 PERSONAL HYGIENE AND DECONTAMINATION

The SUXOS/DS and the UXOSO are responsible for establishing and maintaining appropriate equipment and personnel decontamination areas and ensuring that Tetra Tech employees and subcontractors follow this plan. The UXOSO will assist to ensure that adequate decontamination procedures are identified for tasks and followed to prevent contamination of individuals or the environment beyond the EZ. All workers are responsible for following site-specific and task- or area-specific decontamination requirements when leaving the EZ, for avoiding contamination when possible through engineering controls and use of prescribed PPE, as specified in the APP/SSHP and AHAs, as well as implementing proper hygiene, such as the washing of hands and face when appropriate, following completion of the decontamination sequence (and before eating, smoking, drinking fluids, etc.).

Specific hygiene and decontamination procedures are addressed in Section 8.12.3 of the APP.

13.0 EMERGENCY EQUIPMENT AND FIRST AID

Information on emergency equipment required to be on site for emergencies is addressed in Section 8.2.4 of the APP. A list of emergency equipment and the equipment's location is included in Table8-1 of the APP.

First aid and cardiopulmonary resuscitation are addressed in Section 5.9 of the APP, and bloodborne pathogens training is addressed in Section 5.10 of the APP.

14.0 EMERGENCY RESPONSE AND CONTINGENCY PROCEDURES

14.1 CORRELATION TO THE EMERGENCY PLANS IN THE ACCIDENT PREVENTION PLAN

Emergency response or responding to emergencies is defined in 29 CFR 1910.120 as a response effort by employees from outside the immediate release area or by other designated responders (e.g., mutual aid groups, local fire departments) to an occurrence that results or is likely to result, in an uncontrolled release of a hazardous substance. Responses to incidental releases of hazardous substances where the substance can be absorbed, neutralized, or otherwise controlled at the time of release by employees in the immediate release area or by maintenance personnel are not considered to be emergency responses within the scope of this standard. Responses to releasing hazardous substances where there is no potential safety or health hazard (i.e., fire, explosion, or chemical exposure) are not considered emergency responses. Tetra Tech Emergency Response Plans are contained within the APP and described below constitute an Emergency Action Plan as required by 29 CFR 1910.38.

See Section 8.2 of the APP, which contains the required Emergency Response Plans (which meet the requirements of 29 CFR 1910.38 – Emergency Action Plans) for this project, including:

- Spill Emergency Plan
- Fire Emergency Plan
- Medical emergencies, including:
  - Decontamination during medical emergencies
  - First aid
  - Medical datasheet
- Inclement weather

14.2 PRE-EMERGENCY PLANNING

The elements of the emergency action plan related to pre-emergency planning are contained in the APP section 8.2.1.

14.3 PERSONNEL AND LINES OF AUTHORITY FOR EMERGENCY SITUATIONS

The elements of the Emergency Action Plan related to personnel and lines of authority for emergencies are contained in Section 8.2 of the APP.

The SUXOS/DS is the primary Emergency Coordinator (EC) for the project. The EC will take charge and determine, direct, and delegate personnel and resources to manage the emergency. Key responsibilities of the EC are to:

- Initiate evacuation if needed
- Initiate emergency response agency notification
- Evaluate and assess an emergency to ensure that response activities are commensurate with the level of the emergency, and as discussed in this plan, are implemented
- Interface and coordinate with outside agencies responding to on-site emergencies

14.4 CRITERIA AND PROCEDURES FOR EMERGENCY RECOGNITION AND SITE EVACUATION

In the event of an emergency, the EC will activate an air horn (or vehicle/equipment horn if available) to signal an evacuation. The emergency signal will be **long steady beeps** indicating the initiation of evacuation procedures.

An evacuation will be initiated whenever recommended hazard controls are insufficient to protect site workers' health, safety, or welfare. Specific examples of conditions that may initiate an evacuation include, but are not limited to, the following: severe and sudden extreme weather conditions, fire or explosion, evidence of acute personnel overexposure to a chemical, the discovery of unanticipated waste materials that are unknown, and emergencies that could also occur due to activities or conditions not directly related to site work (adjacent operations).

In an emergency, personnel in affected work zones, will immediately and safely stop work and assemble near the SZ or another safe area (upwind whenever possible) identified by the UXOSO (or immediate supervisor of that operation), where accountability of personnel will be performed. Personnel will then proceed to the designated evacuation area.

The location of assembly and evacuation areas and routes will be upwind of the site as determined by the wind direction whenever possible. The UXOSO will ensure the diagrams showing these safe egress routes and location of assembly areas and evacuation areas are kept current. All site personnel will be briefed on the assembly and evacuation locations and routes (including alternate locations for each work location and will be updated whenever these change).

For efficient and safe site evacuation and assessment of the emergency, the EC will have the authority to initiate proper action if outside services are required. Under no circumstances will incoming personnel or visitors be allowed to proceed into the area once the emergency signal has been given and the order to evacuate is issued. Once the alarm has been sounded, the EC must establish that access for emergency equipment is available and that the equipment that may cause combustion has been shut down if safe to do so. As soon as possible, and while the personnel's safety is being confirmed, emergency agency notification (numbers included in Table 8-2) will commence. The UXOSO will brief site personnel each day or when the location of either the assembly or evacuation area is revised.

If an emergency warranting evacuation occurs, the following procedures are to be initiated:

- Declare the evacuation via cellular telephones, hand signals, voice commands, and line of sight communication, two-way radios, or vehicle/air horns as necessary.
- Use the following signals when communication via vehicle horn or air horn is necessary:
  - **Steady long beeps will be used to indicate emergencies.**
- Report to the designated evacuation area for accountability.
- Do not allow personnel back into the work area until the UXOSO, or PM/COR PM has given the "all clear" for employees to return to the site.
- Describe the incident precipitating the evacuation to the UXOSO with pertinent incident details.

14.5 DECONTAMINATION AND MEDICAL TREATMENT OF INJURED PERSONNEL

In the event of a medical emergency, first aid and CPR assistance will be provided by CPR-/first aid-trained individuals. The injured party will be moved as minimally as possible if the scene remains safe for the injured or ill person and first aid responders or responding emergency personnel. If it is safe to move the person without further injury or if the location may become compromised, they will be moved to the nearest appropriate location for continued care. No person will enter an unsafe location to rescue an injured worker if the scene poses a hazard that could injure or trap the would-be rescuer.

Medical emergencies, should they occur on the project site, will typically rely on emergency responders as determined by emergency dispatch personnel for patient stabilization and transport to the hospital. In the event of a medical emergency in which actual or suspected serious injury occurs, the following procedures will be implemented:

- Survey the scene and evaluate whether the area is safe for entry.
- Render first aid and CPR as necessary.

- Obtain emergency medical services for ambulance transport to a hospital by contacting the installations emergency contact number from a cell phone or landline from a cell phone or landline. This procedure will be followed even if there is no visible injury. Provide the following information to the emergency dispatch personnel:
  - Identify location by address or nearest cross street and request medical assistance and provide a name and telephone number. Stay on the line with dispatch.
- Evacuate other personnel in the work area to a safe distance until the EC determines that it is safe for work to resume. If there is any doubt regarding the area's condition, work will not commence until the hazard control issues are resolved.
- Notify the PM and SHM as well as the client. The PM and SHM will notify the USACE representative.

Emergency medical assistance at the project site includes assistance from emergency responders and emergency hospital. The location of and directions to the hospitals from the site are included in Figure 8-1, and contact numbers for the hospitals and ambulance services and CORE are provided in Table 8-2.

CORE will be contacted immediately following appropriate first responder patient care or when the patient is transferred to emergency responder personnel to help assist with patient and case management and recommendations.

14.5.1 Decontamination during Medical Emergencies

Based on the nature of the planned activities, the need for specific personal decontamination activities in an emergency medical situation is possible if the person is saturated with fuel product or is contaminated with explosive residues. Workers that may potentially come in contact with fuel- and petroleum-contaminated soil will typically be wearing PPE; however, if during refueling or a spill, workers become saturated with fuel product, decontamination may be required. If decontamination becomes necessary, decontamination procedures will be performed only if doing so does not further jeopardize the involved personnel's welfare. Decontamination will be postponed if the incident warrants immediate evacuation.

As soon as possible and before transportation to a medical center:

- The contaminated site worker will be brushed of gross soil (before drying) and rinsed with water as necessary to remove fuel and soil from clothing and skin. If material gets in the eyes, a 15-minute eyewash will be performed immediately.
- Contaminated clothing will be removed and disposed of (wrap with a dry blanket if possible).
- First aid treatment will be rendered as necessary.
- If decontamination is not feasible, as much information as is known will be provided to emergency responders about the potential contaminants (e.g., fuel product, site contaminants).

14.5.2 First Aid

Tetra Tech will ensure that a minimum of two people on-site have current certifications in CPR, first aid, and bloodborne pathogens. Those designated as SUXOS/DS and UXOSO will have this training. Other than rendering basic CPR and first aid, these employees are not expected to perform emergency medical duties; however, they are authorized to perform emergency rescue or other duties up to their training level.

For first aid injuries that are not deemed an emergency, appropriate care following first aid may include stabilization and transport to the hospital for evaluation. Subcontractors will be instructed to do the same as per their corporate procedures. Tetra Tech will have industrial first aid kits, including bloodborne pathogens kit, trauma kit, AED, fire blanket and burn gel, and other emergency supplies in the SZ area near MEC/MPPEH clearance activities. Also, the UXOSO pickup truck is designated as emergency transport vehicles in the event they are needed. CORE will be contacted immediately following appropriate first responder patient care or when the patient is transferred to emergency responder personnel to help assist with patient and case management and recommendations.

14.6 ROUTE MAP TO EMERGENCY MEDICAL FACILITIES AND PHONE NUMBERS FOR EMERGENCY RESPONDERS

The elements of the Emergency Action Plan, including the route map to emergency medical facilities and phone numbers for emergency responders, are included in the APP as follows:

- The emergency route and driving directions are included in Figures 2 in the APP.
- Phone numbers for emergency responders are included in Table 8-2 of the APP.

14.7 CRITERIA FOR ALERTING LOCAL EMERGENCY RESPONDERS

Section 8 of the APP discusses the medical support agreement for this project.

DIVE OPERATIONS PLAN

ATTACHMENT 2

FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

Contract No.: W912DR-21-D-0002 **Delivery Order** W912DR22F0121

Prepared for:

US Army Corps of Engineers, Baltimore Division,

October 2022

APPROVALS

By their signature, the undersigned hereby certify that this Dive Operations Plan has been reviewed and approved for use during the Former Fort Devens Army Installation, Military Munitions Investigation in the Nashua River.

________________________ Date: 9/30/22

Tetra Tech Project Manager
Jennifer Harlan, PMP

________________________ Date: 9/30/22

Tetra Tech Diving Program Manager
Scot Wilson

________________________ Date: 9/30/22

Tetra Tech Diving Safety Officer
Patrick Oberley

CONTENTS

TABLES

APPENDICES

ABBREVIATIONS AND ACRONYMS

ºF	degree Fahrenheit
AHA	activity hazard analysis
AOPI	Areas of Potential Interest
APP	Accident Prevention Plan
CFR	Code of Federal Regulations
CPR	cardiopulmonary resuscitation
DDC	Designated Dive Coordinator
DMM	discarded military munitions
DOT	Department of Transportation
EC	Emergency Coordinator
EM	Engineering Manual
EOD	Explosives Ordnance Disposal
ESP	Explosives Safety Plan
EZ	exclusion zone
FFA	Federal Facilities Agreement
MDoT	Massachusetts Department of Transportation
mm	millimeter
MPPEH	munitions potentially presenting an explosive hazard
MR-QAPP	Munitions Response-Quality Assurance Project Plan
OSHA	Occupational Safety and Health Administration
PFD	personal floatation device
PM	Project Manager
ppm	parts per million
RSE	Removal Site Evaluation
SCUBA	self-contained underwater breathing apparatus
SHM	Safety and Health Manager
SOP	Standard Operating Procedure
SUXOS/DS	Senior UXO Supervisor/Dive Supervisor
USACE	U.S. Army Corps of Engineers
UXO	unexploded ordnance
UXOSO	UXO Safety Officer

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1.0 INTRODUCTION

1.01 This Dive Operations Plan addresses the health and safety practices and controls that will be implemented by all Tetra Tech employees and subcontractors (if subcontractors are required) participating in diving operations to perform underwater intrusive military munitions investigations at the Nashua River Former Fort Devens project site. The military munitions investigation will be performed on an approximate 3-mile stretch of the Nashua River that includes the five Areas of Potential Interest (AOPIs) near Former Fort Devens. The five AOPIs are associated the following four bridges from south to north: State Route 2, Jackson Road, Hospital Road, and West Main Street, and a portion of the Bill Ashe Trail

1.02 Diving operations are tentatively scheduled to begin in Spring 2023. Activities to be performed under this Dive Operations Plan comply with Occupational Safety and Health Administration (OSHA) Standard 29 *Code of Federal Regulations* (CFR) 1910.120, 29 CFR 1910 Subpart T – Commercial Diving Operations (including Appendix B – Scientific Diving as applicable), Engineer Manual (EM) 385 1-1 Section 30 (U.S. Army Corps of Engineers [USACE] dated 2014), and the Tetra Tech Diving Safe Practices Manual (DSP-1) (Appendix A).

1.03 This Dive Operations Plan will be implemented in conjunction with the Accident Prevention Plan (APP), which is the overarching safety plan for the project. Both documents will be available and accessible to all project personnel during diving activities. Diver personnel will be familiarized with both the APP and this Dive Operations Plan before beginning fieldwork.

1.04 The selection of SCUBA to conduct UXO diving operations for this project is based on balancing the UXO explosive safety hazards with the site-specific diving hazards. Under the specific site conditions of this project, the explosive safety risk is greater than the risk to the diver of using SCUBA. The use of SCUBA will allow the single tended UXO diver to remain neutral in the water column minimizing contact with the bottom and lower the potential for uncontrolled contact with UXO. There are no confined spaces or obstructions to the surface. The water depth will be less than 15 feet with a majority of the diving occurring in depths less than 5 feet. The river current is negligible, and the diver work effort will be light to moderate.

1.05 All members of the dive team are qualified unexploded ordnance (UXO) technicians and prior Navy Explosives Ordnance Disposal (EOD) divers. The UXO technician qualifications are addressed within the APP.

1.06 Should this approved Dive Operations Plan require modification or should any of the diving procedures or activities change, any changes must be reviewed and approved by the Tetra Tech Dive Operations Manager, Scot Wilson; the Tetra Tech Diving Safety Officer, Patrick Oberley; and the USACE Designated Dive Coordinator (DDC).

2.0 DESCRIPTION OF PROJECT

2.01 The Former Fort Devens was active from 1917 to 1996 and was placed on the National Priorities List in 1991. In May 2021, the Army and USEPA signed a Federal Facilities Agreement (FFA). The river is primarily used by recreational users (i.e., canoeing, kayaking, fishing), with trails along some of its banks used for hiking. Massachusetts Department of Transportation (MDoT) divers perform bridge inspections and associated maintenance along the Nashua River. The Nashua River is also known to have an infestation of water chestnut, a non-native, invasive aquatic plant. Active management of this invasive species has been performed by volunteers with the Nashua River Watershed Association since 2014.

Recently, military munitions have been recovered within the project area. Recovered military munitions include:

- Summer 2020: During magnetic fishing, two MK-II hand grenades and an un-fuzed 60-millimeter (mm) mortar were found.
- March 2021: During a MDoT bridge inspection, three practice 2.36-inch M6A1 rockets, a practice 60mm mortar, and an expended M18 smoke grenade were discovered.

Based on the recovered munitions findings, under the FFA in place for Fort Devens, USEPA Region 1 initiated an Informal Dispute with the Army and a Removal Site Evaluation (RSE) was conducted. Based on the 2021 RSE, there is no evidence the Army used the banks of the Nashua River or the river itself for munitions-related operations. The most likely source of potential munitions in the Nashua River is due to discarded military munitions (DMM).

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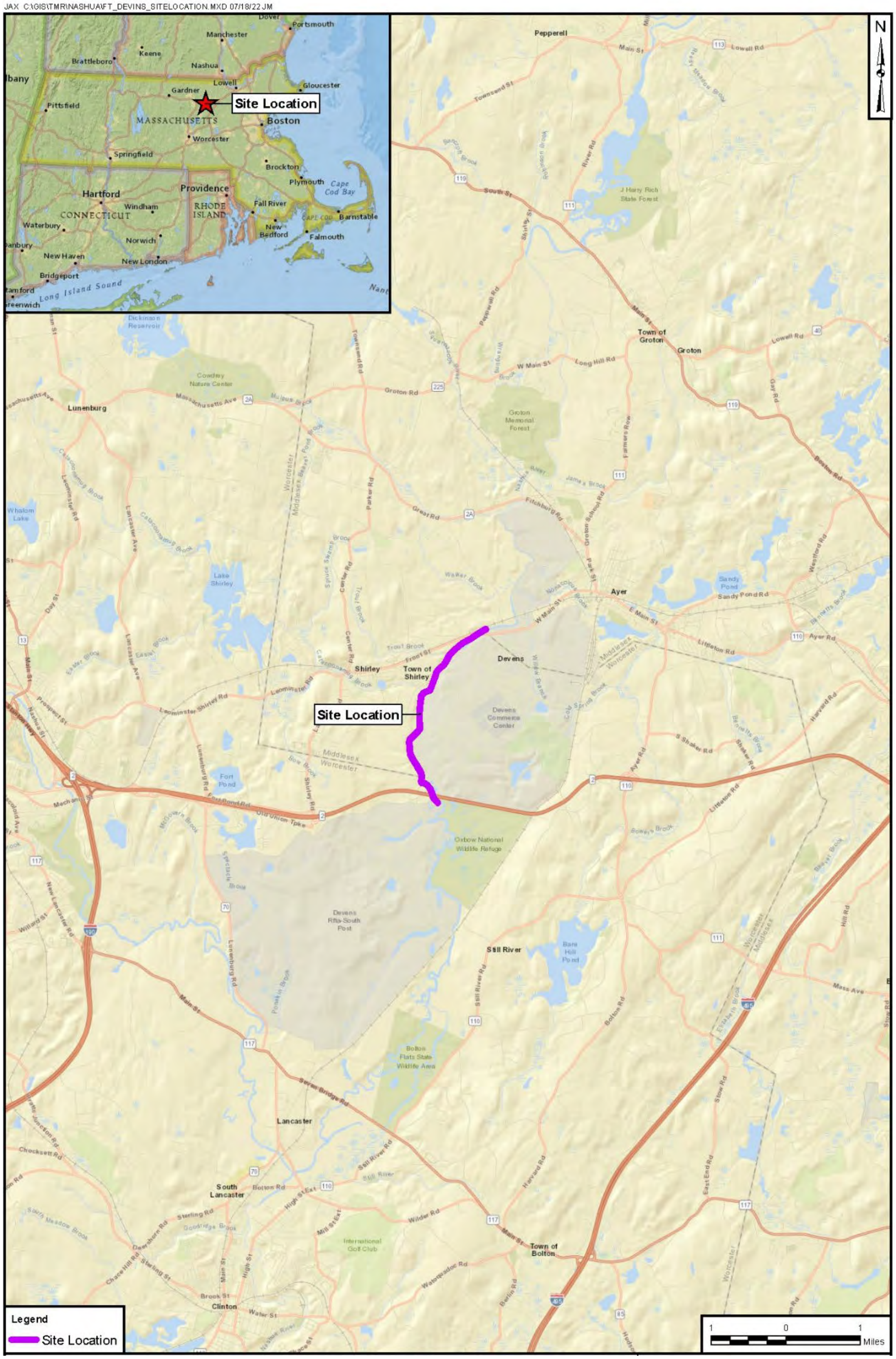

Figure 2-1. Regional Location Map

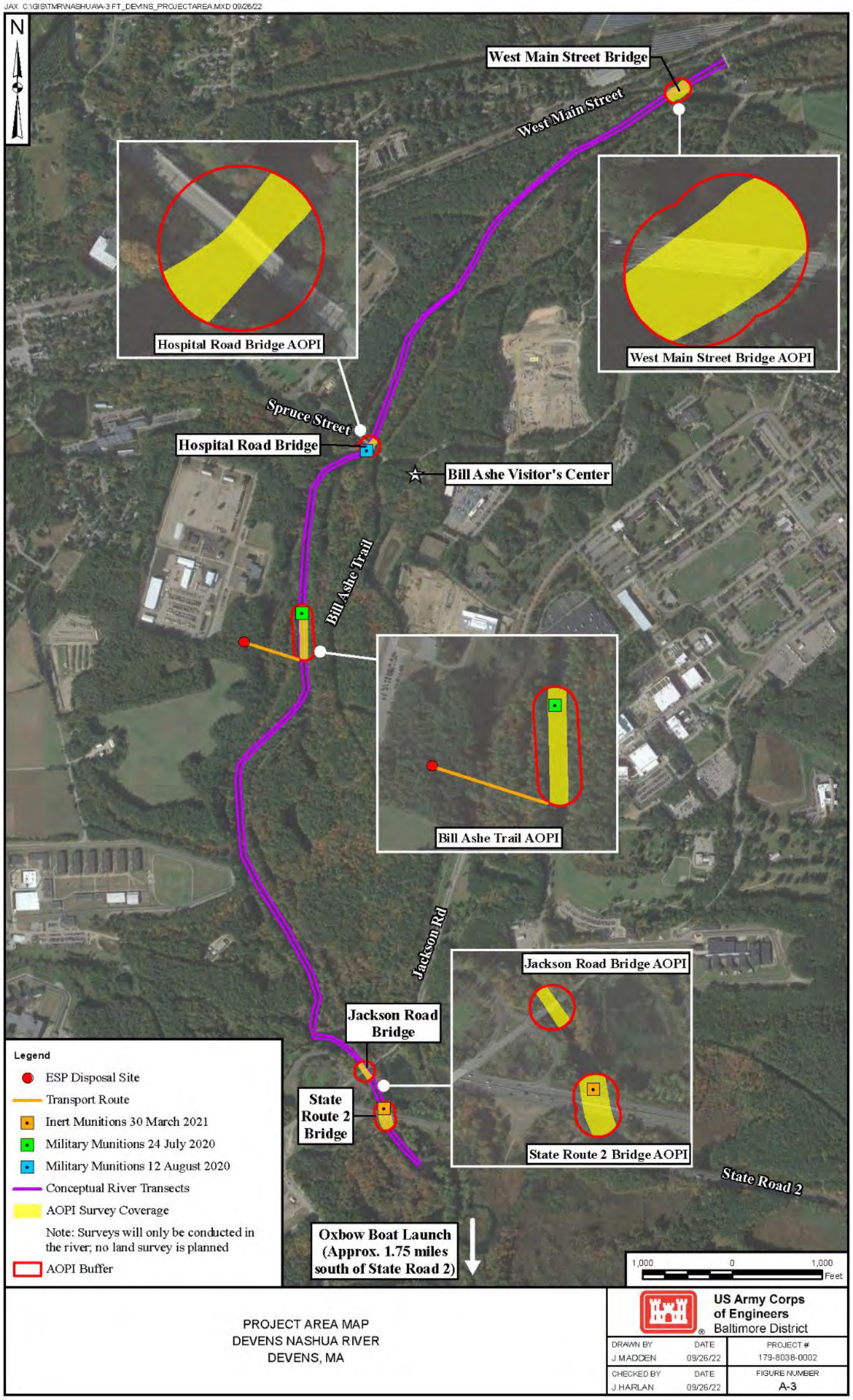

Figure 2-2. Site Location Map

2.1 INTRUSIVE INVESTIGATION

2.1.01 The objective of military munitions investigation is to investigate targets selected from the geophysics investigation being conducted prior to the intrusive investigation task. UXO technician divers will intrusively investigate metallic targets that are potential military munitions items within the boundaries of the site including the five AOPIs and 3 miles of river.

2.1.02 Two 15.5 feet low-impact Mk 3 Zodiac inflatable boats will be used to conduct diving operations. As an alternative, one of the dive boats may be a 15 to 20 feet shallow draft aluminum work boat. The vessels will be anchored using a mushroom anchor or equivalent. The dive boat will be equipped with a diver communication system, a diver recall device, lost diver buoy, backboard, supplemental oxygen, first aid kit, diving supervisor kit, required dive flags, additional air tanks, and spare diving equipment. The minimum manning while conducting diving operations will be the Diving Supervisor/Senior Unexploded Ordnance Disposal Supervisor, Diver, Standby diver, and tender. The boats will include water-level ladders/platforms for safe entry and egress by divers.

2.1.03 During intrusive diving investigations, the surface and subsurface exclusion zones (EZs) specified in the Explosives Safety Plan (ESP) will be established and maintained by the UXO dive team. If the EZ is breached by non-essential personnel, the Senior UXO Supervisor/Dive Supervisor (SUXOS/DS) will halt work until the EZ can be re-established. The intrusive dives to investigate the digital geophysical mapping targets will consist of utilizing self-contained underwater breathing apparatus (SCUBA) gear, AGA full face masks, diver navigation tablet, diver communication system, and an underwater metal detector to clear a 2-foot radius around each GPS target position to a depth of 2 feet or the depth of refusal whichever is shallower. The depth of refusal is the depth the diver is no longer able to penetrate the substrate because of rocks or hardened sediment layers. A single tended diver will be utilized. When each target is located, the diver will remove sediment around the target to investigate and identify the source. Non munitions related debris will be recovered and collected for recycling/disposal unless it is physically unsafe to bring them to the surface. When military munitions or MPPEH are identified during the investigation, items that are determined “acceptable to move” by the SUXOS and UXO Safety Officer (UXOSO) will be brought to the surface and transferred to the safety boat. The recovered military munitions/MPPEH will be either bunkered in the safety boat using sandbags or collected in a mesh bag suspended from a float at a depth that results in no fragmentation hazard at the surface and towed or transported to a staging location on land for disposal in accordance with the standard operation procedures (SOPs) and requirements identified in the Munitions Response-Quality Assurance Project Plan (MR-QAPP) and ESP. Items that are determined by the SUXOS and UXOSO as not “acceptable to move” will either be disposed of by blow-in-place procedures in accordance with SOPs and requirements identified in the MR-QAPP and ESP or will be left in place until additional consultations and disposal determinations are made.

2.2 DIVE TASKS AND ACTIVITY HAZARD ANALYSIS

2.2.01 The scope of work for the dive-related tasks during military munitions investigation includes the following, each having a preliminary Activity Hazard Analysis (AHA) in Appendix B:

- Boat Operations
- Diving Operations and Intrusive Investigations

- Military Munitions/MPPEH Management and Disposal

2.2.02 As new activities or tasks are identified or the work environment of the task changes, new or revised AHAs will be prepared. New AHAs will be submitted to the Corporate Safety and Health Manager (SHM) and the USACE Team for review and acceptance. Revised AHAs will be submitted to the SHM and USACE Project Manager/DDC for review if the Risk Assessment Code increases from that of the original AHA.

2.3.02 In addition to the above tasks, divers working from vessels (as opposed to shore-based entry, if required) will also review the vessel operations AHA prepared for the APP. Other tasks not directly related to diving are evaluated and covered under the APP tasks and its associated AHAs.

2.3.03 Pre- and post-diving inspection checklists can be found in Appendix A, Attachments 2 and 3, respectively.

2.3.04 Upon field task completion, Tetra Tech will demobilize equipment and supplies from the site.

3.0 ORGANIZATIONAL STRUCTURE AND RESPONSIBILITIES

3.01 Tetra Tech professional staff will be conducting field activities, including diving-related tasks performed during military munitions intrusive investigation activities. All UXO divers exceed the UXO diver qualification IAW TP-18 and are prior Navy EOD divers.

3.02 The SUXOS, Don Schwalback, is the Tetra Tech Dive Supervisor for all diving operations performed on this project. He is responsible for all aspects of the diving operations affecting the health and safety of dive team members. The Dive Supervisor will be physically at the dive location where the dive operations are conducted. The dive location for this project is defined as the surface or vessel from which a diving operation is conducted (anticipated to be the MK 3 inflatable boat or shallow draft aluminum work boat).

3.03 Additional qualified divers will be used as part of the team for rotation of diver personnel within the dive team configurations listed below to allow for rest periods for the divers.

3.04 The names of the dive team members, other than the SUXOS/Dive Supervisor (Don Schwalback), UXOSO (Patrick Oberley), and UXOQCS (Kevin Borkowski) are not yet known and are subject to change depending upon availability when the dive work commences. When team members are identified by the Dive Program Manager, the names will be listed in Appendix C of this Dive Operations Plan and copies of each team member's qualifications, certifications, and medical "fit to dive" statements will be maintained on-site for each diver. The dive team and each member's qualifications will be submitted under separate cover to the DDC for review prior to commencement of diving operations.

3.05 A support vessel and vessel operators/crew will be available to assist the dive team in the event of an emergency, for enforcement of the required exclusion zones during intrusive diving operations, and to transfer recovered military munitions/MPPEH to the disposal staging area. Each vessel will have all applicable up-to-date vessel safety and emergency equipment, and each person designated as a vessel operator will have the required qualifications and training for operation of vessels as specified in the APP.

3.1 INTRUSIVE DIVE TEAM

3.1.01 The intrusive dive team will be made up of no less than four persons as follows, working from the dive vessel.

- A tended diver in the water
- A standby diver
- A dive tender
- The Dive Supervisor

3.2 DIVER QUALIFICATIONS AND TRAINING

3.3.01 The dive team members (other than the SUXOS/DS) will rotate during each dive event as required to offset the effects of fatigue and cold or heat stress. When a diver is assigned to a specific role, the person assigned to that role will be trained and qualified in the duties and responsibilities that each position on the team is assigned (diver, tender, etc.). The Dive Supervisor, under the direction of the Dive Program Manager (Scot Wilson) who reviews and approves all divers used on Tetra Tech projects, will verify that all assigned divers have proper diver certification and training, the required “fit to dive” medical clearance from the examining physician, and those performing military munitions-related diving operations have UXO technician credentials for performing diving activities during this project. The SUXOS/DS will ensure that all parties involved in these activities have reviewed and are familiar with the APP, this Dive Operations Plan (including the Dive Safe Practices Manual), and AHAs by signature of the team members.

3.3.02 All team members’ qualifications and certifications will be provided to the Dive Program Manager (Scot Wilson) and will be provided to the USACE DDC for review prior to beginning any diving operations. If divers are added to the dive team during execution of the project or if the names of divers change, their names and qualifications will be provided to the USACE DDC for review prior to the new diver performing any dive team related responsibilities. The UXOSO will maintain all certifications and qualifications in on-site files.

3.3.03 All divers at this site are required to have the following qualifications and certifications:

- All divers must be deemed “fit to dive” by an examining physician on an annual basis (within previous 12 months) according to Association of Diving Contractors International Consensus Standards or similar standards by a hyperbaric physician or other licensed physician with knowledge of diving physiology. Statement must be signed and stamped by the examining physician.
  - After any serious diving-related injury or illness such as an over-pressurization injury and/or decompression illness, divers shall be re-examined by a hyperbaric physician and be re-certified as “fit to dive.”
- Each diver will have current training in the use of emergency oxygen systems specific to underwater diving that meets the requirements of a nationally recognized training organization such as Divers Alert Network, Professional Association of Diving Instructors, National Association of Underwater Instructors, the YMCA, or other recognized sources. All classes will contain a hands-on component and cannot be taken online. Evidence of this will be a photocopy of the certificates. The certificate(s) will state the date of issue and length of validity.
- Each diver will have current training in first aid/cardiopulmonary resuscitation (CPR), including automatic external defibrillator training from a training provider such as the American Red Cross, the American Heart Association, or from an organization whose training adheres to the standards of the International Liaison Committee on Resuscitation, or from a Licensed Physician. All classes will contain a hands-on component and cannot be taken online. Evidence of this will be a photocopy of the certificates. The certificate(s) will state the date of issue and length of validity.
- All members of the intrusive investigation team are qualified UXO technicians who have a Certificate of Training from U.S. Naval School EOD, Elgin Air Force Base, Florida; or Indian Head, Maryland.
- All intrusive investigation team divers will have U.S. Navy Diver certification.
- Each diver will have at least 1 year of commercial experience in their assigned position.
- Each diver will provide dive-log evidence that they have training and experience consistent with the performance requirements of the project. Divers will have completed at least four

working dives with similar decompression techniques as those in this Dive Operations Plan, using the particular diving techniques and equipment. Divers will demonstrate that at least one of the four qualification dives was performed in the last 9 months prior to the start of dive operations.

4.0 DIVING EQUIPMENT

4.01 Dive-specific equipment is listed below:

- Divers will wear appropriate thermal protection consisting of a dive skin or wetsuit (partial or full depending on diver comfort and other factors). Gloves and boots will also be worn.
- Diver gloves will have Kevlar (or suitable equivalent) palm lining for handling of debris with potentially sharp edges or coral.
- A professional-grade diving mask and snorkel.
- Swim fins.
- Dive knife.
- Weight belt and weights capable of quick release.
- Buoyancy compensator vest having a manually activated inflation source, an oral inflation device, and an exhaust valve.
- Safety harness (for tethering when a tethered diver is used) with a positive buckling device, attachment point for safety line, and a lifting point to distribute the pull force of the line while maintaining body in heads-up position when unconscious.
- Primary and secondary regulator system with pressure and depth gauges.
- Dive light.
- Compass.
- 80-cubic-foot compressed seamless steel or aluminum air cylinders filled with purified breathing air (see below). Cylinders must meet U.S. Department of Transportation (DOT) 3AA or DOT 3AL and have identification symbols stamped on shoulder of tank. Each tank must have current hydrostatic and visual inspections.
- Reserve breathing supply available that can be turned on immediately by the diver in the event of loss of air. The reserve breathing air supply will be of sufficient capacity to recover the diver and complete emergency recompression (if required) in the event of loss of primary air but no less than 30 cubic feet (0.85 cubic meters). The supply will be pressurized to at least 90 percent of its working PSI rating and equipped with a separate 1st and 2nd stage regulator.
- Communication device (if equipped with mask) or line pull assembly.
- Timekeeping device (Dive Supervisor) to record diving times.
- Dive computer (records depth and bottom times, etc.).

4.02 All dive equipment used on this project is subject to a Diving Equipment Preventive Maintenance Program. This program ensures that equipment is inspected and serviced to meet the manufacturer’s maintenance interval. In addition, equipment will be maintained in compliance with the manufacturer’s recommendations. Damaged or worn equipment will be repaired or replaced as required prior to being put into service.

4.03 All dive equipment and safety gear will be inspected daily before use. Damaged equipment will be taken out of service and repaired or replaced before further use. After use, equipment will be cleaned (with light soapy water and rinse according to manufacturer instructions) and will be stored in a dry location.

4.04 The dive team will utilize a gasoline powered diving air compressor set up at the Tetra Tech staging area on land to fill SCUBA tanks for use. This system will have current certification and inspection for providing air purity standards as follows:

- Air will not contain a level of carbon monoxide greater than 10 parts per million (ppm);
- Air will not contain a level of carbon dioxide greater than 1,000 ppm;
- Air will not contain a level of oil mist greater than 5 milligrams per meter cubed;
- Air will not contain a level of hydrocarbons other than methane greater than 25 ppm; and
- Air will not contain a noxious or pronounced odor.

4.05 A copy of the current breathing air source certification will be provided to the USACE DDC prior to commencement of diving operations.

5.0 DIVING PROCEDURES

5.1 PRE-DIVING ACTIVITIES

5.1.01 Prior to the initial dive operation, a pre-dive conference will be held with key personnel such as the DDC, Dive Supervisor, and the Dive Safety Officer at a minimum. During the pre-drive conference, the AHAs will be covered in detail.

5.1.02 If for any reason the dive plan is altered in mission, depth, personnel, or equipment, the DDC will be contacted in order to review and accept the alteration prior to actual operation.

5.1.03 Pre-diving activities are as follows:

- The UXOSO (duties and responsibilities of these roles are described further in the APP) will verify all team personnel (including dive team and support personnel) have attended the site-specific APP and Dive Operations Plan training and have reviewed the AHAs, and that copies of all certifications and training are on-site (prior to first dive and all new divers).
- The UXOSO and Dive Supervisor will test and conduct an emergency drill prior to commencement of project dive operations and ensure that emergency contacts listed are correct and that the recompression chamber facilities and hospitals listed in Table 7-1 have been notified of the diving operations.
- The UXOSO, Dive Supervisor, and dive team will hold a briefing each day to discuss personnel assignments, techniques, and equipment to be used, working depths and estimated bottom times, water temperatures, and to review the AHAs and emergency procedures. Support personnel (e.g., support vessel and crew) will attend briefings as well.
- Diving equipment will be inspected each day by the divers and immediately prior to the dive by the Dive Supervisor. The Dive Supervisor will review Appendix A, Attachment 1 (Diving Supervisor Dive Plan Brief) to ensure the proper checks are made and documented each day prior to starting dive activities.
- Appendix A, Attachment 2 includes the pre-dive checklist that will be filled out daily by the Dive Supervisor prior to commencing diving activities. Daily before diving and during diving, the Dive Supervisor will evaluate conditions, as necessary, such as temperature (water and air), tide (high and low), current speed/direction, wind speed/direction, sunrise and sunset times, and wave action (height and direction). The vessel operator will monitor the weather forecast or be in communication with the UXOSO who will monitor the weather forecast and report the forecast to the Dive Supervisor.
- A working means of communication will be verified (cell phone [waterproof phones] and radios) between support vessel, the dive vessel, and shore personnel each day prior to operations. Vessels will have access to marine radio channel 16 (emergency channel). The Dive Supervisor will ensure that communications are working between the support boat(s) and the other team members. Radio checks will be confirmed to ensure vessels remain on the same operational channel.
- Review emergency signals, including air/boat horn signals, hand signals, and line tug/ping signals (see Attachment 8 of Appendix A). If the divers need to be recalled to the boat for

an emergency (divers without communication devices), four pulls will be given on the line or four hits to a metal pipe (ping) with a hammer to signal to come to the surface.

- Check diver's physical condition.
- Go over anticipated hazards of the dive.
- Ensure a Stokes litter or backboard with flotation is available for emergency retrieval of an injured or unconscious diver onto boat or, if diving is done from land entry, is immediately available onshore.
- Review emergency procedures, contacts, and numbers, and ensure a vehicle is available at (or within proximity to) the designated evacuation site for transportation to the hospital if required. Ensure the team knows the location of the emergency numbers, the emergency evacuation areas, and routes to the hospital which are shown on Figures 7-1 and 7-2.
- Review dive techniques and equipment to be used to accomplish the task. Review information and procedures from the MR-QAPP with the divers on the tasks, and what to record and collect during the dive (e.g., photos, hand-held magnetometer use, etc.) to minimize the need for rework and to ensure proper task procedures are followed.
- Prior to entry into the water, the Dive Supervisor will ensure the boat motor is in neutral or is shut off and that personnel are entering the water so that the propeller is not engaged. The Dive Supervisor will only call for engagement of the motor when divers are not in proximity to the propeller and when it is safe to engage the propeller.

5.2 DURING DIVE PROCEDURES

5.2.01 The during diving procedures are as follows:

- When the team arrives at the dive site, the vessel captain will position the boat between the diving work zone and potential other boat traffic, and place the motor in neutral or hold position as required. The divers will suit up and don required safety equipment and gear. Support boats will be positioned outside the exclusion zone and as necessary to maintain the exclusion zone from other boaters who may try to enter the area.
- A standby diver will be readily available on the dive boat in case of emergency.
- Diving will be discontinued if sudden squalls, electric storms, heavy seas, or any other condition exists that, in the opinion of the Dive Supervisor and/or vessel operator, jeopardizes the safety of the team. At no time will diving be conducted in poor weather conditions, when currents exceed 1.5 knots, in heavy wind conditions unsafe for boating or diving operations, or in marginal visibility conditions.
- The vessel will be located between the divers and any potential vessel traffic to minimize the potential for vessel strikes.
- A red and white "diver down" and a Code Alpha flag (international diver signal) will be displayed at the dive site.
- All dives will be "no decompression" dives.

- A ladder extending below the surface of the water and handrails 3 feet minimum above the diving platform will be provided to assist the divers on entry and exit from the water (inflatable boats are exempt from this requirement).
- The propeller of the vessel will be stopped before the diver enters or exits the water and when divers are retrieved from the water.

5.3 POST-DIVING PROCEDURES

5.3.01 The Dive Supervisor will check the physical conditions of the divers between rotations and at the end of shift. Any adverse health problems, however minor they may seem (including any rashes, itching, etc.), must be reported to the Dive Supervisor as soon as the diver has knowledge of the condition. The Dive Supervisor must follow the Post-Dive Checklist in Appendix A, Attachment 3.

- The Dive Supervisor will ensure divers wait at least 12 hours before flying after any dive. This interval should be extended to 24 hours following multiple days of repetitive dives.
- Divers will clean and stage equipment for next day's diving event and shower at the shower facility after dives.
- Complete the Dive Profile Log for each dive (see Attachment 6 of Appendix A).
- Forward copies of the Dive Profile Log to the Diving Program Manager (Scot Wilson).
- Review information from daily dives and evaluate progress. Plan for the next day's diving and get sufficient rest.

6.0 SITE CHARACTERIZATION

6.01 The primary hazards associated with diving operations include drowning, dive-related illnesses (e.g., bends, arterial gas embolism, barotrauma), heat stress and cold stress, being carried away by strong surface currents and severe weather conditions, encountering dangerous marine life, and being struck by surface vessels. Boating operations in support of diving operations also present a variety of hazards. Divers on this project may be exposed to military munitions/MPPEH that could detonate under certain conditions or if not handled properly. Diving-related hazards are the intent and focus of this Dive Operations Plan and are addressed below. Other related hazards such as vessel operation and use, and UXO and explosive hazards are referenced to the appropriate section of the APP and/or MR-QAPP and will be addressed with divers prior to the initiation of diving operations in addition to those presented in this Dive Operations Plan.

6.1 DIVE HAZARDS

6.1.1 Diver Drowning

6.1.1.01 Drowning is a potential hazard during diving operations. Drowning hazards during diving operations could result from running out of breathing air (empty tank or no or inoperable reserve air supply), medical emergency (e.g., heart attack) of a diver, or regulator malfunction while underwater. Procedures in this plan will be followed to minimize the potential for drowning under these scenarios and include regular inspection, servicing, and maintenance of dive gear; procedures that control dive times; use of certified Grade D breathing air; diver carried reserve air supply for emergencies; dive team configuration and buddy system observation; and evaluation of diver fitness through the Tetra Tech “fit to dive” medical surveillance program.

6.1.2 Diver-Related Illnesses

6.1.2.01 The maximum depth of the dives during this project is 20 feet and the average depth of dives is anticipated to be approximately 8 feet. All dives at this site will be “no decompression” dives. Although rare at shallow depths, divers could suffer the effects of decompression sickness or an arterial gas embolism or barotrauma if they surface improperly, run out of breathing air, or do not follow the dive tables and safety precautions. These illnesses can be prevented by following the procedures in this plan and those in Appendix A.

6.1.2.02 In addition, emergency equipment for the dive team will include oxygen, which can be administered by qualified persons for diving emergencies. As a precaution, Table 7-1 includes the location and telephone number of the nearest recompression chamber in MA.

6.1.3 Thermal Stress to Divers

6.1.3.01 The water temperatures in the Nashua River range from an average low around 35 degrees Fahrenheit (°F) to an average high of 70 °F. Underwater temperature conditions can change from thermoclines and currents where present and in general, deeper waters will be cooler than surface and/or shallow waters. Because of the relatively cold water temperatures compared that of average body temperature, there is a risk that divers could develop cold stress from immersion in the water. However, it is just as likely that divers could develop heat stress from exertion undertaken during diving related operations. The likelihood of heat stress occurring depends on environmental conditions (water and surface), the level of work activity, and the control measures that are used to manage body heat (work/rest cycles, physical conditioning, and protective clothing).

6.1.3.02 Appropriate control measures will be taken to manage these thermal stress concerns as described in the Heat Stress and Cold Stress sections of the Site Safety and Health Plan (SSHP). The Diving Supervisor (or his designee) will monitor water temperatures and surface air temperatures and wind speed (for potential wind chill effect) in the work area and will monitor the effectiveness of the personal protective gear and modify these controls as needed to provide for diver safety and comfort. If wearing a dive ensemble at the surface, workers could also have heat stress effects. Vessels that support divers will have canopies or other means of shade or shelter to allow divers to either cool down (avoid radiant heat load) or warm up as appropriate. Rotation of diver personnel may also be used as necessary to allow divers to warm up or cool down between dives. The Dive Supervisor, with assistance by the UXOSO, will ensure that the requirements for heat and cold stress prevention and mitigation are implemented as required in the AAP. All dive team members will be briefed on heat and cold stress hazards and prevention.

6.1.4 Strong Currents and Severe Weather Dive Hazards

6.1.4.01 Severe weather (strong wind or thunderstorms) could occur and significant current or wind action on the surface of the water could occur. The potential for severe weather conditions and water conditions will be monitored by the Dive Supervisor before and during dives. The Dive Supervisor will make decisions related to diver safety when strong currents, heavy winds, or other hazardous conditions present. Additional information related to severe weather is included in Section 7 and will be reviewed with all dive team members.

6.1.5 Vessel Strikes during Diving Operations

6.1.5.01 Divers in the water and in dive support vessels could be struck by the other Tetra Tech support vessel, including propellers if engaged and operating. In addition, other vessels could come into the work area where dive operations are being conducted if exclusion zones are not able to be effectively controlled or the public ignores exclusion zone warnings and diver work zone controls. To minimize the potential for injury to divers from Tetra Tech and other vessel traffic, work zone controls will be established during diving operations. An “ALPHA” flag and red and white “diver down” flag will be displayed at the dive site. During all diving operations, exclusion zones will be established to keep unauthorized personnel a safe distance away from active operations, including an exclusion zone requirements related to military munitions as specified in the ESP.

6.1.5.02 When divers enter or are retrieved from the water, all motors (inboard and/or outboard) on the dive support vessel will be in the neutral position or in the off position so that potential strikes from propellers do not occur.

6.1.6 Diver Exposure to Hazardous Wildlife

6.1.6.01 In the Nashua River there is limited hazardous wildlife that may be encountered; however, the divers will be aware of their surroundings and watch for wildlife which could cause injury to divers if present and if contact with the wildlife occurs.

6.1.7 Other Hazardous Conditions

6.1.7.01 Other hazardous conditions, though less likely to occur than the above hazards during diving activities, include:

- Underwater Obstacles – Underwater obstacles such as rock structures are present in the river. In addition, it is possible that man-made obstacles (sunken debris, fishing line, and other cultural debris) may be present in some areas. If divers are investigating around large debris or loose formations, debris could shift and trap a diver if loose. Each location where divers will work will be evaluated for underwater obstacles and the potential for diver safety to become compromised.

- Electrical Shock – Electrical shock is rare under or in the water but may occur when using power equipment underwater or topside. A ground fault interrupter must be used with electrical equipment employed on the vessel, both on the surface and in the water.
- Contaminated Water – Divers could encounter potentially dangerous or unpleasant forms of pollution in the water; however, this is not anticipated to occur unless there is a spill or release that occurs to waters during or prior to the commencement of diving operations. Other potential contaminants could include contact with munitions constituents if broken military munitions is found and handled during intrusive investigations or during in-water disposal operations, though it is not anticipated that such exposures would occur frequently or in high concentration, and contamination would be localized and would dissipate readily. If unforeseen contamination (e.g., unknown sheen or discoloration of the water, drums, or other potentially hazardous material) are discovered during the course of the investigation, or if spills are reported to the river waters, the dive team will not conduct the diving until the exposure hazard is properly evaluated and will not pose a hazard to the divers as per Section 30.A.14(c) of EM 385-1-1. If contamination comes into contact with the diver, the SHM will be notified, and the process for decontamination and follow-up will be established.
- Explosive Material – Divers could make contact with explosive hazards, which are known to be present in the form of military munitions in the river and are the subject of investigation by divers. In addition, divers could be exposed to explosives through the set-up and use of donor explosives used by divers which are set to detonate and destroy military munitions within the river environment (when in-water disposal is warranted). Explosive hazards are addressed within the ESP and through procedures included in the SOPs. All investigation of military munitions and use of donor explosives will be by divers qualified as UXO technicians. Prior to detonation of explosives, all divers will be out of the water and the dive team and boats will be located out of the exclusion zone prior to detonation as required by the ESP.
- Boating – Safe vessel operations, including qualifications for vessel operators, safety of passengers onboard vessels, and vessel emergency equipment are addressed in more detail within Boating Instruction HSE 1-10 located in Appendix B, which will also be reviewed by all dive team members.
- If unanticipated or new hazards are discovered during the course of the investigation, they will be reported immediately to the Dive Supervisor. If the situation presents an immediate hazard to divers, diving operations will halt until the situation is evaluated and hazards mitigated. The Dive Supervisor will report the hazards to the Project Manager (PM), Dive Program Manager, and SHM, and evaluation of the hazard and any required mitigation will be evaluated. The PM will report these hazards to the USACE PM and the USACE DDC. AHAs will be updated as required and if this plan requires update, changes will be submitted for USACE PM and DDC review.

Table 6-1. Site Conditions in the Nashua River

Surface and Underwater Conditions	Visibility	Water Temperature	Thermal Protection	Currents
Light to moderate current with underwater obstructions.	Variable 0 to 10 feet	35 to 75°F	Dry suit, wet suit, dive skin or coveralls for warmer water	Weak to moderate

7.0 EMERGENCY MANAGEMENT PLAN

7.01 The following Emergency Management Plan includes the required elements of EM 385-1-1 Section 30.A.18 for diving activities.

7.01.01 Spill Plans and Response

Tetra Tech will conduct cleanup operations in the event of a spill of hazardous materials. The UXOSO will manage the collection of spilled material with the appropriate absorbent materials (e.g., sorbent pads, sorbent socks, chemical protective gloves, and bags) into a DOT approved container for disposal. A complete spill kit will be maintained on site when spills are a potential hazard. Chemicals brought to the site will be in small quantity containers in order to limit the amount of material spilled, should a spill occur. As part of mobilization training all personnel will be trained in the procedures for cleanup of small spills.

In the event of a spill or leak of any potentially harmful material, onsite personnel will:

- Notify the SUXOS/DS and UXOSO immediately
- The SUXOS/DS or UXOSO will notify the PM and SHM of the spill/leak with relative information (time, chemical identity, quantity, location, hazards listed on the SDS), and any corrective actions/measures taken
- Locate the source and stop the spill/leak if it can be done safely
- Begin containment and recovery of spilled material using appropriate PPE and spill cleanup equipment and materials
- Determine if quantities meet or exceed the reporting requirements for spills.
- Once notified, the PM will notify USACE representative.
- Tetra Tech will assist the USACE representative as directed with any required notification to regulatory agencies if the spill is reportable.
- In no case will Tetra Tech report a spill to a regulatory agency without the USACE representative and/or KO concurrence.
- An investigation and incident report will be prepared and corrective actions identified.
- Waste from the spill will be evaluated and managed for proper disposal in accordance with federal and local laws and regulations and base requirements.

7.01.02 Firefighting Plan and Explosion Procedure

Workers will not fight any fires other than incipient-stage fires (small fires that have recently occurred and can be reasonably extinguished immediately). There will be at least one fire extinguisher at each active work location. Fire extinguishers will also be located in each boat and in the crew pickup trucks. The fire extinguishers are intended to fight only incipient-stage fires. In no case will workers attempt to fight any fire that cannot be reasonably extinguished within 30 seconds to 1 minute.

If a fire breaks out, call or designate someone to call the local fire department before attempting to put out the fire (incipient stage only) and only if fighting the fire does not put anyone at further risk. Ensure a means of egress is available in the event the fire cannot be extinguished. The local Fire Department will respond.

To use the fire extinguisher, remember the word P.A.S.S. – pull the pin, aim the nozzle at the base of the fire, squeeze the lever, and sweep side to side at the base of the fire. Workers will be given fire extinguisher training during project orientation.

Fire extinguishers will be inspected by the UXOSO initially and then every month (at a minimum). Additionally, all fire extinguishers will be inspected and serviced annually by a qualified professional. Any defective or partially used fire extinguisher will be red-tagged and taken out of service until such time that it can be serviced. Fire extinguishers will be secured or supported when transported and in storage. During project demobilization, all fire extinguishers and other hazardous material will be properly dispositioned for further use at other Tetra Tech projects or for use by others at the base, if suitable.

In the event of a fire or explosion, contact the appropriate emergency authorities by calling emergency services. Any fire must also be reported to the appropriate client point of contact and the SHM.

7.01.03 Man Overboard/Abandon Ship

In the event of a man overboard, the following will occur:

- The person who observes the man overboard shall shout out “man overboard” and the side of the boat (port or starboard) the incident occurred.
- The person who went overboard should shout out to those on the boat if his or her going overboard was unnoticed and should use the whistle on the PFD if present.
- Throw a life ring over the side as near as possible to the person in the water.
- Notify the boat operator as quickly as possible and keep track of the person in the water so they do not become lost.
- Direct the boat operator to the direction of the person so that a rescue can be performed.

Abandon Ship Procedure

In the event an abandon ship order is issued, the following will occur:

- Follow the direction of the boat operator, who will direct personnel to the appropriate station onboard the vessel.
- Ensure PFD is securely fastened.
- Note the location of and distance to the nearest land and remain with your group until instructed to abandon ship.
- Deploy rescue raft (if equipped) on windward side of the boat and await orders to board.
- The boat captain or designated person will activate the ship’s emergency communication devices (marine distress call via radio, air horn, marine flares, etc.) as capable based on the nature of the emergency and will retrieve the survival kit as applicable.

- Enter the water by the safest means. Use ladder, if present, to enter the water before jumping overboard.
- If the boat is on fire or there is risk of explosion, stay at least 200 yards from the boat.
- If raft is equipped, stay in raft, attempt to flag down a rescue boat, and paddle toward shore. If the current takes you away from shore, try to paddle perpendicular to the current, toward areas where more land is visible or where more boaters may be present.
- As a group, or if personnel are separated and in the water, remain calm. To conserve energy and reduce risk of hypothermia, float on your back with your knees bent toward your chest. If together as a group, huddle together.

7.01.04 Contingency Plan for Severe Weather

The potential for severe weather is possible, as storms can occasionally be severe. The UXOSO will monitor the weather forecast a minimum of two times per day and more frequently as required (e.g., when a storm is forecast in the area). If particularly ominous weather conditions are predicted (e.g., approaching thunderstorm cell), the UXOSO will regularly monitor radio broadcasts or host nation weather service reports. Management will evaluate the situation and take appropriate action in advance of the storm to maintain worker safety, including travel to and from work, and evaluate whether to shut down the site, secure equipment, and/or perform specific tasks as necessary before the storm arrives.

In preparation for an approaching storm, the SUXOS/DS and UXOSO will determine the appropriate length of time that it will take to safely halt operations and secure equipment and operations in advance of the storm so that work can be halted with enough advance time for the safety of crew and equipment. Equipment will be secured and all doors and windows of the equipment (e.g., equipment cabs) will be closed. Tools and supplies will be stored in a designated secure location.

Nearby thunderstorms, if present, could have lightning associated with them. When a storm arises, the UXOSO will determine if lightning is within 10 miles of the site. Once lightning is seen, count the number of seconds until you hear the thunder. Divide the number of seconds by 5 to get the distance the lightning is away from you. If lightning is 10 miles away or less, work shall stop until 30 minutes after the last audible thunder or visible flash of lightning. A lightning meter may be used, as well, if available on-site. If lightning is observed, all work will stop until no lightning activity is observed for a minimum of 30 minutes, and all outdoor workers will seek shelter in a fully enclosed vehicle cab or other fully enclosed structure.

The SUXOS/DS and UXOSO will assess what work procedures can be safely performed when wind conditions exceed 20 miles per hour (mph) for any activities that can be affected by wind; lesser wind speeds may require consideration of work suspension depending on conditions. The SUXOS/DS and UXOSO will also consider fugitive dusts, the safety of equipment in high winds, and the protection of workers from flying debris.

7.02 In addition, Appendix A, Attachment 4 of this DOP contains the following emergency procedures for SCUBA diving that will be reviewed with all divers:

- Buddy separation
- Lost diver

- Loss of air/equipment malfunction
- Mechanical injury
- Fouled/trapped diver
- Loss of breathing media
- Loss of communications
- Injury in the water

7.03 Because this project involves diving operations, a local recompression chamber location and Dive Alert Network information are provided in Table 7-1 of this plan.

7.1 EMERGENCY SERVICES

7.1.01 The nearest emergency services provider to the Fort Devens site where diving operations will be performed is:

UMass Memorial Health Hospital
60 Hospital Rd,
Leominster, MA 01453

Their telephone number is **(978) 466-2000** and also located in Table 7-1. The route to this hospital from the staging area is included as Figure 7-1.

7.1.02 The nearest emergency services provider with diving hyperbaric chamber facilities is:

Ft. Norma Knight Hyperbaric Medicine Center
243 Charles Street
Boston, MA 02114

This center is located in the Massachusetts Eye and Ear Hospital, next door to Massachusetts General Hospital. The route to this hospital from the staging area is included as Figure 7-2.

7.2 EMERGENCY NOTIFICATION AND TRANSPORT PLAN

7.2.01 During diving events, the SUXOS/DS is considered the Emergency Coordinator (EC). If the Dive Supervisor is involved in the emergency, the alternate EC is the UXOSO. The EC is responsible for initiating any evacuation activities, coordination of diver emergency procedures, emergency treatment, coordinating emergency transport of site personnel as necessary, and notification of emergency response units. The EC will conduct an inspection of emergency response equipment on a daily basis and communicate the emergency response plan to the dive team personnel. Emergency contact information (emergency services, USACE, and Tetra Tech personnel) are listed in Table 7-1.

7.2.02 In the event of serious personal injury (fatality, patient unconscious, possibility of broken bones, severe bleeding that will not stop, severe burns, blood loss, drowning, shock, trauma, chest pain, difficulty breathing, seizure, electrocution, disorientation, suspected poisoning), the EC will immediately take the following steps:

- Establish the safety and location of all personnel (in water personnel first) and recall all divers to the dive vessel – diving operations will immediately stop.

- Designate a person to call emergency services from a cellular telephone by calling 911 and report the nature of the injury and location where the injured person will be brought to on-shore. The caller will stay on the line with the 911 dispatcher.
  - In the event the cellular telephone is not functioning or another cellular telephone is unavailable (e.g., on the support vessel) the marine radio, channel 16 will be used to contact the U.S. Coast Guard for assistance.
- The injured or ill diver will be brought on board the dive boat (if emergency occurs in the water) by project team personnel using the sling, ladder, or stokes-type stretcher with flotation as necessary. The tender may be required to enter the water to assist in rescue and securing the victim in the sling or stretcher; however, bringing the injured party onto the boat will likely require assistance of personnel on the support boat unless the observer/assistant reboards the boat.
- Further stabilization of the injured will be performed in the boat on deck, and first aid/CPR and emergency oxygen will be administered as appropriate.
- All divers will exit the water and be accounted for by the Dive Supervisor.
- Summon the support boat to come to aid as required (while ensuring support vessel approach will not injure anyone in the water).
- The injured will remain in the stretcher/litter if already in the stretcher if possible (depending upon on the nature of the emergency which may dictate removal from the stretcher if it inhibits the administration of first aid or CPR) to minimize the amount of movement during transport.
- The vessel will transport the injured to the nearest accessible public dock or shore with road access (field decision) and ensure that emergency dispatch is informed of the intended location. The main dock to be used for emergencies is the Bill Ashe Visitors Center Canoe and Kayak dock. However, situations may arise that dictate alternate egress routes that would be more expedient for the medical care of the victim and will be used as determined by the EC.
- Assist the emergency responders as necessary to facilitate movement of the injured to the ambulance.
- Provide a copy of the injured party's medical data sheet (addressed in the APP) to responding medical personnel.
- Designate someone to accompany the injured party to the hospital.
- Call WorkCare regarding the injury or illness.
- Notify the USACE PM, USACE DDC, PM, Dive Safety Manager, and SHM.
- Follow up on the injured and complete the Tetra Tech Incident Investigation and Reporting Procedures and complete ENG Form 3394, USACE Incident Investigating and Reporting (more information on incident reporting is provided in APP).

- Diving operations will not recommence until the emergency has been handled, the situation has been reviewed, and the Dive Operations Manager, PM, and DDC determine that diving can re-commence.
- Evaluate the Dive Operations Plan to determine if the plan or AHA requires update.

Table 7-1. Emergency Contact Information

Emergencies- Ambulance/Fire/Police	**911**
Emergency Hospital UMass Memorial Health Hospital 60 Hospital Rd Leominster, MA 01453	(978) 466-2000
Hyperbaric Chamber Hospital Norma Knight Hyperbaric Medicine Center Massachusetts Eye and Ear Hospital 243 Charles Street Boston, MA 02114	(617) 573-4411 (emergency services)
Clinic Fallon Clinic 165 Mill Street Leominster, MA 1453	(978) 466-3301 (non-emergencies)
CORE Injury Case Management	1 855-683-9006
Poison Control	1 800-222-1222
USACE PM, (Baltimore District) Peter Philips	(410) 962-2714 (office) (443) 613-3607 (cell)
USACE OESS, Marty Holmes	(410) 962-2258 (office) (410) 982-9724 (cell)
USACE DDC, David Holland	
Tetra Tech PM, Jennifer Harlan	(406) 940-5040
Tetra Tech SHM, Jeffrey Streib, CIH, CSP, CHMM	(240) 727-9240
Tetra Tech Dive Safety Scot Wilson	(360) 626-3193
Tetra Tech SUXOS/DS, Don Schwalback	(360) 941-0912
Tetra Tech UXOSO, Patrick Oberley	(865) 364-5437

TETRA TECH PERSONNEL MUST HAVE A COPY OF THE MAP TO THE HOSPITAL AND EMERGENCY CONTACT INFORMATION AVAILABLE IN THEIR VEHICLE.

TETRA TECH PERSONNEL ARE REQUIRED TO HAVE A PARTNER ON THE SITE AT ALL TIMES

Hospital:	UMass Memorial Health Hospital 60 Hospital Rd, Leominster, MA 01453
	• Head Southeast on Hospital Rd • Right on Givry St. • Turn right on Jackson Rd. • Ramp on right for MA-2 West • At Exit 99B, head right on the ramp for MA-12 North toward Fitchburg

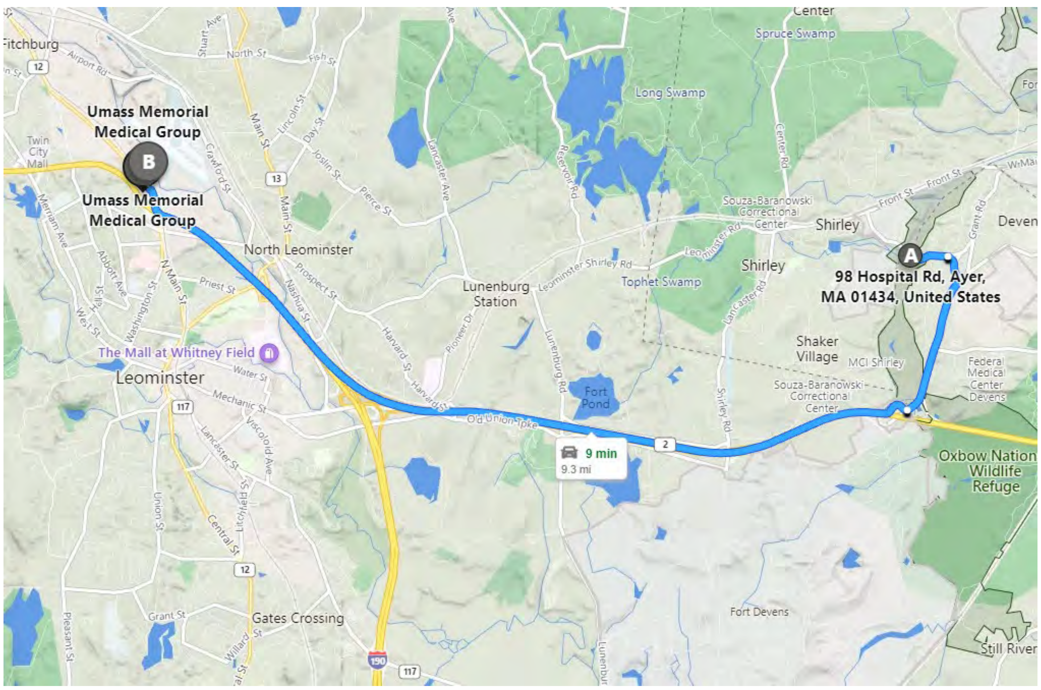

Figure 7-1. Emergency Route to UMass Memorial Hospital from Fort Devens

Hospital:	Ft. Norma Knight Hyperbaric Medicine Center 243 Charles Street Boston, MA 02114
	• Head Southeast on Hospital Rd • Right on Givry St. • Take 1st left on Jackson Rd. • Stay straight to go onto MA-2 E. Pass through 1 roundabout. • Enter next roundabout and take the 2nd exit onto Concord Ave/US-3 S/MA-16/MA-2. • Enter next roundabout and take the 1st exit onto UX-3 S/MA-2. • Turn slight right onto Gerrys Landing Rd. • Take the ramp toward Gov't Ctr. • Stay straight to go onto David G Mugar Way. • Turn left onto Charles St. • Turn right onto Charles Cir/MA-3. • Hospital is on the right.

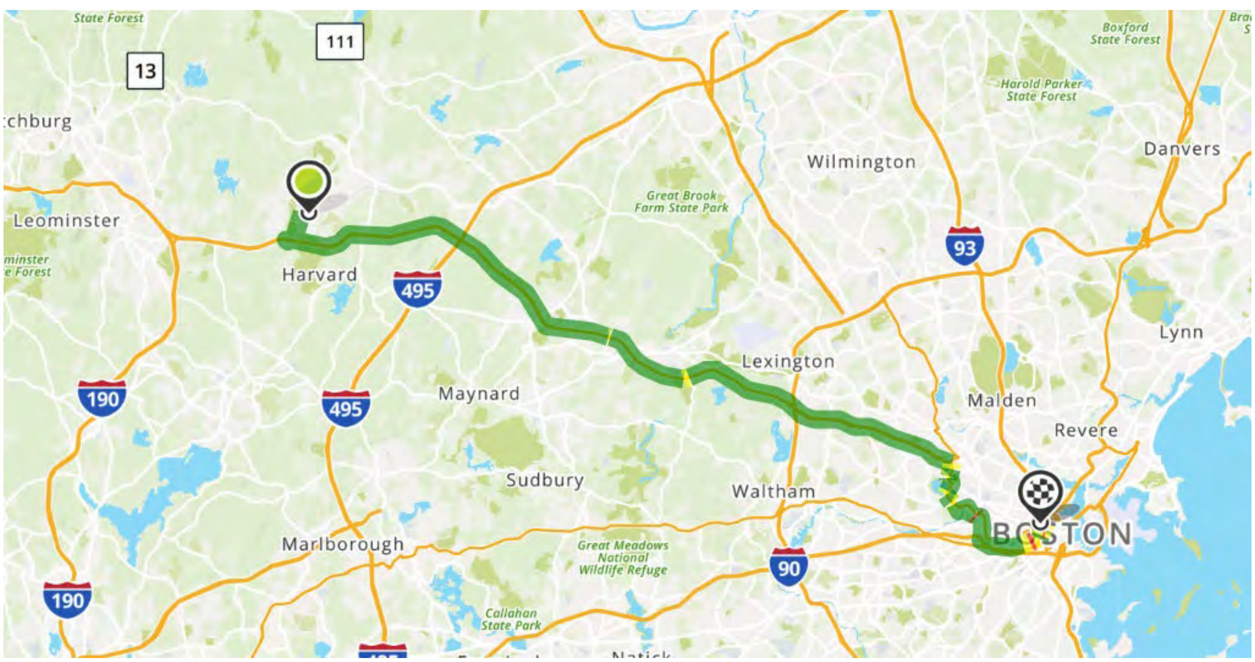

Figure 7-2. Emergency Route to Ft. Norma Knight Hyperbaric Medicine Center from Fort Devens

7.3 EMERGENCY EQUIPMENT

7.3.01 A means of routine and emergency communication (waterproof cellular telephone) for contacting emergency services will be immediately available onboard the dive team vessel and each support vessel. Each vessel will have a marine radio with Channel 16 and other designated channels for routine communication. Working radio and cellular telephone communications will be verified in the field at the start of the project and daily.

- A copy of this Dive Operations Plan will be immediately available on the dive vessel during diving activities. Emergency numbers in Table 7-1 will be posted in each vessel and the location known to all team members.
- A first aid kit meeting the requirements of American National Standards Institute Z308.1 and any appropriate optional fill contents based on the hazard assessment will be available in dive support locations (e.g., on the dive vessel or support vessel).
- An oxygen resuscitation system that contains a pocket mask with oxygen inlet, nonrebreather mask, demand inhalator, and/or demand resuscitator capable of delivering oxygen for a minimum of 30 minutes at 15 liters per minute or until emergency medical assistance can be administered.
- A throw bag and/or life ring buoy [Type IV personal floatation device (PFD)] (on support vessel) will have at least 90 feet of line.
- A buoy will be attached to the diver for observation by vessel-based dive team personnel.
- A stokes litter or backboard with floatation capability equipped with at least four body straps, snap buckles, and a head block.
- A device will be used that minimizes the possibility of entanglement of the diver's tether in the propeller of the vessel.
- All safety equipment for the vessel will be as required by the U.S. Coast Guard and EM 385-1-1 as outlined in the Boating Instruction located in Appendix B . The small boat inspection checklist will be followed for performing the daily vessel inspection as outlined in the instruction.
- Dive team members who are onboard the dive vessel will wear a Type II or better (or auto-inflatable PFD based on the hazard assessment) unless they are equipped with and are wearing the full dive ensemble as standby diver.

8.0 FIELD PERSONNEL REVIEW

8.01 This form serves as documentation that field personnel have read and understand the provisions of this Dive Operations Plan. This record of review will be maintained on-site by the UXOSO as a project record. All dive team members will sign this form prior to commencement of diving operations. In addition, the APP and all pertinent AHAs will be reviewed and signed by all team members prior to beginning work.

"I have read and I understand the information contained in this Dive Operations Plan for the Military Munitions Investigation to be conducted in the Nashua River. I will comply with the provisions contained herein."

Name (Print and Sign)	Date
______________________________	____________
______________________________	____________
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9.0 REFERENCES

OSHA. Standard 29 *Code of Federal Regulations* (CFR) 1910.120, 29 CFR 1910 Subpart T – Commercial Diving Operations.

USACE. 2014. Safety and Health Requirements. Engineer Manual (EM) 385-1-1, November 30.

APPENDIX A

DSP-1, DIVE SAFE PRACTICE MANUAL

TETRA TECH

Diving Safe Practices Manual

April 2022

Safety Excellence

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REVISION RECORD

Revisions to this document will be reviewed and approved through the same level of authority as the original document. The marine operations program manager must authorize all changes made to the Diving Safe Practices Manual (DSPM). At a minimum, annual reviews of the DSPM will be conducted to ensure the manual's adequacy and applicability. Revisions or changes will be documented and summarized below.

Revision	Date	Pages Affected	Reason	Authorized By
Rev 0	April 15, 2019	All	Issued for Tetra Tech Munitions Response Operating Unit.	Scot Wilson
Rev 1	February 15, 2021	All	Annual Review.	Scot Wilson
Rev 2	April 29, 2022	All	Annual Review.	Scot Wilson

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ABBREVIATIONS AND ACRONYMS

ACDE	Association of Commercial Diving Educators
ACFM	actual cubic feet per minute
ACS	air control system
ADCI	Association of Diving Contractors International
AED	automated external defibrillator
AGE	arterial gas embolism
AHA	activity hazard analysis
ANSI	American National Standards Institute
Army	U.S. Army
ATA	atmosphere absolute
CFR	Code of Federal Regulations
CRL	corporate reference library
CPR	cardiopulmonary resuscitation
DCS	decompression sickness
DDC	district diving coordinator
DDESB	Department of Defense Explosives Safety Board
DOP	diving operations plan
DOT	Department of Transportation
DPIC	designated person in charge
DRB	diving review board
DS	diving supervisor/ field operations lead
DSO	diving safety officer
DSR	diving safety representative
DSPM	diving safe practices manual
EM	engineers manual
ESSQ	environment, safety, security and quality
FFW	feet of freshwater
FSW	feet of seawater
HAZWOPER	hazardous waste operations and emergency response
HASP	health and safety plan
MEC	munitions and explosives of concern

ABBREVIATIONS AND ACRONYMS (Continued)

MMRP	military munitions response program
NIOSH	national institute for occupational safety and health
NOAA	national oceanographic and atmospheric administration
NOSSA	naval ordnance safety and security activity
OSHA	occupational safety and health administration
PFD	personal flotation device
PPM	parts per million
PSI	pounds per square inch (gauge)
SSA	surface-supplied air
SADS	surface air delivery system
SCUBA	self-contained underwater breathing apparatus
SDS	senior diving supervisor
SHM	safety and health manager
SOP	standard operating procedures
SSHO	site safety and health officer
SUXOS	senior UXO supervisor
TP	technical paper
TMR	Tetra Tech Munitions Response
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USN	U.S. Navy
U.S.	United States
UXO	unexploded ordnance

1.0 PURPOSE

This Tetra Tech Munitions Response (TMR) Diving Safe Practices Manual (DSPM) provides TMR employees and subcontractors with the requirements and guidance for conducting safe diving operations. Contractors working directly for the client will be required to have safe practices that meet or exceed the requirements of this manual while operating or using TMR-owned or leased equipment or property.

This manual ensures TMR diving operations meet and/or exceed the requirements of federal and state agencies. The project management team, designated dive supervisor/lead divers, project quality managers, and site safety and health officers (SSHOs) will ensure compliance with Occupational Safety and Health Administration (OSHA) regulations and standards by implementing these procedures during dive operations.

This manual was prepared in accordance with the OSHA regulations. Federal, state, and local regulations were also considered during the preparation of this manual. If a conflict arises between the current edition of this manual and applicable or updated federal or other legal directives or statutes, the latter shall always take precedence.

2.0 FEDERAL AND STATE STANDARDS REQUIREMENTS

This manual was developed using guidelines, procedures, rules, and regulations from the following government and civilian agencies:

- OSHA
- United States (U.S.) Army Corps of Engineers (USACE)
- The Association of Diving Contractors International (ADCI)
- U.S. Navy (USN)
- U.S. Coast Guard (USCG)
- U.S. Army (Army)
- National Oceanographic and Atmospheric Administration (NOAA)

This manual provides the **minimum regulatory standards** for team composition, diving procedures, equipment maintenance, and operations.

3.0 SCOPE

This document contains procedures applicable to all TMR projects involving underwater operations that use divers or snorkelers to perform work or support scientific research projects. The procedures in this document shall meet the requirements in 29 *Code of Federal Regulations* (CFR) 1910.401, Subpart T. Requirements that are not specifically included in this DSPM will be included in the project specific Diving Operations Plan (DOP) which is part of the project specific Health and Safety Plan (HASP).When contracted to dive for clients who mandate following USACE standards, additionalequipment, procedures, and review requirements will be addressed in the project specific DOP.

The specific requirements are identified in Section 30 of USACE Engineers Manual (EM) 385-1-1, Safety and Health Requirements Manual. If there are any conflictsbetween this manual, OSHA, and/or federal and state/ local regulations, the **most stringent regulations will take precedence**, provided site safety is not compromised. All conflicts will be detailed, with procedures provided in the project specific DOP.

4.0 REVISIONS

A review of this manual will be conducted annually. Revisions will be periodically completed based on new advances in diving practices, technological advances, changes in regulations, methods, and the procurement of new diving systems or equipment.

5.0 DIVING REVIEW BOARD

The Marine Operations Program Manager is designated the Chairman of the TMR Diving Review Board (DRB) and is responsible for updating this manual. The Diving Safety Officer (DSO) will maintain the qualification records of personnel approved for diving and will recommend approval of all other divers (including subcontracted divers) involved with TMR projects to the chairman. The Senior Diving Supervisor (SDS) is responsible for the operational readiness of the TMR dive equipment and supporting assets. The SDS also provides supervision of the TMR divers, makes recommendations to the Chairman for dive staff assignments.

6.0 GENERAL RESPONSIBILITIES

This manual will be reviewed by the Chairman, DSO, and the TMR senior diving supervisor (SDS) for technical content involving TMR diving. They will ensure diving operations are conducted in a safe and efficient manner throughout the company. Their responsibilities include:

- Review existing policies and procedures to ensure safe, effective diving operations.
- Develop recommendations to improve diving operations.
- Review and discuss diving accident report releases by various sources and ensure the distribution of copies to Dive Team members.
- Review any TMR near-miss or actual diving mishaps and develop procedures and policies to prevent future occurrences.
- Ensure that the TMR dive program conforms to all the guidelines in this DSPM, as well as all applicable federal, state, and local laws and regulations.
- Coordinate proper recordkeeping for diving personnel, diving operations, and dive equipment maintenance.
- Coordinate periodic diver training and safety programs as needed.
- Review, prior to approval, prospective TMR dive operations that use non-standard diving modes and procedures or carry above average risk.

- Review the qualifications and performance of all divers and potential Diving Supervisors/ Lead Divers.
- Stay updated on new safety procedures, as well as OSHA, USN, USCG, USACE, and ADCI requirements.
- The Quality Department will review this manual for compliance with appropriate laws and regulations.
- Approval authority rests with the TMR President, with review by the Marine Operations Program Manager.
- The Chairman of the DRB will be responsible for all required corporate recordkeeping in accordance with this manual, and maintenance of all identified references.
- For unexploded ordnance (UXO) diving operations, the Marine Operations Program Manager will review and approve all TMR employees and subcontractor personnel involved in UXO diving.

The DSPM will never substitute for prior planning, sound judgment, and a continuing concern for maximum safety. Safety is not a rulebook; it is a state of mind and must be continually maintained in our workplace culture. However, not all circumstances or situations can be explained and detailed in this DSPM. For this reason, TMR only recommends deviating from these guidelines when, in the opinion of the diving supervisor/ field operations lead (DS), an emergency exists where the health and safety of personnel is a concern. The DS will have final authority regarding safe conditions at the dive site. A written event report will be submitted to the Chairman of the DRB within 48 hours of the deviation from the DSPM to document possible changes to this manual and conformation to OSHA and other regulatory requirements.

6.1 Waiver of Requirements

The DRB may grant a waiver for specific requirements of training, examinations, and minimum activity to maintain certification.

6.2 Marine Operations Manager/Chairman, DRB

The Marine Operations Program Manager is the Chairman of the TMR DRB. The DRB is composed of the Chairman, the DSO, and the SDS. The Chairman of the DRB is responsible for managing the TMR Diving Program in conjunction with the assigned board members; they will maintain the diving logs and references as required by OSHA in 29 CFR 1910.401, Subpart T. The DSO will maintain qualifications and physical records for all TMR divers in conjunction with the military munitions response program (MMRP) Field Operations Manager. The Chairman will review and approve divers, including subcontractors who are assignedto individual projects. The chairman identifies DSs. Upon concurrence of the DRB, the chairman forwards the recommendations to the TMR management team who officially assigns them to the position in writing.

6.3 DSO/DRB Member

The diving safety officer (DSO), as a permanent DRB member, is responsible for the safe conduct of UXO and construction diving operations. The DSO is responsible for the appropriate diver training and qualifications for UXO operations. The DSO will submit to the Chairman the names of qualified UXO divers to be certified by TMR to work on TMR projects. The DSO will maintain a recent copy of the USN Diving Manual. OSHA, USACE, USCG, American National Standards Institute, applicable local regulations and the Association of Diving Contractors International Consensus and Technical Standards.

The DSO will make these manuals available to the diving supervisors as required.

6.4 SDS/DRB Member

The senior diving supervisor (SDS) will be a senior TMR diver designated by the Chairman and will be a permanent member of the DRB. The SDS is responsible for the operational readiness of the TMR dive equipment and supporting assets. The SDS will supervise a designated diving equipment maintenance technician. The diving equipment maintenance technician and other personnel needed to support program readiness will be approved by the Chairman and TMR management team as needed and are not permanent staff members. The SDS provides supervision of the TMR divers and makes recommendations for dive staff assignments. The SDS is the subject matter expert for development of new diving procedures, technology, and capabilities.

6.5 Senior UXO Supervisor

A senior UXO supervisor (SUXOS) will be designated, in writing by the TMR field operations management team to projects that have both a UXO removal/investigation requirement and a diving requirement. The SUXOS will coordinate all ordnance response requirements and establish safe proceduresfor the investigation and removal of all UXO hazards.

On larger operations involving both diving and UXO operations, the DS will normally supervise diving, and the SUXOS will oversee the UXO response. The same person can serve as SUXOS and DS,if that person has both qualifications on smaller projects. The SUXOS shall be a qualifiedTMR environmental safety supervisor person in accordance with the guidelines outlined in Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP) 18, Reference (e).

6.6 Diving Supervisor/ Lead Diver

The diving supervisor (DS) will be designated in writing as the Designated Person in Charge (DPIC) for each diving operation. This designation is based on knowledge, experience, and level of training. The DS is the DPIC of the overall diving operation and is responsible for the planning and execution of the dive, as well as the safety and health of the dive team. The DS will be a qualified TMRqualified SUXOS. In carrying out these duties, their responsibilities will include, but will not be limited to:

- Ensuring that all dive team members who are exposed to, or control the exposure of others to, hyperbaric conditions will be trained in diving-related physics and physiology.
- Ensuring that each dive team member will be assigned tasks in accordance with the employee's experience or training. Limited additional tasks may be assigned

to an employee undergoing training, provided that these tasks are performed under the direct supervision of an experienced dive team member.

- Ensuring that a dive team member will not be required to be exposed to hyperbaric conditions against the employee's will, except when necessary to complete decompression or treatment procedures.
- Ensuring that a dive team member will not be permitted to dive or otherwise be exposed to hyperbaric conditions for the duration of any physical impairment or condition which is known and is likely to adversely affect the safety or health of a dive team member.
- Investigating and evaluating each incident of decompression sickness based on the recorded information, consideration of the past performance of decompression table used, and individual susceptibility.
- Taking appropriate corrective action to reduce the probability of or recurrence of decompression sickness.
- Preparing a written evaluation of the decompression procedure assessment, including any corrective action taken, within 10 days of the incident of decompression sickness.
- Being fully aware of all relevant governmental regulatory agency regulations that apply to the diving operation and the diving mode employed.
- Being in immediate control and available to implement emergency procedures during diving operations. The dive supervisor/lead diver is not permitted to dive unless another qualified person is present and has been formally appointed and designated to assume this responsibility.
- Ensuring, prior to diving, that all additional parties are informed that diving operations are about to be undertaken. These parties include, but are not limited to, craft masters, boat pilots, harbormasters, managers of pipelines, and managers for civil engineering sites and inland waterways.
- Ensuring that diving operations are conducted from a suitable and safe location on the surface.
- Establishing a project specific DOP, and ensuring that sufficient air supply, supplies, and proper equipment are available for the safe and timely completion of the job task. This must be approved by the TMR DRB prior to conducting any diving evolution.
- Briefing the dive team as to the plan of attack, and soliciting suggestions outlined in Attachment 1, Diving Supervisor Dive Plan Brief, native file format located in the Guidelines Templates and Tools folder in the Corporate Reference Library (CRL). During the briefing, they will make team assignments, designate required equipment, review diving signals, establish a positive diver recall method, and cover emergency procedures.
- Using the TMR Diving Supervisor Pre-Dive and Post-Dive Checklists (see Attachments 2, Diving Supervisor/Lead Diver Pre-Dive Checklist, and 3, Diving Supervisor/Lead Diver Post-Dive Checklist, which are also available in the native file format located in the Guidelines Templates and Tools folder in the CRL

- Ensuring all members of the diving team are familiar with the emergency procedures contained in the Emergency Procedures (see Attachment 4, which is available in the native file format located in the Guidelines Templates and Tools folder in the CRL).
- Being aware of the procedures to follow and the routes to take to obtain medical support in the event of an accident, either diving- or non-diving-related.
- Ensuring that a two-way communication system is available and tested.
- Ensuring that the Emergency Phone Numbers Checklist (see Attachment 5, which is available in the native file format located in the Guidelines Templates and Tools folder in the CRL) is completed and posted at the dive site.
- Determining the qualifications and proficiency of all personnel and ensuring that no dives are made by unqualified persons.
- Verifying that all equipment required is on scene and in working order.
- Ensuring that all relevant operating instructions, manuals, decompression schedules, treatment tables, and regulatory publications are available on the dive site.
- Maintaining a dive profile log for each diver, which includes depth, bottom time, and residual nitrogen time (see Attachments 6 and 7, which are also available in the CRL).
- Terminating diving operations at any time when, in their opinion, safe diving procedures are not being followed or conditions prevent safeguarding the divers. The diving supervisor/lead diver will not resume diving operations until the unsafe conditions have been removed or corrected.
- Ensuring that, after every dive, the Post-Dive Checklists in Attachment 3, which is available in the native file format located in the Guidelines Templates and Tools folder in the CRL, are used.
- Ensuring that, after any treatment or unplanned dive conducted outside the no-decompression limits, the diver is instructed to stay awake and remain in the vicinity of the chamber for at least 1 hour.
- Reporting all accidents or incidents involving personnel as required by TMR procedures and relevant governmental regulations.
- Ensuring all reports and paperwork are completed and submitted at the end of the diving day.
- Maintaining certification in cardiopulmonary resuscitation (CPR), first aid (American Red Cross or equivalent), automated external defibrillator (AED), and emergency oxygen administration.

6.7 Divers and Snorkelers

Divers must be at least 18 years of age, be medically certified as "fit to dive," this statement must be in writing by a qualified physician on the diver’s final medical clearance cover sheet. They must have a knowledge of diving theory, diving-related physics, and physiology. They will provide copies of their certifications to the DRB before being allowed to dive. On divingprojects involving UXO operations, the minimum age of the diver must be 21 years, they must be cleared by the Bureau of Alcohol, Tobacco, Firearms and Explosives per regulation concerning the handling of explosives.

Divers must have a full understanding of the diving equipment in use, and of the tasks assigned. A diver is assigned by the DS to perform specific tasksunderwater and topside. The diver must be qualified for the diving technique, equipment selected, and the task assigned. Each diver will meet the following requirements:

- Know how to use the tools, equipment, and systems relevant to assigned tasks.
- Know the techniques of the assigned diving mode.
- Accomplish all tasks assigned by the DS. If the diver is assigned a task for which they do not consider themselves to be qualified either by training or experience, the diver will immediately inform the DS.
- Read, understand, and comply with all TMR policies and with applicable government regulations as they relate to their qualifications or performance while engaged in diving.
- Maintain a high level of physical fitness.
- Immediately obey all commands or instructions from the DS return to the surface, or first decompression stop, as appropriate.
- Keep topside personnel advised of conditions on the bottom.
- Be responsible for the diving gear worn and ensure that it is complete, in good repair, and ready for use at any time in accordance with regulations or instructions concerning its use, maintenance, repair, and testing.
- Report to the DS any defect or malfunction of the diving equipment provided for the diving operation.
- Ensure the deepest depth of the dive has been established before ascent.
- Report to the DS any recent medical treatment or illness so that the proper determination can be made concerning the diver's fitness to dive.
- Immediately report all symptoms or suspected symptoms of decompression sickness as early and accurately as possible.
- Always follow safe diving practices during the diving operation, whether topside or in the water. The diver will bring any questionable items to the attention of the DS diver and will be alert for the safety of all.
- Remain awake and in the vicinity of the decompression chamber for at least one hour following recompression treatment or a hyperbaric exposure beyond no-decompression limits.
- Know and observe the rules for ascending to altitude, including flying after diving.
- Ensure that their diving equipment has been properly maintained, prepared, and tested before each dive. This requirement should never be delegated to others.
- Maintain a divers' logbook, which details all dives, medical examinations, courses taken, and personal equipment maintenance.

- Ensure their medical certificates are up to date and recorded in the diving logbooks. Divers will present their logbooks to the diving supervisor/lead diver at every job when requested.
- Ensure that they are not exposed to hyperbaric conditions against their will, except when necessary to complete decompression or treatment procedures.
- Maintain certification and demonstrate hands on proficiency in CPR, First Aid, AED, and emergency oxygen administration as outlined in the regulatory guidelines.

A diver may refuse to dive, without fear of penalty, whenever they feel it is unsafe for them to make the dive. It is the diver's responsibility and duty to refuse to dive if, in their judgment, conditions are unsafe or unfavorable, or if they would be violating the precepts of their training, abilities or the regulations and guidelines in this manual or the project DSPM.

6.8 Standby Diver

The standby diver is a fully qualified diver, assigned as a safety contingency to provide emergency assistance, and is ready to enter the water when conducting diving operations. When assigned during buddy diving, where two divers are conductingthe dive together, they will be ready to enter the water prior to commencing the dive, and then may remove tank, mask, and fins at the DS's discretion.Under no circumstances will they leave the dive site. The standby diver receives the same briefings and instructions as the working divers, wears the same diving equipment,monitors the progress of the dive, and is fully prepared to respond if called upon for assistance. While acting as a standby diver, **in addition to** the requirements listed above,the standby diver will:

- Be rested and fully capable of performing emergency rescue assistance.
- Be sufficiently free of residual nitrogen to allow for enough bottom time for the prescribed task at the working depth without exceeding the no-decompression limits for that depth.
- Be dressed appropriately to allow prompt entry into the water as directed by the DS.
- Remain at their station throughout the entire dive.
- Refuse any tasks that might interfere with their duties as a standby diver whenever there is a diver in the water.

6.9 Dive Tender

The tender is a member of the dive team who works most closely with the diver on the bottom. Though it is preferred that the tender be a qualified diver, it is not mandatory. If the tender is not a qualified diver, they must be familiar with line pull signals and all emergency procedures. The tender is assigned by the DS to continuously tend (monitor) the diver. There may be multiple tenders assigned to a diving station. They will devote their full attention to tending the diver or station they are assigned to, from preparation of the dive through its completion. They will not be assigned any other task while the diver is in the water. The tender shall further:

- Assist the diver in dressing and undressing and confirm that the diver's equipment is functioning properly.
- Always tend the diver’s safety line and be aware of the diver’s depth and location.
- Set up and operate all equipment as directed by the DS.
- Immediately inform the DS if they are assigned a task for which they do not consider themselves qualified either by training or experience.
- Be alert and immediately report any conditions that are hazardous or unsafe.
- Assist in topside work as required or directed.
- Maintain certification in CPR, first aid, AED, and emergency oxygen administration.

  Maintain certification and demonstrate hands on proficiency in CPR, First Aid, AED, and emergency oxygen administration.

7.0 DIVING POLICY

It is the policy of TMR to consistently provide safe diving operations that meet the client’s required level of work and that are following applicable laws and regulations. This work shall be consistent with the project-defined scope, schedule, budget, and level of quality. To accomplish this objective, TMR will provide the appropriate qualified personnel, resources, and guidance to the Operating Units where diving operations are required. Such resources may include specialized diver expertise that may be in another office, or corporate affiliate, or maybe subcontracted to an appropriate subcontractor.

This DSPM addresses procedures for the safe utilization of self-contained underwater breathing apparatus (SCUBA) and surface-supplied air (SSA) diving operations. Surface air delivery system (SADS) operations are covered under TMR SCUBA procedures. Mixed-gas diving is not authorized for employees of TMR covered under these procedures. All dives will be planned to adhere to the Standard Air, No Decompression, or Shallow Water dive tables set forth in the USN Diving Manual, refer to Attachment 10, available in the Guidelines Templates and Tools folder in the CRL.

The individual local or state requirements will be reviewed and incorporated into the project specific DOP. This review will be performed prior to commencing any diving operations within the affected state. Prior to diving, the project specific DOP must be approved by the Chairman of the TMR DRB for UXO and construction diving or the Tetra Tech scientific DSO for scientific diving, with the approved copy forwarded to and retained by the TMR Chairman of the DRB.

8.0 SCIENTIFIC DIVING

Scientific diving will be conducted in accordance with Tetra Tech Corporate Safety DCN 02-15 Scientific Diving Program[1] in the Corporate Health and Safety Manual. If scientific diving operations are conducted using TMR diving systems and oversight by a TMR DS

[1] https://tetratechinc.sharepoint.com/:b:/r/sites/Health-Safety/Health%20%20Safety%20Manual/02_General%20Health%20and%20Safety%20Programs/DCN%2002-15%20Scientific%20Diving%20Program.pdf

is required (e.g., UXO escort operations) or tasking involves intrusive diving operations in a UXO environment, the procedures outlined in this manual, project specific DOP and applicable underwater UXO standard operating procedures will be followed.

9.0 REQUIREMENTS FOR DIVING AND SNORKELING

9.1 General Requirements

The requirements presented in this section will be used in conjunction with procedures and requirements for individual dive techniques presented in the following sections of the DSPM. All dives will be executed under the regulations and guidelines outlined in Section 2.0.

- The qualifications of personnel and equipment requirements for snorkeling are the same as diving, except for the required air supply for diving.
- A ladder extending a minimum of 3 feet below the diving platform below the surface of the water and appropriate handrails will be provided to assist the diver on entry and exit from the water. (*Note: Inflatable boats are exempt from this requirement.*)
- A means will be provided to assist an injured diver from the water.
- When diving from vessels, the international code alpha and recreational dive flag with a minimum dimension of 23 square inches will be displayed whenever diving operations are being conducted. The flag will not be removed until diving operations have been completed and all divers are safely out of the water. TMR divers will comply with all site-specific local, state, federal, and international regulations regarding marking of diving activities.
- For enclosed areas, i.e., Intracoastal Waterway or marinas, individual buoys with recreational diver flags will mark the outline of the diving area. The divers may have a "marker" buoy with the recreational dive flag to determine their exact location. A rigid replica of the International Code Alpha flag at least 1 meter in height and visible from all directions will be displayed at the dive location.
- A diver will be stationed at the underwater point of entry when diving is conducted in enclosed or physically confining spaces.
- Positive communications to the recompression facility, the designated medical facility, and any required transportation to these facilities (medivac, ambulance, etc.) will be checked daily. This communication will include cellular telephone or radio communications with a constantly manned location with telephone access at the dive site. Diving operations will not be conducted without established communications.
- The DS will not be permitted to dive unless another qualified supervisor is present and has assumed the DS roles and responsibilities.

9.2 Snorkeling Requirements

TMR employees engaged in snorkeling operations will comply with the general requirements for diving and the following additional requirements, unless otherwise specified in a project specific and approved DOP:

- Snorkeling will be conducted only with prior approval and acceptance of the district diving coordinator (DDC) and/or the TMR DSO.
- Snorkeling will be allowed only for shallow water site assessments and reconnaissance. It will not be used for structural inspections or other work.
- An on-site snorkeling team shall be made up of no less than two persons: snorkeler and observer/assistant. Additional site personnel may be required by the DDC or DSO based on site hazards and conditions. Snorkeling team plans and procedures shall be developed and enacted by a team supervisor who is qualified and experienced in snorkeling and incorporated in the DOP.
- Snorkeling will only be done on the surface of the water. Breath-hold or free diving of any kind is not permitted.
- Generally, untethered snorkeling will NOT be allowed in waters deeper than 5 feet of seawater (FSW), in bodies of water that a snorkeler cannot wade across, or anywhere a differential in pressure threat may exist.
- Snorkeling in open waters greater than 5 feet deep may be allowed by the DDC, based on an acceptable Activity Hazard Analysis (AHA) and compliance with the following:
  - Any requirements incorporated in the approved DOP.
  - A single snorkeler shall be tethered with a harness and a maximum of 40 FSW of floating line. The tether must be constantly tended from the shore or boat.
  - The snorkeler must wear a device providing a minimum of 15.5 pounds of positive buoyancy (Type III personal flotation device [PFD], fully inflated snorkeling vest, etc.).
  - There are no potential tether entanglement hazards in the snorkeling area (e.g., overhanging branches, surface stumps, rocks, etc.).
- All snorkelers and observers/assistants will be certified as skin divers (snorkelers) or open water divers by a nationally recognized organization (e.g., Professional Association of Diving Instructors, National Association of Underwater Instructors, etc.) or the U.S. Forest Service Snorkel Safety Program.
- An observer/assistant will always accompany each untethered snorkeler either along the shore or in a boat and be within 50 feet of the snorkeler.
- Two untethered snorkelers in the same body of water may act as observer/assistant for each other if they remain within 50 feet of each other.
- Non-snorkeling observer/assistants shall wear a PFD and be equipped with a throw bag and/or ring buoy with at least 70 FSW of line and must be capable of performing a rescue on the specific snorkeler(s) in an emergency.
- Areas of extreme water velocity and turbulence will be avoided, especially those immediately upstream from debris jams or bedrock outcrops.
- Snorkelers will be provided with appropriate thermal protection.
- Employees will be determined medically fit by a licensed physician (doctor of osteopathy or medical doctor) prior to snorkeling. This certification shall be signed by a physician familiar with sports medicine, and state that each snorkeler is

physically and medically fit to perform snorkeling activities according to commonly accepted sports medicine guidelines.

- All snorkeling team members shall be certified in first aid and CPR. Certification shall be in accordance with most recent emergency cardiovascular care guidelines, and/or American Heart Association or American Red Cross standards.
- A first aid kit will be available at each location where snorkeling is being performed. A means of securely transporting an unconscious person, such as a litter or stretcher, shall be provided when snorkeling is conducted in areas inaccessible to vehicles or boats.
- A means of communication capable of contacting emergency services must be available at locations where snorkeling is performed.
- Each snorkeler will be equipped with a professional grade mask, fins, snorkel, and snorkeling vest.
- A snorkeling protocol will be developed and included in the project DOP. It will contain as a minimum, the following:
  - An AHA for each specific snorkeling mission (Particular detail will be given to currents and other environmental considerations.)
- Records for snorkeling activities will be maintained and will include as a minimum:
  - Snorkeler’s annual physician certifications
  - AHAs
  - A snorkeling plan incorporated in the DOP that is based on the requirements of USACE EM 385-1-1; Section 30.A.15.a-e
- Snorkelers will wear apparel which provides appropriate protection from environmental conditions. The apparel must include fins or other appropriate foot protection.

9.3 SCUBA / SADS Diving Requirements

TMR employees engaged in SCUBA diving operations will comply with the general requirements for diving and the following additional requirements, unless otherwise specified in a project specific and approved DOP:

- The minimum sized SCUBA tank allowed as primary air is a standard 80 cubic-foot aluminum tank pressurized to at least 90 percent, or 2,700 pounds per square inch (PSI) at the beginning of dive operations.
- Divers shall terminate their dive so that they reach the surface with a minimum tank pressure of 500 PSI.
- Audio communications are preferred in all diving situations. However, this type of communication is not required for a diver who is accompanied by another diver (buddy), or who can communicate with the tender on the surface via a safety line using line pull signals.
- The planned time of such a diving operation will not exceed the no decompression limits according to the USN Dive Manual, or the air supply duration of the cylinders in use, exclusive of the reserve supply. The cylinder pressure will be determined immediately before each dive.

- Each diver will be equipped with a knife, a diving wristwatch, a depth gauge or dive computer, a facemask, a submersible cylinder pressure gauge, and a buoyancy compensator.
- A weight belt or integrated weight system with a quick release that is appropriate for the suit and the depth of the dive will be worn.
- A cylinder harness with a quick release will be worn to secure the SCUBA cylinders to the diver.
- The weight belt and cylinder harness will be independently attached to permit release of either one without interference by the other.
- A personal flotation or buoyancy compensation device will be worn. An exception will be considered during approval of the DOP for diving in enclosed spaces or under the ice.
- SCUBA diving operations will not be conducted at depths deeper than 100 feet.
- DSO or DDC exemption approval is required for dives to any depths from 100 feet to 130 feet, and if approved, a recompression chamber must be available on site and within 5 minutes of reaching the surface.
- During all SCUBA dives, a standby diver will be available while a diver is in the water.
- A SCUBA diver will be line-tended from the surface or accompanied by another diver in the water in continuous visual contact during the diving operations. If any SCUBA diver is tended, they will wear a harness meeting the following standard:
  - Each tethered SCUBA diver shall wear a safety harness with a positive buckling device, attachment point for the safety line, and a lifting point to distribute the pull force of the line over the diver's body while maintaining the body in a heads-up vertical position when unconscious.
- A diver-carried independent reserve breathing gas supply consisting of the following will be provided for each diver:
  - Each diver shall be equipped with a minimum 30 cubic-foot bailout bottle for emergency use pressurized to at least 90 percent of its working PSI rating and equipped with a separate first- and second-stage regulator. An "octopus" is not considered to be an alternate air source.

SADS – This system is a configuration of the SCUBA diving system. It is used for very shallow water operations performed in water **not to exceed 3 feet**. The SCUBA diving requirements listed above are applicable for all SADS diving operations.

9.4 Surface-Supplied Air Diving Requirements

Employees engaged in SSA diving will comply with the general requirements for diving, and the following additional requirements, unless otherwise specified in a project specific and approved DOP:

- The approximate depth of each dive will be determined prior to the start of operations.
- A weight belt appropriate for the suit and depth of the dive will be worn, except when conditions dictate otherwise for the safety of the diver.

- A five-point safety harness, with a positive buckling device, will be worn under all other types of equipment (*except when diver is dressed in heavy gear*). This harness will have an attachment point for the umbilical to distribute the weight of the diver's body and prevent any strain from being placed on the diver's mask or helmet if/when the umbilical is pulled on. The safety harness will also have a lifting point to distribute the pull force of the line over the diver's body. The safety harness may be equipped with a backpack to contain a bailout bottle.
- SSA dives will not exceed 190 FSW and will not enter exceptional exposure dives as set forth in the USN standard air decompression tables.
- A decompression chamber will be ready for use on site for any dive outside the no-decompression limits or deeper than 100 FSW.
- Each diver will be continuously tended by another dive team member while dressed on the side and while in the water.
- A diver will be stationed at the underwater entry point when penetration diving is conducted in enclosed or physically confining spaces.
- A standby diver will be available while a diver is in the water.
- Each diver will have a primary air supply capable of supplying the diver(s) with the specified air volume, pressure, and flow rate, in accordance with the manufacturer's specifications associated with the diving apparatus worn, throughout the planned depth of the dive, including any required decompression.
- Each dive location air control systems (ACS) will have a reserve breathing air supply, in line, capable of supporting the dive operation.

  Each diver must have a reserve breathing supply available that can be turned on immediately by the diver in the event of loss of air. The reserve breathing air supply shall be of sufficient capacity to recover the diver and complete emergency recompression (if required) in the event of loss of primary air but no less than 30 ft^3 (0.85 m^3). Heavy-gear diving is exempted from these provisions because the gear carries its own reserve.
- On all dives deeper than 100 FSW or outside the no-decompression limits, an extra breathing gas hose capable of supplying gas to the diver in the water will be available to the standby diver.
- On all dives deeper than 100 FSW or outside the no-decompression limits, an in-water stage will be provided.

10.0 DIVER TRAINING AND QUALIFICATIONS

The following section describes the minimum requirements for TMR divers. Additional training may be needed for site-specific conditions, or as required under federal, state, or local regulations.

The level of experience or training required by the standard depends on the job the employees are required to do. All dive team members must have either experience or training in the use of tools, equipment, systems, techniques, operations, operational procedures, and emergency procedures that are pertinent to, and necessary for, the assigned tasks for the diving mode.

It is essential that those dive team members who are exposed to hyperbaric conditions, or those members who control the exposure of others, have knowledge of the physiological effects of diving and the related effects of pressure. Accordingly, this standard also requires that employees be trained in diving-related physics and physiology. Employee qualifications achieved through field experience and classroom training may be used to meet the requirements of the standard.

- Divers must have federal training certificates (USACE, NOAA, and/or military diving schools) or civilian diving school certificates of completion for the appropriate training level issued by any ANSI/ACDE accredited schools.
- Each dive team member must be trained and demonstrate hands on proficiency in CPR (American Red Cross orequivalent), first aid, AED, and emergency oxygen administration.
- Each member of the TMR diving team will be qualified to conduct the work assigned by completion of training and/or experience. This qualification will be documented by completion of a certified course of instruction, to include one or more of the following: a certified commercial course (Association of Commercial Diving Educators accredited), a civilian certification with experience for the profile of the dive, or a documented military diver training and experience.
- All divers will maintain a personal dive log that will document all hyperbaric exposures. Additionally, dates of diving physicals and a record of all relevant training will accompany the log. The following minimum information should be included in the log:
  - Location of exposure
  - Maximum depth
  - Time left surface, total bottom time, and time reached surface
  - Type of breathing apparatus and mixture used
  - Task performed
  - Decompression table and schedule used
  - Any decompression sickness symptoms or injury
  - Signature of the DS
  - Comments

10.1 Entry Level Tender Training

All TMR non-divers who have the required skills and training to participate in diving-related activities must be trained and certified by qualified TMR diving personnel or an internationally recognized agency.

10.2 SCUBA Training

All TMR divers will provide a copy of their diver certification to the Chairman of the DRB that represents successful completion of a swimming evaluation, practical diver training, written examination, and open water evaluation. Scientific divers will also provide a copy of their diver certification to the DRB. The certificate from the training activity will be used to document the location and date of training. The dive log will document the depth and number of diving qualification dives.

10.3 Surface-Supplied Diver Training

The training certificate to document previous training and dive log to document the number of dives and depth of diving qualifications will be provided. Training dives will be required to ensure all divers are current in the type of equipment and the depth expected of the diving project.

11.0 PERSONNEL REQUIREMENTS

In establishing the number of dive team members required for a dive, proper consideration must be given to 29 CFR 1910.421(d), Planning and Assessment, and 29 CFR 1910.421(e), Hazardous Activities. The second provision requires employers to provide a means to assist an injured diver from the water, such as a small boat or stokes basket, which may necessitate additional dive team members.

11.1 Self-Contained Underwater Breathing Apparatus (SCUBA)

For diving that requiring the use of SCUBA and SADS, the minimum number of divers are required for the work:

Dive Team Composition SCUBA – Untethered, 0 to 100 FSW	
Personnel	**Number**
Diving Supervisor	1
Divers (in visual contact)	2
Standby Diver*	1
TOTAL TEAM	**4**

Dive Team Composition SCUBA – Tethered with communications, 0 to 100 FSW	
Personnel	**Number**
Diving Supervisor **	1
Diver in water	1
Standby Diver* (tethered with communications)	1
Tender	1
TOTAL TEAM	**4**

** The standby diver will be rested and capable of performing emergency rescue assistance. When work is limited to no decompression limits, the standby diver shall be sufficiently free of residual nitrogen to allow for 25 minutes of bottom time at the working depth without exceeding "No Decompression Limits."*

*** The supervisor may be the standby tender for dives under 100 FSW.*

11.2 Surface-Supplied Diving (0-100 FSW with no Decompression Diving)

For surface-supplied diving, from 0 to 100 FSW, the minimum number of divers required to perform the work is listed below:

Dive Team Composition Surface Supplied Air – 0 to 100 FSW Within No Decompression Limits		
Personnel	**Number**	**Penetration Dive**
Diving Supervisor *	1	1
Diver	1	2
Standby Diver**	1	1
Tender	1	2
TOTAL TEAM	**4**	**6**

** The supervisor may be the standby tender for dives under 100 FSW.*

*** The standby diver will be rested and capable of performing emergency rescue assistance. When work is limited to no-decompression limits, the standby diver shall be sufficiently free of residual nitrogen to allow for 25 minutes of bottom time at the working depth without exceeding "No Decompression Limits."*

11.2.1 Deploying the Standby Diver as a Worker Diver

The standby diver may be deployed as a working diver provided **all** the following conditions are met:

1) Surface-supplied no-decompression dive of 60 FSW or less;
2) Divers are in proximity, (based on site specific requirements), with unimpeded access to each other;
3) Divers always have communications with each other;
4) No entanglement hazards exist;
5) Prior to deploying the standby diver, the work area shall be determined to be free of hazards (i.e., suctions, discharges) by the first diver on the job site;
6) The dive is NOT a penetration or confined space dive; and
7) Each diver has a full-time tender (which brings the minimum number of team members to five).

11.3 Surface-Supplied Diving (Deeper than 100 FSW or decompression diving)

For surface-supplied diving deeper than 100 FSW, or decompression diving, the minimum number of divers required to perform the work is listed below:

Dive Team Composition Surface Supplied Air – 0 to 100 FSW Requiring Decompression All Surface Supplied Air, 101 to 190 FSW			
Personnel	**No Decompression Dives**	**Decompression Dives**	**Penetration Dives**
Diving Supervisor	1	1	1
Chamber Operator*	1**	1***	1
Diver	1	1	2
Standby Diver**	1	1	1
Tender	1	1	2
Standby Diver Tender	1	1	1
TOTAL TEAM	**5/6**	**5/6**	**8**

** The Competent Person/chamber operator may be any non-diving member of the dive team when the chamber is only for emergency use when diving within the no-decompression limits. Saturation diving requires that a life support technician will serve as the chamber operator.*

*** The standby diver will be rested and capable of performing emergency rescue assistance. When work is limited to no-decompression limits, the standby diver shall be sufficiently free of residual nitrogen to allow for 25 minutes of bottom time at the working depth without exceeding "No Decompression Limits."*

**** The Competent Person/chamber operator may be any non-diving member of the dive team if all diving ceases during chamber decompression.*

11.4 Other Diving Operations

Additional dive crew members may be required for any diving operations involving an increased likelihood of diver entrapment or the potential for rendering the diver unconscious or incapacitated from chemical, physical, electrical, or topside hazards. These operations include, but are not limited to:

- Diving on ordnance and/or explosives projects
- Diving from a small boat
- Diving in remote areas where assistance from non-diving crew personnel is not immediately available, but within communication range
- Penetration diving, both horizontal and vertical
- Diving requiring crane operations
- Diving in any situation where the diver uses surface-tended equipment
- Diving from a platform greater than 8 feet above the water surface

12.0 MEDICAL REQUIREMENTS

Each diver will receive a diving physical examination initially when assigned diving duties and yearly thereafter. In addition, a medical examination will be conducted whenever a diver has been hospitalized for more than 24 hours due to an injury or illness. A determination as to their fitness to continue to dive will be prepared by the examining physician. The physician will prepare a written report containing the following statement: “Based on the following, I certify the diver as ‘Fit to Dive’.” In addition, the report will contain the following information:

- Medical requirements of this standard and a summary of the nature and extent of hyperbaric exposure to which the diver will be exposed, including diving modes and types of work to be assigned (TMR will provide the dive information).
- The diver’s medical history (a diver’s Medical History and Supplemental Diving Questionnaire, available in the CRL), which will be filled out completely and will be provided to the examining physician.
- The results of the medical examination. A basic diving physical examination will be conducted initially and annually for all TMR divers, which will include a chest X-ray, vision testing, audiogram, pulmonary function test, blood chemistry panel, complete blood count with differential, urinalysis with microscopic analysis (U.S.), and any additional tests required by the examining physician. An electrocardiogram will be performed. An exercise stress test may be indicated based on a risk factor assessment performed by the doctor.
- The examining physician’s opinion of the employee’s fitness to be exposed to hyperbaric conditions, including any recommendations or limitations to such exposure. TMR will provide the employee with a copy of the physician’s written report.

Determination of the employee’s fitness to dive will be based on the physician’s written report and review by the DRB. If the physician has recommended a restriction or limitation on the employee’s exposure to hyperbaric conditions, and the employee does not agree with the physician’s findings, the employee has the right to obtain his own diving-certified physician to perform a diving physical. If the second physician does not agree with the findings of the first physician, a third physician will be consulted for resolution.

13.0 EQUIPMENT CONSIDERATIONS

The DS, in conjunction with the DRB, will establish the equipment requirements for individual projects. This list will be included in the DOP and will includethe required dive gear, boat equipment, and any required task-specific equipment. This list should be submitted to the project manager when the DOP has been approved. Each equipment modification, repair, test, calibration, or maintenance service that is required will be recorded by means of a tagging or logging system. This system will includethe date, serial number of the item, nature of the work performed, and the initials of the person who conducted the work.

13.1 Equipment Maintenance

Typically, TMR underwater operations use a variety of diving systems and component equipment. Dive equipment is considered life support equipment and should be treated as such.

- All equipment will be maintained in accordance with the directives set forth by OSHA and the Manufacturer's Specifications.
- Any maintenance performed on equipment will be logged on the maintenance form and forwarded to the diving systems equipment manager for entry into the equipment maintenance log.
- DS shall have the required expertise to maintain the systems used by TMR.
- Dive Team Members shall treat all equipment in a responsible manner and immediately inform the DS of any potential equipment problems that they may observe.
- Bi-annual air quality tests will be performed on all breathing air compressors, and the results kept on file by the Chairman of the DRB.
- Equipment requiring periodic calibrations shall be sent to their respective manufacturers or licensed professionals for proper maintenance and calibration. The DS shall inform the diving systems equipment manager of any equipment taken offline.

Using the information provided by the diving systems equipment manager, the TMR equipment manager will manage, and report equipment concerns in accordance with TMR Procedure PO-18, Warehouse Management.

13.2 Air Supply Requirements

Air used in diving operations will be procured from a facility where the compressors meet the requirements established in Compressed Gas Association Pamphlet G-7.1 or more stringent standards. The tanks will be filled with compressed air from a source that complies with, at a minimum, 29 CFR 1910.430 (equipment). The breathable air supplied to the diver will be tested every 6 months and will not contain:

- A level of carbon monoxide greater than 10 parts per million (ppm)
- A level of carbon dioxide greater than 1,000 ppm
- A level of oil mist greater than 5 milligrams per cubic meter
- A level of hydrocarbons, other than methane, greater than 25 ppm
- Noxious or pronounced odor

A copy of the latest air test results will be reviewed and/or obtained and filed with the diving systems maintenance log and associated project DOP. When using local established vendors, a check of current certification is requiredevery 6 months. If air test results are not available, TMR will draw an air sample from thecompressor for appropriate analyses prior to using air from this source.

13.3 Regulators

The dive equipment maintenance manager will be responsible for inspecting and scheduling maintenance on their regulators prior to the first use and every 12 months thereafter. Documentation of the inspections and maintenance will be maintained in the TMR diving systems maintenance log and associated system files.

13.4 Compressed Air Cylinders

Compressed breathing air cylinders will:

- Be constructed with seamless steel or aluminum that meets U.S. Department of Transportation (DOT) 3AA and DOT 3AL specifications.
- Have identification symbols stamped into the shoulder of the cylinder.
- Be inspected internally and externally for corrosion and pitting on an annual basis. If a defect is found that may impair the safety of the pressure vessel, a hydrostatic test must be performed.
- Be hydrostatically tested every fifth year in accordance with DOT regulations. The test dates will be stamped into the shoulder of each cylinder. Documentation of each cylinder inspection will be maintained in the TMR diving files.
- Be stored in a ventilated area and protected from excessive heat.
- Be secured from falling.
- Have shutoff valves recessed into the cylinder or protected by a cap, except when in use, when installed with a manifold, or when used for SCUBA diving.

13.5 Air Compressor Systems

Air compressors used to supply air to the diver will:

- Be equipped with a volume tank that has a check valve on the inlet side, a pressure gauge, a relief valve, and a drain valve.
- Have intakes located away from areas where exhaust fumes or other air contaminants may be present.
- Be tested every 6 months by means of samples taken at the connection to the distribution system to ensure that the air supplied meets all applicable standards (see Section 3.6.1, above). Non-oil lubricated compressors do not have to be tested for oil mist.
- Be equipped with a moisture separator and filtration system.

A log shall be maintained showing all tests, repairs, maintenance, and run time on all air compressors systems.

13.6 Surface Supplied Air

The diver’s surface-supplied air supply may originate from an air compressor, a bank of high-pressure air flasks, or a combination of both. Regardless of the source, the air must:

- Meet the purity standards stated above;
- Be supplied in an adequate volume for breathing;

- Have a rate of flow that properly ventilates the helmet or mask; and
- Be provided at enough pressure to overcome the bottom water pressure and the pressure losses due to flow through the diving hose, fittings, and valves.

The air supply requirements depend on specific factors for each dive, such as depth, duration, level of work, number of divers being supported, and type of diving system being used.

The capacity of the primary air supply must meet the consumption rate for the designated number of divers for the full duration of the dive (bottom time plus decompression time). The maximum depth of the dive, the number of divers, and the equipment to be used must be considered when sizing the supply.

The secondary air supply must be sized to support recovery of all divers using the equipment and dive profile of the primary supply, if the primary supply malfunctions or fails at the worst-case time (i.e., immediately prior to completion of planned bottom time of maximum dive depth, when decompression obligation is greatest).

13.6.1 Breathing Gas Supply Hoses

Breathing gas supply hoses will:

- Have a working pressure at least equal to the pressure of the total breathing gas system;
- Have a rated bursting pressure at least 4 times the working pressure;
- Be tested annually (at a minimum) to 1.5 times their working pressure;
- Have their ends taped, capped or plugged when not in use;
- Have connections made of corrosion resistant material, and be resistant to accidental disengagement; and
- Have connectors with a working pressure at least equal to the hose to which they are attached.

13.6.2 Divers' Air Supply Hoses

Umbilical's will:

- Be marked (starting from the diver's end) at 10-foot increments for the first 100 feet; and 50-foot increments thereafter;
- Be made of kink-resistant material;
- Have a working pressure greater than the pressure equivalent of the maximum depth of the dive plus 100 PSI.

13.7 Gauges and Timekeeping Devices

The following requirements apply to each diver's gauge or timekeeping device:

- Each depth gauge will be deadweight tested or calibrated against a master reference gauge every 6 months, and when there is a discrepancy greater than 2 percent of full scale between any two equivalent gauges.

- A cylinder pressure gauge that is capable of being monitored by the diver during the dive will be worn by each SCUBA diver and surface-supplied diver when equipped with a bailout bottle.
- Each SCUBA diver will wear a diving watch capable of displaying elapsed time.
- A timekeeping device will be available at each dive location.
- Dive computers will be approved for use after the review and approval of the DRB (see paragraph 13.10 below).

13.8 Buoyancy Control

The following requirements apply to each diver's buoyancy control device:

- A dry suit or buoyancy compensator not directly connected to the helmet or mask will be equipped with an exhaust valve.
- Helmets or masks directly connected to a dry suit or other buoyancy-changing device will be equipped with an exhaust valve.
- When used for SCUBA diving, a buoyancy compensator will have an inflation source separate from the breathing gas supply and a manual inflator hose.
- An inflatable flotation device capable of maintaining the diver at the surface in a face-up position, having a manual activated inflation source independent of the breathing gas supply, an oral inflation device, and an exhaust valve is required for SCUBA diving, except when diving in enclosed spaces or under the ice.

13.9 Masks and Helmets

The following requirements apply to each diver's mask or helmet:

- Surface-supplied masks/helmets will have a non-return valve at the attachment point between helmet or mask and hose that will close readily and positively. Masks/ helmets will also have an exhaust valve.
- Surface-supplied air masks and helmets will have a minimum ventilation rate capability of 4.5 actual cubic feet per minute at any depth at which they are operated, or they will have the capability of maintaining the diver's inspired carbon dioxide partial pressure below 0.02 atmosphere absolute (ATA) when the diver is producing carbon dioxide at the rate of 1.6 standard liters per minute.

13.10 Dive Computers

Dive computers that calculate decompression time based on time and depth are not to be used unless authorized by the DS and incorporated into the projectspecific DOP. They must be checked for accuracy prior to use.

13.11 Backpacks

Backpacks worn during diving operations without integrated flotation devices and weight systems must be equipped with a quick-release device.

13.12 Handheld Power Tools

Handheld power tools are not normally used during SCUBA diving operations, but, if used, they will be used in accordance with the following safeguards:

- Handheld power tools and equipment will be de-energized before being placed into or out of the water.
- Handheld power tools will not be supplied with power from the dive location until requested from the diver.
- Two-way voice communications between divers and topside must be used.

13.13 Dive Tables

Dive tables shall be made available to divers at all diving locations.

13.14 Welding/Cutting/Burning

Welding, cutting, and burning procedures are not addressed in this manual. When a diving project requires welding, cutting, or burning operations, those specific procedures will be addressed in the project specific DOP for that project.

13.15 First Aid/CPR/AED/Emergency Oxygen

A first aid kit, appropriate for diving operations, will be available at the dive site. This kit will contain a Divers Alert Network/ American Red Cross standard first aid handbook or equivalent, a bag-type resuscitator with transparent mask and tubing, and astokes litter or backboard with flotation capabilities.

Additionally, a portable source of emergency oxygen will be available at the dive site for transport of a diving-related casualty to the hyperbaric treatment facility. An AED will also be on site during all active diving operations.

13.16 Equipment Procedures Checklists

Pre-dive and post-dive checklists for both SSA and SCUBA operations will be used during setup and breakdown of the dive station.

14.0 RECORDKEEPING REQUIREMENTS

The following records are required by 29 CFR 1910.401, Subpart T, and will be maintained as follows:

- The TMR Chairman, via the DRB, will maintain all historical records.
- Records will also be retained in the project, office, or department files, in accordance with TMR Procedure PO-08 Document Control and Records Management.
- Records and documents will be maintained in accordance with 29 CFR 1910.401, Subpart T, and will be provided upon request to employees, designated representatives, and others as determined by TMR.

14.1 Dive Profile Log (Depth-Time Profile)

The TMR Dive Smooth Log (Attachment 7, which is available in the native file format located in the Guidelines Templates and Tools folder in the CRL) will be forwarded to the Chairman of the DRB and maintained for 1 year. If there has been a diving-related illness or injury on the project, the records will be maintained for a period of 5 years. After the 5-year time limit, the records will be forwarded to the National Institute for Occupational Safety and Health (NIOSH). The Tetra Tech scientific DSO will maintain copies for all scientific divers.

14.2 Diving-Related Injury Records

Any diving-related injury or illness, which requires any dive team member to be transported to a hospital for treatment related to any diving incident, will be reported to the safety and health manager (SHM) and documented by specifying the circumstances of the incident and extent of the injuries in the section provided in the Dive Profile Log.

The SSHO will subsequently report this accident/ incident to the TMR organization in accordance with procedure DCN 02-02, event reporting and investigation. The Dive Smooth Log and written Accident/Incident Report will then be forwarded to the designated SHM, and copied to the Chairman of the DRB. The Chairman will include the DiveProfile Log sheet in the TMR Dive Log, which is available in the native file format locatedin the Guidelines Templates and Tools folder in the CRL.

14.3 Recording of Dive

As stated above, a Dive Profile Log sheet will be completed for each dive, and, upon completion of the dive, will be forwarded to the Chairman of the DRB. The Chairman of the DRB will include the Dive Profile Log sheet in the TMR Dive Log, which will document all dives conducted by TMR personnel. The Diver's Medical History and Supplemental Diving Questionnaire must be completed for each diver before they commence diving.

14.4 Decompression Procedure Assessment Evaluation

In the event of a diving-related incident that requires treatment by recompression, the section of the Dive Profile Log sheet for Decompression Procedure Assessment Evaluation will be completed and forwarded to the Chairman of the DRB, who will include the log in the TMR Dive Log. The Dive Log will be maintained for a period of 5 years. The Chairman of the DRB or designee will conduct the accident investigation.

14.5 Equipment Inspections and Testing Records

The current log entry or tag for required equipment must be maintained until the equipment is removed from service.

14.6 Records of Hospitalization

All medical records generated by a hospitalization visit must be forwarded to the TMR Medical Provider.

14.7 Diver Medical Records

The Tetra Tech Corporate Safety Procedure DCN 3-02F, MS-2, Release of Medical and

Exposure Records[2] form is retained by TMR Human Resources Department. The Tetra Tech Corporate Safety Procedure DCN 3-02F, MS-1, Physician's Certification form[3] is retained by the Tetra Tech Medical Provider, and copies are maintained in project site files by the SSHO. All personal information protected by the Health Insurance Portability and Accountability Act is maintained by Tetra Tech's independent medical provider. Employee medical records will be handled in accordance with Tetra Tech Corporate Safety Procedure DCN 1-04, Recordkeeping and Reporting Requirements[4].

Diver qualification medical records that are signed by the TMR Medical Provider will be maintained for the duration of employment plus 30 years in accordance with 29 CFR 1910.1020(d).

14.8 Diving Safe Practices Manual

The current version of this DSPM is required to be maintained at the dive location.

14.9 Forwarding of Records

Employers are no longer required to notify and/or transfer records to NIOSH. OSHA's 29 CFR 1910.1020(h)(1) provides that whenever an employer is ceasing to do business, they must "transfer all records subject to this section to the successor employer. The successor employer shall receive and maintain these records.

14.10 Termination of Diving Operations

If TMR ceases to do business, the successor employer will receive and retain all dive and employee medical records required by 29 CFR 1910.1020(h)(2); The employer shall notify affected current employees of their rights of access to records at least three (3) months prior to the cessation of the employer's business

14.11 Training Records

Copies of each diver's successful completion of a military or federally accredited dive training or civilian accredited commercial dive training certification, and any other certificates of any specialized training (relevant to the job), will be forwarded to the Chairman, of the DRB via the DSO and kept on the project site. Additionally, any training conducted in preparation for the job will be documented and retained on site and copies forwarded to the Chairman of the DRB.

15.0 OPERATIONS PLANNING

This section provides guidance on effective dive planning for any size operation. The success of any diving operation is a direct outcome of careful, thorough planning. The site-

[2] https://tetratechinc.sharepoint.com/:b:/r/sites/Health-Safety/Health%20%20Safety%20Manual/03_Environmental%20and%20Remediation%20Operations/DCN%2003-02F%20MS-2%20Release%20of%20Medical%20and%20Exposure%20Records.pdf

[3] https://tetratechinc.sharepoint.com/:b:/r/sites/Health-Safety/Health%20%20Safety%20Manual/03_Environmental%20and%20Remediation%20Operations/DCN%2003-02F%20MS-1%20Physicians%20Certification%20Form.pdf

[4] https://tetratechinc.sharepoint.com/:b:/r/sites/Health-Safety/Health%20%20Safety%20Manual/01_Health%20and%20Safety%20Program%20Administration/DCN%2001-04%20Recordkeeping%20and%20Reporting%20Requirements.pdf

specific circumstances of each operation determine the scope of the planning effort, but certain considerations apply to every operation.

The DOP provides a basic outline of minimum required information to successfully planthe diving operation. A project specific DOP will be developed and implemented by the DRB, Project Manager and designated DS for each separate diving project. The SSHO for the project shall complete applicable self-assessmentchecklists. The project DOP for federal clients will comply with EM-385-1-1.30.A.16. A project DOP shall be developed to address the general diving and to include the following:

- Describe dive team composition, personnel qualifications, and responsibilities, along with the proper up-to-date documentation.
- Provide name and qualifications of the designated person in charge/diving supervisor responsible for diving activities (that is, years and type of experience and training background).
- Describe safe work practices for other activities to be performed during this project (for example, use of ladders, fall protection, use of electrical power tools, and use of personal protective equipment).
- Describe site-specific training, diver workups, equipment uses, and other training requirements (e.g., hazard communication, first aid, and CPR).
- Describe methods to identify and protect wetlands, endangered species, or cultural/historic resources, if applicable.
- Describe procedures for operating in inclement weather, including lightning, high winds, and severe rainstorms.
- Describe the Emergency Response Plan for equipment, incident response, treatment, evacuation, and notifications.
- Provide supplemental diving safety procedures.

The DOP can reference overlapping plans or other pertinent project documents to minimize redundancy.

15.1 Risk Management and Assessment

Identifying the risks of the dive and developing a plan of action to minimize one's exposure to risk is crucial to safe and effective diving operations. The DOP will be developed to address possible emergencies that may arise at each specific dive site. This plan shall incorporate steps for extraction of a stricken diver from the water, subsequent first aid and emergency response, and evacuation to a higher level of care. Job hazard analysis forms and safety checklists that are site-specific may be substituted providing they meet or exceed the requirements outlined in this manual and are approved by the diving supervisor/lead diver. Each team member shall be provided a copy of the DOP prior to starting a job.

Once on the job, the DS shall give a safety briefing to the dive team prior to each day of diving, and at the start of a new task. Emergency procedures will be reviewed on site to include local emergency/rescue points of contact. Wherever practicable, dives will be planned within the No Decompression Limits according to the USN dive tables and procedures.

The project manager, field management team and DS, prior to the start of any fieldwork, must complete detailed planning and all required forms. Dive Team members must be made aware of the following:

- All known and potential safety issues at the job site as reflected on the AHA form.
- Required scope of work and individual responsibilities as detailed in the Pre-Dive Briefing Form.
- Equipment and tool requirements for all tasks
- Contingency and emergency plans
- All quality procedures and any issues as reflected in the quality management forms

Diving shall be discontinued if sudden squalls, electric storms, heavy seas, unusual tide, or any other condition exists that, in the opinion of the DS, jeopardizes the safety of the divers. It must be noted here that **ANYONE ON A TMR DIVE TEAM CAN STOP WORK** on a job if they feel that the work environment is or becomes unsafe.

Prior to diving, the DS shall be responsible for examining the dive site to identify potential hazards. Some examples of potential surface and subsurface hazards include the following:

- Surface vessel traffic and/or vehicular traffic
- Swift currents and sea state
- Subsurface/underwater debris
- Overhead crane operations
- Mooring lines
- Pedestrian traffic/onlookers
- Petroleum products and/or other materials that are hazardous to divers and/or tenders
- Airborne contaminants
- Contaminated water
- Outfall and intake pipes
- Flotsam/jetsam (marine debris)
- Propeller/thrusters and intake/discharges of moored vessels
- Potential for structural collapse
- Hazardous marine life
- Limited access and/or confined workplace
- Fishing lines and nets
- Turbid (limited visibility) water
- Hazardous materials
- Abandoned piles and/or other structures
- Sonar equipment likely to be used or tested on nearby vessels

15.2 Termination of Dive Operations

The working interval of a dive will be terminated under any of the following conditions:

- The activities are completed as planned.
- A diver requests termination.
- A diver fails to respond correctly to communications.
- Communications are lost and cannot be quickly re-established between the diver and a dive team member at the dive location, or between the designated person-in-charge and the person controlling the vessel in live boating operations.
- A diver begins to use diver-carried reserve breathing gas or the dive location reserve breathing gas.
- The DS determines that any unsafe condition exists.

16.0 CONSIDERATIONS FOR DIVE PLANNING

TMR diving mode options include SSA SCUBA (including the SADS configuration), and snorkeling. Specific tasks and environmental conditions will dictate the safest and most efficient diving mode; however, there are certain requirements that must be followed regardless of the chosen dive mode selected.

16.1 Primary Breathing Air Supply

Air will be the primary breathing gas used during diving operations. A low-pressure air compressor, volume tank and filter assembly or high-pressure cylinders, with a regulated supply, provide the breathing air during SSA diving. Compressed air cylinders worn by the diver or mounted on the SADS supply the primary breathing air during SCUBA diving operations.

16.2 Reserve Breathing Air Supply

High-pressure air cylinders connected to the dive manifold supply the reserve air to the SSA Diver. Additionally, the diver carries a reserve breathing air supply known as a bail-out system. The bail-out system provides a reserve air supply for the diver when surface-supplied air is compromised.

A redundant and separate tank and regulator carried by the diver provide the reserve air supply for SCUBA (including on SADS configured) diving operations.

16.3 Exposure Protection

The site and environmental conditions are directly related to the type and amount of exposure protection required for a diver’s comfort and safety. In cold or contaminated water, a dry suit with an adequate thermal undergarment is required. In the absence of contaminants, a neoprene wetsuit may be worn. A lightweight wetsuit, dive skin, or swimsuit with chaffing coveralls may be considered in warmer climates, providing the environment in which the dive will take place is free of contamination. Divers will wear some form of hand and foot protection while working in the water to minimize the possibility of injury. A neoprene or Lycra wetsuit hood is suggested when using SCUBA to provide protection for the diver's head and ears.

16.4 Dive Team Assignments

Each TMR Dive Team will have, as a minimum, four qualified personnel. The marine operations program manager will assign personnel to the dive teams. Personnel requirements are outlined in Section 11. Team assignments will be based on the scope of the project and the availability of qualified personnel. The logistics of the project and any unusual safety considerations at the job site may dictate additional personnel requirements.

- Additional personnel may be required to supplement the dive team to comply with standards set forth by a client or agency. In these instances, the required standards will be reviewed and strictly adhered to.
- All diving projects undertaken by the company for government clients (e.g., USN or the USACE) will be carried out in strict compliance with DDESB TP-18 and EM-385-1-1 Section 30.

16.5 Decompression Procedures

The standard of practice is to plan dives as no decompression dives according to the USN no-decompression dive table limits. Should situations arise that necessitate the use of decompression diving to complete the scope of work safely and efficiently, USN Standard Air Dive Tables and outlined ascent procedures will be implemented and incorporated into the DOP at that time.

16.6 Water Entry/Egress

A securely attached ladder or platform will be provided for the diver to enter and exit the water. The ladder must extend at least 3 feet below the surface of the water and be capable of supporting the combined loads of both the diver and tender.

Divers shall enter the water in a controlled manner. In turbid or low visibility water conditions, there is always a possibility of submerged hazards or protruding objects that could pose a danger to the diver; therefore, extreme caution must be exercised during water entry.

Equipment required for the safe extraction of an unconscious diver from the water shall be provided at each dive site.

16.7 Warning Display

An International Alpha code flag and recreational "Diver Down" flag shall be prominently displayed during all diving operations. Flags will be placed in a highly visible position to provide as much warning as possible for all approaching vessels. For work in navigable waters, flag dimensions shall be at least one meter in height and width (or as specified by local jurisdictions) and navigation lights and shapes displaying underwater operations (red/white/red and ball/diamond/ball) at night.

16.8 Pre-Dive Brief

Prior to each dive, the DS shall conduct a pre-dive Briefing to inform each Dive Team Member of the following:

- Diver's health and readiness
- Standard and emergency procedures for diving mode employed and location of work
- Review of the AHAs, equipment checklists, and hazards or environmental variables that will impact diving operations
- Quality procedures
- Any deviations from standard procedures which may be necessitated by the operation
- Diver re-call procedure
- Factors which will terminate the dive

17.0 SPECIAL CONSIDERATIONS FOR DIVE PLANNING

In addition to the requirements above, there are many other items or circumstances that must be considered when planning a dive, regardless of the chosen diving mode.

17.1 Hazardous Environmental Conditions

Effective dive planning must provide for extremes in environmental conditions. Diving will be discontinued if sudden squalls, electric storms, heavy seas, unusual tide, excessive current or any othercondition exists that, in the opinion of the DS, jeopardizes the safety of the divers.

17.2 Communications

Adequate communications for the dive site will be provided as follows:

- **Diver to diver** – Wireless through water communication is preferred for SCUBA operations, but diver-to-diver hand signals or line pull signals, in accordance with the Navy Diving Manual, are acceptable, refer to Attachment 8 USN Diving Line Pull and Hand Signals, which is also available in the native file format located in the Guidelines Templates and Tools folder in the CRL. Surface-supplied diving requires an operational two-way audio communication system between the diver and topside.
- **Surface to Diver/Diver to Surface** – Wireless through water communication is preferred for SCUBA operations, but line pull signals in accordance with the USN Diving Manual, are acceptable. SSA diving requires an operating two-way audio and video communication systems between the diver and topside.
- **Emergency Assistance** – Telephone communications will be maintained on site via cell phone, or two-way radio communications with a constantly manned location to activate emergency services if required.

17.3 Cold Water Diving

Cold water diving is defined as diving in water at or below a temperature of 37 degrees Fahrenheit. Cold water diving requires the use of special equipment and techniques. All dives conducted in cold water will be in accordance with Attachment 9, Cold Water Considerations and Safety Precautions, which is available in the native file format located in the Guidelines Templates and Tools folder in the CRL.

Hypothermia demands immediate treatment and prompt evacuation to a medical facility. The DS will also take into consideration hypothermia for the surface support personnel. The responding medical facility must be notified of the possibility of hypothermia prior to the commencement of diving operations. Emergency re- warming and evacuation plans should be established with the medical facility's recommendations.

Diving under the ice requires extremely specialized training and equipment and **will not**

be performed by TMR employees under this policy.

After approval of the DRB and project DDC (if applicable); Standard Operating Procedures (SOPs) addressing the special requirements and support will be developed prior to commencing any under ice diving and included in the project specific DOP.

17.4 Diving at Altitude

Diving operations may be required in bodies of water at higher altitudes. Because of the reduced atmospheric pressure, dives conducted at altitude require more decompression than identical dives conducted at sea level. Standard air decompression tables, therefore, cannot be used as written.

Planning must address the effects of the atmospheric pressures that may be lower than those at sea level.

- No correction is required for dives conducted at altitudes between sea level and 300 feet; the additional risk associated with these dives is minimal.
- At altitudes between 300 and 1,000 feet, correction is required for dives deeper than 145 FSW (actual depth).
- At altitudes above 1,000 feet, correction is required for all dives.

High-altitude diving requires special equipment and techniques and will be conducted in accordance with the provisions of the USN Diving Manual.

After approval of the DRB and project DDC (if applicable); SOPs addressing the special requirementsand support will be developed prior to commencing any high-altitude diving and includedin the project specific DOP.

17.5 Diving on UXO

Diving involving the potential interaction with munitions or munition remnants, specifically munitions and explosives of concern (MEC), combines the inherent risk of diving and the explosive hazards of munitions. UXO is the most hazardous classification of MEC. Diving to investigate, recover, or dispose of munitions found underwater, regardless of the type or fuzing, will only be accomplished by specifically trained and qualified UXO divers. Divers must be qualified in accordance with DDESB TP-18. Unknown items found in this environment will be treated as MEC (UXO) until properly identified and classified in a different less hazardous category.

Generally, it is safer for divers to work in pairs rather than alone. However, when diving on in an environment when MEC may be present, the use of two divers doubles the exposure to the potential munition items and the amount of bottom time expended and increases the risk to life from a possible unintentional detonation. Consequently, the Diving Supervisor, should employ a single tended or marked diver when any intrusive activity, manipulation, or removal of the munitions is anticipated. However, the option to use two or more divers for underwater munitions operations is authorized with prior approved planning.

When performing activities not involving intentional contact with MEC and using anomaly avoidance techniques within a munitions environment, it is preferred to deploy two UXO divers. Deploying one UXO diver and one non-UXO diver is allowable if approved in the DOP and authorized by an approved explosive safety submittal or explosive safety plan.

The development and use of SOPs within the DOP to address the hazards associated with munitions is required when conducting UXO diving.

17.6 Diving in Contaminated Water

Divers may encounter dangerous or unpleasant forms of pollution such as effluent from a sewer or industrial outfall, oil leaking from a wellhead or damaged fuel tank, toxic materials, biological hazards,volatile fuels leaks, and munitions including chemical warfare material can cause severe problems.

The dive team should not conduct the dive until the contaminant has been identified, the safety factors evaluated, and the process for decontamination set up. When diving in a known or suspected radiological environment, proper radiological procedures must be followed.

When diving in contaminated waters, the appropriate dress should be a fully contained dry suit with gloves and hood, with a positive-pressure full face mask or the Dirty Harry surface-supplied diving system. Technical advice for contaminated water diving is available from the NOAA Hazardous Materials Department at (206) 526-6317.

18.0 DIVING HAZARDS

In addition to environmental hazards, and the hazards directly attributable to diving, a diver may occasionally be exposed to operational hazards that are not unique to the diving environment. These hazards are described below.

- **Underwater Obstacles** – Various underwater hazards, such as broken pilings, rocks, wrecks, dumping grounds, and discarded munitions, offer serious hazards to divers.
- **Electrical Shock** – Electrical shock is rare underwater but may occur when using power equipment underwater or topside. A ground fault interrupter must be used with electrical equipment employed on the dive site, both on the surface and underwater.

- **Explosions** – Explosions may occur during demolition tasks or during ordnance clearance operations, intentionally or accidentally. When using explosives, or as identified during UXO diving, separate SOPs and work plans will be developed to cover all aspects of the use or possibility of encountering explosives/ordnance underwater. All divers will be out of the water prior to any planned detonation of explosives or ordnance.
- **Explosives** – All diving-related explosives will be pre-approved. The procedures for explosives handling, use, storage, and underwater procedures will be detailed in the specific DOP for the project.
- **Sonar** – Additional precautions are required when diving in the vicinity of vessels that employ active sonar. Ships use low-frequency sonar for object location and depth finding. It is a dense, high-energy pulse of sound that can cause damage to divers' ears. Avoid diving in the vicinity of low-frequency sonar and approach no closer than 600 yards. The optimal separation distance is 3,000 yards.

Additionally, the USN Diving Manual has a worksheet to compute actual time and distance restrictions for various types of sonar. This worksheet considers such variables as depth, time, diving apparatus, and wetsuit hoods. High-frequency (greater than 100 kilohertz), short-duration sonar, such as that used with side-scan and hand-held sonar, poses little danger to the diver. The diver will abort the dive if active low-frequency sonar is energized while they are in the water.

- **Marine Life** – Certain marine life, because of its aggressive or venomous nature, may be dangerous to man. Some species of marine life are extremely dangerous, while some are merely an uncomfortable annoyance. Most marine life poses little threat, as they tend to leave humans alone. The diver's best defense against injury is knowledge. All divers should be able to identify the dangerous species that are likely to be found and should be able to deal with each appropriately. The USN Diving Manual provides specific information about dangerous marine life.
- **Ascent to Altitude including Flying after Diving** – Leaving the dive site may require temporary ascent to a higher altitude. For example, divers may drive over a mountain pass at higher altitude or leave the dive site by air. Ascent to altitude after diving increases the risk of decompression sickness because of the additional reduction in atmospheric pressure. The higher the altitude, the greater the risk. The cabin pressure in commercial aircraft is maintained at a constant value regardless of the actual altitude of the flight. Though cabin pressure varies somewhat with aircraft type, the nominal value is 8,000 feet.

For all diving projects, divers will wait at least **12 hours** before flying after any dive, or **24 hours following multiple days of repetitive dives**. The ascent to altitude table located in the USN Diving Manual gives the surface interval (hours, minutes) required before making a further ascent to altitude. The surface interval depends on the planned increase in altitude and the highest repetitive group designator obtained in the previous 24-hour period. Enter the table with the highest repetitive group designator obtained in the previous 24-hour period and read the required surface interval from the column for the planned change in altitude.

18.1 Boating

All boating activities will be conducted according to applicable state, USCG, and Tetra Tech Procedure. Further, the following guidelines will be adhered to:

- Diving operations involving live boating will not be conducted unless cleared by the DDC and/or DSO in writing and documented in the approved DOP or subsequent Field Change Request.
- Live boating **will not** be conducted unless:
    1) Approved by the DDC and/or DSO
    2) In SSA diving at depths that are no deeper than 100 FSW,
    3) In rough seas that significantly impede diver mobility or work function, in non-daylight hours.
- The propeller of the vessel will be stopped before the diver enters or exits the water.
- A device will be used that minimizes the possibility of entanglement of the diver's hose or tending lines in the propeller of the vessel.
- Two-way voice communication between the DS and the person controlling the vessel will be available while the diver is in the water.
- Each diver engaged in live boating operations will carry a diver-carried reserve breathing gas supply.

19.0 OTHER HAZARDS

Other diving-related hazards that may be encountered by TMR divers are described below.

19.1 Noise

Some operations may require the use of generators, pumps, compressors, engines, and other equipment that can generate high levels of noise. Short-term exposure to extremely loud noise and/or long-term exposure to low level noise can cause hearing loss. Personnel assigned to a high noise area will wear proper hearing protection and be enrolled in a hearing conservation program.

19.2 Lifting Hazards

During some operations, there may be several instances when personnel will be called on to lift and/or carry a heavy load, sometime over rough or unstable terrain. When doing so, personnel should be instructed to observe the following rules:

- Test the load to ensure it can be moved safely.
- Plan the move to ensure the travel path is clear.
- Keep the back in its normal arched position while lifting, bend at the knees to lift.
- Lift with the legs and stand up in one smooth motion.
- Move the feet to change direction, do not twist at the waist.

20.0 DIVING EMERGENCY PROCEDURES

20.1 Surface Supplied Diving

20.1.1 Loss of Primary Air Supply

- Activate the secondary back up breathing air supply.
- If necessary, ensure diver goes on bail-out bottle.
- Alert the standby diver.
- Have Diver surface and proceed to ladder or stage.
- Terminate the dive (if instructed by the DS).

20.1.2 Loss of Communications

- Attempt to establish line-pull signals.
- Alert the standby diver.
- If unable to establish any form of communications with the diver within 60 seconds, immediately deploy the standby diver for assistance.
- Ensure diver proceeds to the ladder or stage.
- Terminate the dive.

20.1.3 Fouled or Entrapped Diver

- Diver informs the surface.
- Alert the standby diver.
- Diver determines the nature and extent of entrapment.
- Diver attempts to free themselves.
- If required, deploy the standby diver to assist the diver.
- When free, diver, standby diver and/or tender confirm that direct contact with each other is re- established.

20.1.4 Injured Diver in Water

- Diver informs the surface (if possible).
- Alert the standby diver.
- Diver determines nature and extent of injury.
- Deploy the standby diver to assist diver (if necessary).
- Standby diver remains with diver.
- Extract the diver and provide first aid or emergency oxygen accordingly.
- Request immediate medical assistance and emergency evacuation (if required).

20.1.5 Severance of Complete Umbilical

- Diver activates bail-out bottle.

- Establish line pull signals, if possible, try to inform surface support of the situation.
- Top side crew should secure primary the air supply and activate the air supply to the pneumo hose. If the diver can maintain a hold of the severed section of the hose, they can use it for breathing air and follow it up to the surface.
- Diver surfaces and terminates the dive.

20.1.6 Unconscious Diver

- Attempt to establish voice and line pull communications with the diver.
- Deploy the standby diver.
- Determine the nature and extent of the diver's situation.
- Secure the diver and ensure an open airway; open the dive helmet free flow if the diver is not breathing.
- Extricate the diver, provide First Aid, CPR, AED, and/or emergency oxygen accordingly.
- Request immediate medical assistance and emergency evacuation.

20.1.7 Activate the secondary back up breathing air supply

- Inform the diver of the situation and establish line pull signals if necessary.
- Diver activates bail-out bottle (if necessary).
- Line up air spread to route secondary air source to diver.
- Determine the cause, restore primary air supply prior to continuing the dive.
- Diver surfaces and terminates the dive if primary air not restored.

20.1.8 Equipment Failure – Diver in the Water

- Inform the diver of the situation and establish line pull signals if necessary.
- Evaluate the effect on the diver.
- Alert the standby diver.
- Diver informs topside of their readiness.
- Terminate the dive.

20.2 SCUBA Diving

20.2.1 Out of Air – Primary Source

- Diver activates secondary the air supply.
- Diver informs buddy diver or topside crew.
- Terminate the dive.

20.2.2 Out of Air – Primary and Secondary Source

- Diver surfaces with controlled ascent and informs buddy diver or topside crew.
- Buddy diver gives secondary air source to diver (Buddy breathes).

- Terminate the dive.

20.2.3 Fouled or Entrapped Diver

- Diver determines the extent of entrapment.
- Diver attempts to correct the situation.
- Diver informs topside or buddy diver; deploy the standby diver if required
- When clear, diver returns to ladder and evaluates situation with the DS.
- DS decides to continue or terminate the dive.

20.2.4 Diver Injured in Water

- Diver determines nature and extent of injury.
- Diver informs topside or buddy diver.
- Alert the standby diver and deploy if necessary.
- Buddy/standby diver remains with the diver.
- Extract the diver and terminate the dive.
- Provide First Aid and/or emergency oxygen accordingly.
- Request medical assistance and emergency evacuation (in accordance with the DOP).

20.2.5 Equipment Failure

- Evaluate effect on the system and the diver
- Diver informs topside or buddy diver.
- Deploy the standby diver (if necessary).
- Terminate the dive.

20.2.6 Lost Diver and Communication

- Use the Buddy Recall System.
- DS and divers use through water comms.
- Divers 360 look then surface.
- Use the Buddy Recall System.
- Each diver surfaces.
- Initiate the emergency recall system (surface) if all divers do not surface.
- If a diver is not quickly located, the DS immediately initiates search procedures.
- Deploy standby diver (if necessary) at last known position.
- When located, divers return to ladder and evaluates the situation with the DS.
- DS decides whether to continue or terminate the dive.

20.2.7 Diver Rapid Ascent or Blow up to Surface

- Buddy diver surfaces in a controlled ascent.
- Both divers terminate the dive.
- Deploy the standby diver to assist; if necessary.
- Monitor the diver and provide emergency oxygen accordingly.
- Immediately notify emergency and medical personnel and inform them of omitted decompression.

20.2.8 Loss of Consciousness

- Buddy diver/standby diver initiates rescue procedures.
- Determine the nature and extent of the diver's situation.
- Secure the diver and ensure an open airway; overpressure second stage (if possible) if diver is not breathing.
- Standby diver initiates controlled ascent with secured stricken diver.
- Extricate diver, provide First Aid, CPR/AED and/or emergency oxygen accordingly.
- Request immediate medical assistance and emergency evacuation.

21.0 DIVING SPECIFIC EMERGENCY MEDICAL TREATMENT

21.1 DCS Type 1 – (Pain only)

Diver surfaces with or develops joint pain (dull ache) that gradually worsens over time, develops skin problems such as itching or a rash, or develops swelling and pain in lymph nodes. Time to onset of symptoms is 0 to 24 hours. Actions to be taken:

- Perform necessary first aid and give 100 percent emergency oxygen upon surfacing.
- Contact local emergency resources for transport to nearest hyperbaric facility.
- Follow USN Dive Manual Treatment Table procedures.

21.2 DCS Type 2 – Central Nervous System

Diver has DCS symptoms in water, or surfaces with any neurological symptoms (numbness, tingling, decrease touch sensation, muscle weakness, or paralysis). Time to onset of symptoms is 0 to 24 hours. Actions to be taken:

- Perform necessary first aid and give emergency oxygen upon surfacing.
- Contact local emergency resources for transport to nearest hyperbaric facility.
- Follow USN Dive Manual Treatment Table procedures.

21.3 Arterial Gas Embolism (AGE)

Diver surfaces or becomes unconscious within 10 minutes of surfacing, exhibits signs of a stroke or other neurological disorder, blurred vision, or convulsions. Actions to be taken:

- Perform necessary first aid or CPR.
- Administer emergency oxygen with the diver supine or in the recovery position.
- Contact local emergency resources for immediate transport to the nearest hyperbaric facility and initiate recompression treatment as soon as possible.

21.4 Chokes (Heart Pumps Frothy Blood)

Diver surfaces with chest pain aggravated by inspirations, an irritating cough, an increased breathing rate, increased lung congestion with subsequent heart attack. Death is imminent due to heart attack. Actions to be taken:

- Perform necessary first aid and give emergency oxygen upon surfacing.
- Contact local emergency resources for immediate transport to nearest hyperbaric facility.

21.5 Pneumothorax

Diver displays difficult or rapid breathing leans towards affected side and experiences pain while inhaling deeply. Hypotension, cyanosis, and shock may be present, leading to death. Actions to be taken:

- Position diver on affected side.
- Administer emergency oxygen and treat for shock.
- Contact local emergency resources for immediate transport to nearest medical facility (air must be vented from chest cavity).

22.0 VESSEL OPERATIONS DURING DIVING OPERATIONS

22.1 Safe Boating Guidelines

These procedures are for the safety of the employees and other vessels on the waterways during waterborne operations. If a conflict arises between the current edition of this section and the approved project specific DOP, applicable federal, state, local laws or other legal directives, the latter shall take precedence.

22.2 Preparing for Waterborne Operations

All personnel on board a vessel employed on a TMR assignment will be fully competent in the vessel operations, maintenance, and equipment usage. The DS shall complete any project sailing lists and pre-operation maintenance and safety inspection checklists prior to casting off.

22.3 Operations

All TMR employees regularly involved in boat operations must be knowledgeable and capable in rules of the road, vessel maintenance, marine safety, and vessel registration requirements.

22.4 Rules of the Road

As with vehicular traffic on land, rules exist to promote safe vessel movement on navigable waterways. All employees engaged in waterborne operations will know the rules of the road specific to the project area. The local rules can be researched through the USCG or the applicable state government agency that governs a body of water. Several topics included in the rules of the road, relevant to TMR operations, are listed below.

22.5 Navigation, Signals, Markers and Signs

Each crewmember will know the meaning and use of each signal for meeting and passing situations while underway, for leaving a mooring, and signals used in limited visibility conditions. The required signals will be used in accordance with the rules of the road.

Each crewmember will know and understand the meaning of all navigation markers, buoys, and lights on the waterways. The vessel operator will follow the directions of each navigation marker, buoy and light unless evidence indicates the marker is damaged and providing inaccurate information.

22.6 Anchoring and Mooring

Vessel crewmembers will know how to properly anchor and moor the vessel from which they are operating. They will ensure that the anchor, chain, all lines, fenders, bumpers, and cleats are in good working order. The anchor line should be at least seven times longer than the working water depth. Crewmembers will continually monitor anchor and mooring lines while moored in areas affected by tides and strong currents.

22.7 Required Safety Equipment

All vessels operated by TMR, except for vessels less than 18 feet in length, will have the following equipment on board and in operating condition:

- A fixed fire extinguishing system installed in machinery space(s) or B-1 type extinguishers
- Type 1 PFD required for each person on board plus one throw able Type 4 life ring or cushion
- A Coast Guard approved flare kit
- A sounding device to signal maneuvering intentions and position during periods of reduced visibility
- A fully charged and tested VHF radio, prior to departure from dock
- A bilge pump appropriately sized for the vessel
- Additional engine fluids
- Vessels operated by TMR that are less than 18 feet in length shall have a Type 1 PFD for each person onboard.

22.8 Vessel Maintenance

Due to the difficulty of performing repairs afloat, regular maintenance and necessary services shall be carried out onshore before commencing operations. Use of the owner's manuals, maintenance checklists, and repair logs are necessary to track equipment usage and inform future operators of equipment status.

Engine – The owner's manual will be stored on board each vessel in a watertight bag and compartment. Suggested maintenance schedules will be followed. The engine fuel and oil levels will be checked before each use. Other engine components and propeller(s) will be checked for proper function.

Batteries – Each battery will be checked for proper charge level, cleanliness of contact posts, condition of wiring, and water level if required. Batteries will be secured, and all electrical systems turned off after operations are completed. Bilge pumps are directly wired and as such, will remain in constant operation.

Fuel – Check fuel level of primary tanks and emergency supply tanks prior to embarkation. Refill all fuel tanks, with the proper fuel, to the full level after returning each day. Inspect all fuel lines, bilge, and areas around the vessel for leaks.

Electronic Systems – Inspect all circuits to ensure good connections and operation of all components and equipment. Have spare batteries, fuses, and wiring available for repairs. Ensure connection of shore power after returning, when deemed necessary.

Checklists and Logs – Accurately complete checklists and logs prior to and after each day's operation of the vessel.

Safety Equipment – Inspect all fire extinguishers for annual inspection and pressure, first aid kits for required and expired items, PFD for proper fit or deterioration and for spare carbon dioxide cartridges, signaling devices for expired or deteriorated items, and radios for proper functioning.

22.9 General Marine Safety

Dive operations conducted from the relative stability of a pier or shoreline requires safety awareness and constant diligence. Conducting operations from the deck of a pitching/rolling vessel only compound these requirements. All personnel will conduct themselves in a safe and responsible manner while near or on board any vessel and in accordance with SWP 5- 06 Working over or near water. These guidelines are in place for the safety and wellbeing of TMR employees involved in marine operations.

- A USCG-approved PFD must be available for each person on board the vessel. The PFD must have a proper fit for the individual who will be using it and each person should know how to don the PFD in the vessel and in the water. PFDs must be inspected regularly for damage and excessive wear.
- Shoes should have non-skid soles. Personnel should maintain three points of contact when transferring equipment or personnel to and from the vessel. Deck area should be clear of lines, hoses and unnecessary clutter.
- Personnel should not sit on the edge of a vessel or on lifelines while underway.
- Personnel should avoid sailing at night, in fog, in poor visibility, in ice flows, during flood conditions, debris flows, small craft advisories, gales, hurricanes, or other heavy surf conditions, whenever possible.

- Personnel should be familiar with and have the means to handle emergency situations, including man overboard, abandon ship, fire, loss of power or propulsion, storm, and use of emergency signaling devices, as well as how to recover a person in the water.
- Personnel should know what emergency and standard equipment is required on each TMR owned vessel, where it is located and how to operate that equipment.
- Detailed tide, current, and marine weather forecast should be obtained before commencing waterborne operations.
- Ensure that all equipment is secure or lashed properly when underway.
- Personnel should be familiar with, and anticipate water and weather states and conditions respectively, when mooring.

22.10 Vessel Registration

Each vessel operating on navigable waterways requires a state registration identification sticker or USCG Certification. The designated Equipment Manager will ensure that each TMR vessel maintains a current state registration for the state in which the vessel is located. Trailer registrations, if applicable, will also be kept up to date.

22.11 Chain of Command

22.11.1 Projects that are Captained and Crewed by a Subcontractor

The designated Captain of the vessel will have overall authority for the vessel and personnel aboard. They will work with the Project Manager, DS and SSHO to ensure the safety of all personnel.

22.11.2 Projects that are not Captained and Crewed by a Subcontractor

The Project Manager shall designate the vessel operator for each project. If a designee has not been assigned, the DS will assume or designate the position of vessel operator. The vessel operator has overall authority and responsibility ofthe crew, passengers, and vessel operations safety while moored or underway. Before embarking, the DS will assign crew positions and responsibilitiesto each team member. They will also designate a chain of command should the vessel operator become injured or is away from the vessel. The vessel operator will work with the DS and project SSHO to ensure the safety of all personnel.

22.12 Offshore Operations

When the vessel will be operating greater than 500 yards from the shoreline, in breaking waves, or in a strong current, additional safety precautions are warranted. Under such conditions, any vessel employed on a TMR assignment must adhere to the following:

- The vessel shall be operated by an experienced and qualified boat operator as approved by the Project Manager.
- The vessel operator must perform research on local conditions and be aware of potential hazards.

- A marine weather radio shall be on-board the vessel and periodically monitored to keep abreast of changing weather conditions.
- The vessel must be equipped with a backup propulsion system, such as an extra motor, that can return the vessel to a safe harbor in the event of failure of the primary propulsion system.
- The vessel shall be thoroughly examined by the vessel operator to verify the sound mechanical condition of the vessel and bilge pump, and the presence of appropriate safety equipment as designated above.

23.0 REQUIRED FORMS AND CHARTS

23.1 Forms

The vessel operator will ensure that all required forms are accurately and filled out before embarkation. Spare forms should be kept on board each TMR-operated vessel. The DOP and Attachment 11, Equipment Checklists, will provide the required forms listed below:

- BOAT PRE-OPERATION CHECKLIST
- DIVE EQUIPMENT CHECKLIST (GENERAL, MEDICAL, SCUBA, SADS)
- PRE-DIVE: SSA DIVE HELMET CHECKOFF SHEET
- PRE-DIVE: SURFACE SUPPLIED LIGHTWEIGHT (AGA)

23.2 Charts

The vessel operator will ensure that all required charts and maps for navigation to, from, and within the area of operations are on board before embarkation. All crewmembers will review and become familiar with these charts. These documents should be continually revised, as updates become available.

24.0 REFERENCES

ADCI (Association of Diving Contractors International). 2020. Consensus Standards for Commercial Diving Operations - Sixth Edition (Revision 6.4). Houston, TX. www.adc-int.org

CGA. 2018. G-7.1 Standards - Air quality standards; Compressed Gas Association. Chantilly, VA. www.cganet.com

DDESB (Department of Defense Explosives Safety Board). 2020. Technical Paper-18 Revision 1 - Minimum Qualifications for Personnel Conducting Munitions and Explosives of Concern-Related Activities. Washington, DC.

DOT (U.S. Department of Transportation). 2020. 49 CFR 178.37 - DOT Cylinder Maintenance, Retest and Certification Requirements. Washington DC. www.gpo.gov

OSHA (Occupational Safety and Health Administration). 2021. 29 CFR 1910.401 Subpart “T” - Commercial Diving Operations. Washington DC. www.osha.gov

OSHA (Occupational Safety and Health Administration). 2017. 29 CFR 1910.1020 Subpart Z (h)(1)(2) - Access to employee exposure and medical records. Washington DC. www.osha.gov

Tetra Tech Health and Safety Manual:

________ DCN 1-04, Recordkeeping and Reporting Requirements.[5]

________ DCN 02-02 Event Reporting and Investigation.[6]

________ DCN 02-15 Scientific Diving Program.[7]

________ DCN 3-02, MS 1, Physician’s Certification form.[8]

________ DCN 3-02, MS 2, Release of Medical and Exposure Records.[9]

[5] https://intranet.tetratech.com/healthsafety/Manual/DCN%2001-04%20Recordkeeping%20and%20Reporting%20Requirements.pdf
[6] https://intranet.tetratech.com/healthsafety/Manual/DCN%2002-02%20Incident%20Reporting%20and%20Investigation%20Program.pdf
[7] https://intranet.tetratech.com/healthsafety/Manual/DCN%2002-15%20Scientific%20Diving%20Program.pdf
[8] https://intranet.tetratech.com/healthsafety/Manual/DCN%2003-02F%20MS-1%20Physicians%20Certification%20Form.pdf
[9] https://intranet.tetratech.com/healthsafety/Manual/DCN%2003-02F%20MS- 2%20Release%20of%20Medical%20and%20Exposure%20Records.pdf

________ SWP 05-06 Working Over or Near Water.[10]

TMR (Tetra Tech Munitions Response):

________PO-08 – Document Control and Records Management.

________PO-18 – Warehouse Management.

________TMR HSE 01-10 – Boating

________TMR UXO SOP - Removal of MEC in a Marine Environment

________TMR UXO SOP - Underwater Intrusive Investigation Operations

USACE (U.S. Army Corps of Engineers).

________2014. EM 385-1-1, Section 30. Department of the Army, Washington DC. www.publications.usace.army.mil

USCG (U.S. Coast Guard). 46 CFR CH I Subpart "V" – Marine Occupational Safety and Health Standards - Shipping, Volume 7, Chapter 1 – Coast Guard, Part 197 – General Provisions, Subpart B. Commercial Diving Operations. Department of Transportation, Washington, DC. https://www.law.cornell.edu/cfr/text/46/part-197/subpart-B

USN (U.S. Navy). 2018. U.S. Navy Diving Manual, Volumes 1-5, Revision 7 Change A – Commander, Navy Sea Systems Command, Supervisor of Salvage and Diving. https://www.navsea.navy.mil/Portals/103/Documents/SUPSALV/Diving/US%20DIVING%20MANUAL_REV7_ChangeA-6.6.18.pdf

[10] https://intranet.tetratech.com/healthsafety/Manual/SWP%2005-06%20Working%20Over%20or%20Near%20Water.pdf

25.0 ATTACHMENTS

Attachment 1 – Diving Supervisor Dive Plan Brief

Attachment 2 – Diving Supervisor Pre-Dive Checklist

Attachment 3 – Diving Supervisor Post-Dive Checklist

Attachment 4 – Emergency Procedures

Attachment 5 – Emergency Phone Numbers Checklist

Attachment 6 – Working Dive Log

Attachment 7 – Dive Smooth Log

Attachment 8 – USN Diving Line Pull and Hand Signals

Attachment 9 – Cold Water Considerations and Safety Precautions

Attachment 10 – U.S. Navy Dive Tables

Attachment 11 – Equipment Checklists

GLOSSARY

Definitions are provided for the purpose of understanding their intent as they pertain to a procedure and projects requiring quality program planning. A Master List of Definitions is located in the CRL on the TMR intranet (https://tetratechinc.sharepoint.com/sites/OU-TMR). In addition, the definitions provided below are specific to this manual.

ASME Code or equivalent

ASME (American Society of Mechanical Engineers) Boiler and Pressure Vessel Code, Section VIII, or an equivalent code which the employer can demonstrate to be equally effective.

Arterial Gas Embolism (AGE)

An embolism caused by entry of gas bubbles into the arterial circulation system then act as blood vessel obstructions called emboli.

Atmosphere Absolute (ATA)

Total pressure exerted on an object, by a gas or mixture of gases at a specific depth or elevation, including normal atmospheric pressure.

Bell

An enclosed compartment pressurized (closed bell) or unpressurized (open bell), which allows the diver to be transported to and from the underwater work area and which may be used as a temporary refuge during diving operations.

Bottom Time

The total elapsed time from when the divers leave the surface to the time (rounded up to the next whole minute) they begin their ascent from the bottom or from the deepest depth attained. This time is measured in minutes.

Breath-Holding Diving

A diving mode in which the diver does not use a self-contained or surface-supplied air or oxygen supply.

Buddy Breathing

Sharing of a single air source between divers.

Buddy Diver

Second (paired) member of the dive team set.

Buddy System

Two comparably equipped self-contained underwater breathing apparatus (SCUBA) divers in the water in constant communication.

Buoyant Ascent

An ascent made using some form of positive buoyancy.

Bursting Pressure

The pressure under which a pressure-containment device would fail structurally.

Certified Diver

A diver who holds a recognized valid certification from an organizational member, internationally recognized certifying agency, or through military training.

Chairman, Diving Review Board (DRB)

A Tetra Tech member who is designated by the business unit leader, who manages and oversees the DRB.

Controlled Ascent

Any one of several kinds of ascents including normal, swimming, and air-sharing ascents where the diver(s) maintain control so a pause or stop can be made during the ascent.

Cylinder

A pressure vessel for the storage of gases.

Decompression Chamber

A pressure vessel for human occupancy. Also called a hyperbaric chamber.

Decompression Schedule

A specific decompression procedure for a given combination of depth and bottom time as listed in a decompression table. It is normally indicated as feet/minutes.

Decompression Sickness

A condition with a variety of symptoms, which may result from the presence of gas and bubbles in the tissues of divers after pressure reduction.

Decompression Table

A profile or set of profiles of depth-time relationship for ascent rates and breathing mixtures to be followed by divers after a specific depth-time exposure or exposures.

Decompression Time

Elapsed time from when the divers leave the bottom to the time when they reach the surface.

Descent Time

The total elapsed time from when the divers leave the surface to the time, they reach the bottom. Descent time is rounded up to the next whole minute.

Dive Computer

A microprocessor-based device that computes a diver's theoretical decompression status, in real time, by using pressure (depth) and time as an input to a decompression model, or set of decompression tables, programmed into the device.

Dive Location

The surface location from which diving operations are conducted, such as a vessel, barge, wharf, pier, riverbank or offshore rig.

Dive Location Reserve Breathing Gas

A supply system of air at the dive location that is independent of the primary system and enough to support divers during the planned decompression.

Dive Team

Divers and support employees involved in a diving operation, including the Diving Supervisor/Field Operations Lead.

Diver

An employee working in water using underwater apparatus, including snorkel, that supplies breathing gas at the ambient pressure.

Diver-Carried Reserve Breathing Gas

A diver-carried independent supply of air enough under standard operating conditions to allow the diver to reach the surface, or another source of breathing gas, or to be reached by another driver.

Diving Review Board

The TMR Review Board has oversight for all diving operations within the company. Board members will review the diving procedures and qualification of divers before authorization is given to conduct diving operations. The board is made up of qualified divers from the Marine Operations Group or TMR management team and approved by the President.

Diving Safety Officer

The individual who manages the diving safety and training programs on the Diving Review Board.

Diving Mode

A method of diving requiring specific equipment, procedures, and techniques (e.g., SCUBA, SSA, or snorkeling).

Equivalent Single Dive Time

The sum of the residual nitrogen time and the bottom time of a repetitive dive. Equivalent single dive time is used to select the decompression schedule for a repetitive dive. This time is expressed in minutes.

Heavy Gear

Deep-sea dress, including helmet, breast plate, dry suit, and weighted shoes. Advances in diving equipment and technology have led to heavy gear that does not include a breastplate. Surface-supplied diving gear, including helmet, dry suit, and weighted shoes (e.g., with the helmet directly connected to the dry suit, forming a self-contained pressure envelope for the diver) constitutes heavy gear as well.

Hyperbaric Conditions

Pressure conditions more than surface atmospheric pressure.

In-water stage

A suspended underwater platform that supports a diver in the water.

Lead Diver

A certified diver with the experience and training to lead the diving operations.

Live Boating

The practice of supporting a surface-supplied-air diver from a vessel which is underway

Mixed-Gas Diving

A diving mode in which the diver is supplied in the water with a breathing gas other than standard air.

No Decompression (No "D") Limits

The depth-time limits of the ‘‘no-decompression limits and repetitive dive group designation table for no-decompression air dives,’’ USN Diving Manual or equivalent limits which the employer can demonstrate to be equally effective.

Penetration Diving

Passing through an enclosure or limited access area where the diver’s tending line or umbilical requires tending by another diver.

Pressure-Related Injury

An injury resulting from pressure disequilibrium within the body as the result of hyperbaric exposure. Examples include decompression sickness, pneumothorax, mediastinal emphysema, air embolism, subcutaneous emphysema, or ruptured eardrum.

Pulmonary Over Inflation Syndrome

Disorders that are caused by gas expanding in the lungs, and include arterial gas embolism, pneumothorax, mediastinal and subcutaneous emphysema.

Recompression/Decompression Chamber

A pressure vessel for human occupancy, such as a surface decompression chamber, closed bell, or deep diving system, used to decompress divers and to treat decompression sickness.

Repetitive Dive

Any dives conducted within 12 hours of a previous dive.

Repetitive Group Designation

A letter that is used to relate directly to the amount of residual nitrogen remaining in a diver's body.

Residual Nitrogen

Nitrogen gas that is still dissolved in a diver's tissues after surfacing.

Residual Nitrogen Time

Time, in minutes, which must be added to the bottom time of a repetitive dive to compensate for the nitrogen still in solution in a diver's tissues from a previous dive.

Safety and Health Manager (SHM)

The individual responsible for all safety aspects of the diving evolution. The on-site SSHO qualified person reports to the SHM on all safety related matters.

Scientific Diving

Diving performed solely as a necessary part of a scientific, research, or educational activity by employees whose sole purpose for diving is to perform scientific research tasks. Scientific diving does not include performing any tasks usually associated with commercial diving such as: Placing or removing heavy objects underwater; inspection of pipelines and similar objects; construction; demolition; cutting or welding; or the use of explosives.

SCUBA Diving

A diving mode independent of a surface supply in which the diver uses an open-circuit self-contained underwater breathing apparatus.

Single Dive

Any dives conducted more than 12 hours after a previous dive.

Standby Diver

A designated safety diver at the dive location properly equipped and available to assist a working diver in the water.

Surface Air Delivery System

A SCUBA diving mode where the breathing gas is supplied from the surface on a floating platform by means of a pressurized umbilical hose and controlled by the diver. The umbilical consists of a low pressure gas supply hose, strength member, high pressure hose and gage. The umbilical is positively attached to the diver’s safety harness and supplies a full-face mask outfitted with a through water communication system

Surface Interval

The time a diver has spent on the surface following a dive. It begins as soon as the diver surfaces and ends as soon as he starts his next descent.

Surface-Supplied Air Diving

A diving mode where the breathing gas is supplied from the surface by means of a pressurized umbilical hose. The umbilical generally consists of a gas supply hose, strength member, pneumofathometer hose, and communication line. The umbilical supplies a helmet or full-face mask. The diver may rely on the tender at the surface to keep up with the diver's depth, time, and diving profile.

Tended/Marked Diver

A diver who has a buoy line to the surface or is tended by another diver located in the diving boat or on the surface platform.

Treatment Table

A USN developed and tested depth-time and breathing gas profile designed to treat decompression sickness or pulmonary over inflation syndromes.

Total Bottom Time

The total elapsed time from when the divers leave the surface to the time (rounded up to the next whole minute) they begin their ascent from the bottom or from the deepest depth attained. This time is measured in minutes.

Total Decompression Time

The total elapsed time from when the divers leave the bottom to the time to the time all decompression obligations are met. For No Decompression dives, this is the time the diver reaches the surface. This time is measured in minutes.

Total Time of Dive

The total elapsed time from when the divers leave the surface to the time (rounded up to the next whole minute) until the diver reaches the surface. This time includes all ascent delays and decompression time. This time is measured in minutes.

Umbilical

The composite hose bundle between a dive location and the diver or bell, or between a diver and a bell, which supplies the diver or bell with breathing gas, communications, power, or heat as appropriate to the diving mode or conditions. This includes a safety line between the diver and the dive location or dive bell.

Volume Tank

A pressure vessel connected to the outlet of a compressor and used as an air reservoir.

Working Pressure

The maximum pressure to which a pressure containment device may be exposed under standard operating conditions.

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ATTACHMENT 1

DIVING SUPERVISOR DIVE PLAN BRIEF

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ATTACHMENT 1
DIVING SUPERVISOR DIVE PLAN BRIEF

PROJECT NAME/NUMBER: ____

1. **NOTIFICATIONS –** The following list of notifications is not to be considered all-inclusive and should be modified to fit the intended task. Check off each representative as notified, include the phone number and person talked to:

   Harbor Master: ____

   Pipeline Manager: ____

   Boat Pilot: ____

   Port Services: ____

   Cognizant Authority: ____

   Ambulance/Air Evacuation: ____

   Recompression Chamber: ____

   Medical Facility: ____

   Coast Guard: ____

   U.S. Army Corps of Engineers Representative: ______________________________

   U.S. Navy Representative: ____

   Support Personnel: ____

2. **PERSONNEL ASSIGNMENTS**

   Diving Supervisor/Field Operations Lead: ______________________________

   Senior UXO Supervisor: ____

   Diver/s: ____

   Tender: ____

   Standby Diver: ____

ATTACHMENT 1
DIVING SUPERVISOR DIVE PLAN BRIEF

PROJECT NAME/NUMBER: ____

Tender: ____

Coxswain: ____

Assistance: ____

	YES	NO	COMMENTS
• Has any diver been diving in the last 12 hours?	_______	_______	_____________
• Is any diver taking any type of medication?	_______	_______	_____________
• Does any diver have any aches or pains?	_______	_______	_____________
• Can divers clear on the surface?	_______	_______	_____________
• Is any diver wearing contact lenses?	_______	_______	_____________
• Do divers feel well enough to make the dive?	_______	_______	_____________
• Do divers have any problem making the dive?	_______	_______	_____________
• Do divers know the emergency procedures for the diving mode?	_______	_______	_____________

3. **ENVIRONMENTAL DATA**:

Temperature: Water: ____________Air: ________________________________

Tide: High: ___________/___________ Low: ____________/___________

Visibility expected: ______________________ Bottom type: ______________________

Current speed/direction: ____

Wind Direction/Speed: ____________/_____________

Landmarks: ____

ATTACHMENT 1
DIVING SUPERVISOR DIVE PLAN BRIEF

PROJECT NAME/NUMBER: ____

Sunrise/Sunset: ______________/______________

Wave action: Height: _____________ Direction: ______________________________

Dive platform: ____

4. **OBJECTIVES:**

Purpose of the dive (TASK): ____

Location: ____
General comments: ____

Dive schedule: __________/__________ Depth: __________ Max depth: _________

Dive mode to be used: ____

5. **ANTICIPATED HAZARDS**:

Boating: ____

- o Ensure the "Code ALPHA" flag is flying from the vessel, or a 1-meter rigid "Code ALPHA" flag is prominently displayed from the non-vessel dive platform (pier, shore, etc.).
- o Ensure the "Divers down" flag is also displayed.

Climate: ____

Sea Life: ____

Expected Ordnance: ____

Pollution: ____

Other: ____

6. **EQUIPMENT REQUIREMENTS**:

Diving Mode: ____

ATTACHMENT 1
DIVING SUPERVISOR DIVE PLAN BRIEF

PROJECT NAME/NUMBER: ____

Search Equipment: ____

Recovery Equipment: ____

Explosive Disposal Equipment: ____

Special Task Equipment: ____

7. **GENERAL DIVING SAFETY PRECAUTIONS CHECKLIST**

- Ensure divers are physically and mentally ready to perform the assigned dive task.
- Determine the exact depth of the dive site through use of lead line or Fathometer.
- Gauge diving and emergency air cylinders prior to diving.
- All dives will be no-decompression dives.
- Ensure the dive platform is in a position for rapid and safe recovery of the divers.
- Each diver is responsible for the condition of his/ her own diving equipment.
- Ensure the standby diver is well briefed and ready to enter the water.
- The buddy system will be used whenever possible. If the buddy system is not used or inappropriate for the dive, the diver will be tended.
- Ensure the international code “alpha” and “divers down” are prominently displayed. If diving is not conducted from a vessel, then a 1-meter square rigid replica of the “alpha” flag will be displayed.
- Ensure divers are briefed and protected against local harmful marine life.
- The Diving Supervisor/ Lead Diver must be aware of local ship and small boat traffic in the vicinity of the diving operation.
- Ensure the appropriate diving mode and dress have been selected for the task at hand.
- All dives conducted where there is not free access to the surface must be tended dives.
- Do not inflate life jacket or BCD where ascent to the surface is restricted.
- The Diving Supervisor/ Lead Diver will use the Pre-dive and Post-dive check-off sheets, Attachment 2 and 3, respectively.
- Review the methods of diver recall in accordance with the HASP.
- The dive will be aborted in the event of any equipment malfunction.
- Inflate your life vest if surfacing with injuries or excessive fatigue.
- Use the proper ascent and descent rates of 75 feet per minute for descent and 30 feet per minute for ascent.
- Divers will not position themselves between any objects (camels, pier, boat, etc.).

ATTACHMENT 1
DIVING SUPERVISOR DIVE PLAN BRIEF

PROJECT NAME/NUMBER: ____

- Brief task-specific safety precautions (UXO diving, altitude diving, ordnance/ explosive safety, etc.).
- Brief special line-pull signals Attachment 8.
- Brief appropriate ordnance safety precautions.
- If necessary, review cold water precautions (EHS 2-02 Attachment 9).

8. **COMMUNICATIONS:**

Radio frequency: ____

Radio call signs:

Primary: ____

Secondary: ____

Telephone location: ____

Site cell phone number: ____

Other cell phones: ____

9. **SPECIAL CONSIDERATIONS**:

Meals: ______________ Water: _______________ Heat source: _______________

Clothing change: ____

10. **EMERGENCY PROCEDURES**: Review as outlined in Project HASP and DSPM (EHS 2-02 Attachments 4 and 5).

ATTACHMENT 2

DIVING SUPERVISOR PRE-DIVE CHECKLIST

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ATTACHMENT 2

DIVING SUPERVISOR PRE-DIVE CHECKLIST

PROJECT NAME/NUMBER:____

1. DIVING SUPERVISOR PRE-DIVE CHECKLIST FOR SCUBA DIVING

a. All divers shall have the following equipment, at a minimum:

_______ Proper dress for dive conditions, dry/wet suit, coveralls

_______ Safety Harness w/tending line or witness float attached for single diver
***NOTE*: Mandatory for projects which fall under EM385-1-1 (if any diver is tended).**

_______ Adequate emergency breathing supply with separate independent regulator

_______ SCUBA with regulator

_______ Buoyancy Compensator (BC)

_______ Submersible cylinder pressure gauge

_______ Weight belt

_______ Mask

_______ Knife

_______ Depth gauge

_______ Diving watch or diving computer

_______ Fins

_______ Cylinder pressure is adequate for both the emergency air supply ***(90% capacity @ 2700 psig)*** and primary SCUBA supply ***(2500 psig minimum)***.

_______ All quick-release buckles and fastenings can be reached by either hand and are properly rigged for quick release.

_______ Weight belt is outside of all other belts, straps, and equipment, and is not likely to become pinched under the bottom edge of the cylinders.

_______ Buoyancy Compensator is not constrained, is free to expand.

_______ Check position of the knife to ensure that it will remain with the diver no matter what equipment he may jettison.

_______ Conduct time check and synchronize watches.

ATTACHMENT 2

DIVING SUPERVISOR PRE-DIVE CHECKLIST

PROJECT NAME/NUMBER:____

_______ Open cylinder valve and then back off 1/4 to 1/2 turn.

_______ Ensure all inflation hoses are attached and function properly.

_______ Depth gauge is zeroed.

_______ AGA/ FFM Pre-Dive Checks (Skip if not applicable):

- Adjust pressure equalizer pad.
- Ensure all screws on mask are tight, and exhaust valve retaining ring is tight.
- Check connection from mask to supply hose.
- Check comm wire connection and through water transmitter.
- Don Mask.
- Inhale deeply to turn on positive pressure. (If equipped)
- Check positive pressure flow.

_______ Have diver breathe for 30 seconds. While doing this, diver should be alert for any impurities in the air or for any unusual physiological reactions.

_______ Conduct final review of the dive plan.

_______ Brief the divers on the following reasons for terminating the dive:

- The diver requests termination.
- The diver fails to respond correctly to communications or signals.
- Communications are lost and cannot be quickly reestablished.
- The diver begins to use his/her reserve breathing air.
- Puncture/tear of a dry suit.

_______ Divers physically and mentally ready to enter the water.

_______ Ladder is in place to retrieve divers from water.

_______ Divers know the maximum depth and bottom time.

_______ Review proper/special line pull signals.

_______ Code Alpha and Divers Down flags are displayed.

_______ Conduct Dive Supe checks on Standby diver.

_______ Ensure standby diver knows searching signals.

_______ Verify that personnel and equipment are ready to give proper visual, sound, or radio signals to warn off other vessels.

_______ Ensure O_2 kit is on dive station with adequate supply, and the O2 bottle has been gauged and documented.

_______ Diver or divers are now ready to enter the water.

ATTACHMENT 2

DIVING SUPERVISOR PRE-DIVE CHECKLIST

PROJECT NAME/NUMBER:____

b. Surface Check :

_______ Conduct a breathing check of the SCUBA. Breathing should be easy, without resistance, and with no evidence of water leaks.

_______ Visually check dive partner's equipment for leaks, especially at all connection points (cylinder valves hoses at regulator and mouthpiece).

_______ Check face mask seal.

_______ Check partner for loose or entangled straps.

_______ Check buoyancy. SCUBA divers should strive for neutral buoyancy.

_______ If divers are wearing a dry suit, check valve function and for leaks.

_______ Orient yourself with your surroundings. Note any obstructions that you may encounter upon surfacing.

NOTES:

1. ***Ensure divers are not sick or have not been recently treated for an injury or illness.***
2. ***Ensure all dive station personnel are monitored during surface intervals when extreme weather conditions exist.***

ATTACHMENT 2

DIVING SUPERVISOR PRE-DIVE CHECKLIST

PROJECT NAME/NUMBER:____

2. DIVING SUPERVISOR'S PRE-DIVE CHECKLIST FOR SURFACE-SUPPLIED DIVING

__CAUTION__**:** ***This checklist is an overview intended for use with the detailed Operating Procedures (OPs) from theappropriate equipment checklists as outlined in Attachment 11 and the specific equipment O&M technical manual*****.**

a. Basic Preparation:

_______ ***Dives deeper than 100 FSW or dives requiring decompression***, verify that a recompression chamber is present on the diving station and is on line.

_______ Verify that proper signals indicating underwater operations being conducted are displayed correctly.

_______ Ensure that all personnel concerned, or in the vicinity, are informed of diving operations.

_______ Determine that all valves, switches, controls, and equipment components affecting diving operations are tagged-out to prevent accidental shut-down or activation.

b. Equipment Protection:

_______ Assemble all members of the diving team and support personnel (winch operators, boat crew, etc.) for a pre-dive briefing.

_______ Assemble and lay out all dive equipment, both primary equipment and standby spares for diver (or standby diver), including all accessory equipment and tools.

_______ Check all equipment for superficial wear, tears, dents, distortion, or other discrepancies.

_______ Check all masks, helmets, view ports, faceplates, seals, and visors for damage.

_______ Check all harnesses, laces, strain relief, and lanyards for wear; replace as needed.

c. Helmets and Masks:

_______ Ensure that all set up and operating procedures have been completed in accordance with the appropriate Technical Manual and Operating Procedures.

d. General Equipment:

_______ Check that all accessory equipment – tools, lights, special systems, spares, etc. are on site and in working order. In testing lights, tests should be conducted with lights submerged in water and extinguished before removal, to prevent overheating and failure.

PROJECT NAME/NUMBER:____

_______ Erect diving stage or attach diving ladder. In the case of the stage, ensure that the screw pin shackle connecting the stage line is securely fastened with the shackle pin seized with wire or a safety shackle is used to help prevent opening.

_______ Ensure first aid kits, portable O_2, and automatic external defibrillators are available and working.

e. Preparing the Diving System:

_______ Check that a primary and suitable back-up air supply is available with a capacityin terms of purity, volume, and supply pressure to completely service all divers and standby diver, including decompression, recompressions, and accessory equipment throughout all phases of the planned operation.

_______ Verify that all diving system operating procedures have been conducted to properly align the dive system.

_______ Ensure that qualified personnel are available to operate and stand watch on the dive system.

f. Compressors:

_______ Determine that sufficient fuel, coolant, lubricants, and antifreeze are available to service all components throughout the operation. All compressors should be fully fueled, lubricated, and serviced (with any spillages cleaned up completely).

_______ Check maintenance and repair logs to ensure the suitability of the compressor (both primary and back-up) to support the operation.

_______ Verify that all compressor controls are properly marked, and appropriate valves are tagged with "***Divers Air Supply - Do Not Touch***" signs.

_______ Ensure that the compressor is secure in the diving craft and will not be subject to operating angles, caused by roll or pitch that will exceed 15 degrees from the horizontal.

_______ Verify that oil in the compressor is an approved type. Check that the compressor oil does not overflow the FULL mark; contamination of air supply could result from fumes or oil mist.

_______ Check that compressor exhaust is vented away from work areas and, specifically, does not foul the compressor intake.

_______ Check that compressor intake is obtaining a free and pure suction without contamination. Use pipe to lead intake to a clear suction location if necessary.

_______ Check all filters, cleaners, and oil separators for cleanliness.

ATTACHMENT 2

DIVING SUPERVISOR PRE-DIVE CHECKLIST

PROJECT NAME/NUMBER:____

_______ Bleed off all condensed moisture from filters and from the bottom of volume tanks. Check all manifold drain plugs, and that all petcocks are closed.

_______ Check that all belt-guards are properly in place on drive units.

_______ Check all pressure-release valves, check valves and automatic unloaders.

_______ Verify that all supply hoses running to and from compressor have proper leads, do not pass near high-heat areas such as steam lines, are free of kinks and bends, and are not exposed in such a way that they could be rolled over, damaged, or severed by machinery or other means.

_______ Verify that all pressure supply hoses have safety lines and strain reliefs properly attached.

g. Activate the Air Supply in accordance with approved Operating Procedures:

i. Compressors:

_______ Ensure that all warm-up procedures are completely followed.

_______ Check all petcocks, filler valves, filler caps, overflow points, bleed valves, and drain plugs for leakage or malfunction of any kind.

_______ Verify that there is a properly functioning pressure gauge on the air receiver and that the compressor is meeting its delivery requirements.

ii. Cylinders:

_______ Gauge all cylinders for proper pressure.

_______ Verify availability and suitability of reserve cylinders.

_______ Check all manifolds and valves for operation.

_______ Activate and check delivery.

For all supply systems, double check "Do Not Touch" tags (tag out).

h. Diving Hoses:

_______ Ensure all hoses have a clear path and are protected from excessive heating and damage.

_______ Ensure that the hose (or any length) has not been used in a burst test program. No hose length involved in such a program will be part of an operational diving hose.

_______ Check that hoses are free of moisture, packing material, or chalk.

ATTACHMENT 2

DIVING SUPERVISOR PRE-DIVE CHECKLIST

PROJECT NAME/NUMBER:____

_______ Soap test hose connections after connection to air supply and pressurization.

_______ Ensure umbilical boots are in good condition.

i. Test Equipment with Activated Air Supply:

_______ Hook up all air hoses to helmets, masks, and chamber; make connections between back-up supply and primary supply manifold.

_______ Verify flow to helmets and masks from primary and secondary air supply.

_______ Check all exhaust and non-return valves.

_______ Hook up and test all communications.

_______ Check air flow from both primary and back-up supplies to chamber.

j. Recompression Chamber Checkout (Pre-dive only):

_______ Check that chamber is completely free and clear of all combustible materials.

_______ Check primary and back-up air supply to chamber and all pressure gauges.

_______ Check that chamber is free of all odors or other "contaminants."

_______ Hook up and test all communications.

_______ Check air flow from both primary and back-up supplies to chamber.

k. Final Preparations:

_______ Verify that all necessary records, logs, and timesheets are on the diving station.

_______ Check that appropriate decompression tables are readily at hand.

_______ Place the dressing bench in position, reasonably close to the diving ladder or stage, to minimize diver travel.

l. Dress Diver/s:

_______ Dress divers in accordance with requirements of approved workplan and in considerations of the site environmental conditions.

ATTACHMENT 3

DIVING SUPERVISOR POST-DIVE CHECKLIST

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ATTACHMENT 3

DIVING SUPERVISOR POST-DIVE CHECKLIST

PROJECT NAME/NUMBER:____

______ Check the physical condition of the diver.

______ Instruct the diver to report any physical problems or adverse physiologicaleffects including symptoms of decompression sickness.

______ Advise the diver of the location of the closest recompression chamber that isready for use.

______ Alert the diver to the potential hazards of ascending to altitude, including flyingafter diving (see DSPM Section 18)

______ Assemble diving equipment and return to site support facility.

______ Have divers shower and consume warm liquids, avoid beverages with caffeine.

______ Observe the divers on the surface for symptoms of diving disorders for aminimum of 10 minutes before allowing the divers to leave the dive site.

______ Wash all diving equipment in fresh water and hang to dry.

______ Reorder/replace equipment as necessary.

______ Complete a dive profile log for all divers and submit the log to the Chairman ofthe Diving Review Board for input into TMR's master dive log.

ATTACHMENT 4

EMERGENCY PROCEDURES

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ATTACHMENT 4
EMERGENCY PROCEDURES

GENERAL EMERGENCY PROCEDURES

1. Decompression Sickness or Arterial Gas Embolism:

- Recall all divers.
- Administer first aid, CPR and emergency O_2 as required.
- Notify Recompression Chamber.
- Begin transport to chamber on oxygen.

2. Fire in equipment:

- Evaluate effect of fire on diver AND topside crew.
- Terminate dive.
- Inform crew and diver of action planned.
- Activate plan outlined in Project DOP.

3. Explosive Detonation with Divers in the Water:

- Try to establish communications with the divers using standard line pull signals or communications.
- If contact is established with the divers, recall, recover, and administer first aid as required. Transport in accordance with project DOP as required.
- If communications cannot be established, activate the standby diver and recover the divers via the tending line, and administer first aid as required.
- Request medical assistance and remember that unconscious divers should be treated for possible AGE
- Discontinue diving operations until the cause of the explosion is determined.

4. Boat breakdown:

This situation is considered to constitute an emergency due to the loss of control of the divers.

- Recall and recover the divers.
- Discontinue diving operations.
- Deploy the anchor
- Request assistance via radio, phone, or signals.

5. Variations in ascent rate:

Always ascend at a rate of 30 feet per minute (FPM) (20 seconds per 10 feet of seawater [FSW]). Minor variations in the rate of travel between 20 and 40 FSW/minute are acceptable. Any variation in the rate of ascent must be corrected in accordance with the following procedures; however, a delay of up to 1 minute in reaching the first decompression stop can be ignored.

- **Travel Rate Exceeded.** On a Standard Air Dive, if the rate of ascent is greater than 30 FPM, STOP THE ASCENT, allow the watches to catch up, and then continue ascent. If the decompression stop is arrived at early, start the stop time after the watches catch up.

- **Delay greater than 1 minute, deeper than 50 FSW**. Add the total delay time (rounded up to the next whole minute) to the bottom time, re-compute a new decompression schedule, and decompress accordingly.
- **Delay greater than 1 minute, shallower than 50 FSW**. If the rate of ascent is less than 30 FPM, add the delay time to the diver's first decompression stop. If the delay is between stops, disregard the delay. The delay time is rounded up tothe next whole minute.

6. Unplanned Ascent (Blowup):

- **Ascent from 20 Feet or Shallower with No Decompression Stops Required.**No recompression is required if the diver surfaces from 20 feet or shallower but was within no-decompression limits and is asymptomatic. The diver should be observed on the surface for 1 hour. Consider administering O_2.
- **Ascent from 20 Feet or Shallower (Shallow Surfacing) with Decompression Stops Required.** If decompression is required and the diver surfaces from 20 FSW or shallower (missed the 20- and/or 10-foot stop) and is asymptomatic, thediver is returned to that decompression stop.
    - o If the time from the surface back to the stop was less than 1 minute,add 1 minute to the stop.
    - o If the time from the surface back to the stop was more than 1 minute andthe diver remains asymptomatic, multiply the 20- and/or 10-foot stops by1.5.
    - o Observe diver for 1 hour. Consider administering O_2.
- **Ascent from Deeper than 20 Feet (Uncontrolled Ascent).** Any unexpected surfacing of the diver from depths in excess of 20 feet is considered an uncontrolled ascent. If the diver is within no-decompression limits and asymptomatic, he/she should be observed for at least 1 hour on the surface. Recompression is not necessary unless symptoms develop. Consider administering emergency O_2.
- **Asymptomatic Uncontrolled Ascent.** Asymptomatic divers who experience an uncontrolled ascent and who have missed decompression stops are treated by recompression based on the amount of decompression missed as follows:
    - o **Oxygen Available.** Immediately compress the diver to 60 feet in the recompression chamber. If less than 30 minutes of decompression (total ascent time from the tables) was missed, decompress from 60 feet on appropriate Treatment Table. If more than 30 minutes of decompressionwas missed, decompress from 60 feet on appropriate Treatment Table.
    - o **Oxygen Not Available**. If less than 30 minutes of decompression was missed, compress the diver to 100 feet in the recompression chamber andtreat on appropriate Treatment Table. If more than 30 minutes was missed, compress to 165 feet and treat on appropriate Treatment Table.

- **Symptomatic Uncontrolled Ascent.** If a diver has had an uncontrolled ascent and has any symptoms, he/she should be recompressed immediately in a recompression chamber to 60 FWS.
  - If the diver surfaced from 60 FWS or shallower, compress to 60 FSW and begin appropriate Treatment Table.
  - If the diver surfaced from a greater depth, compress to 60 FSW or depth where the symptoms are significantly improved, not to exceed 165 FSW, and begin appropriate Treatment Table.

7. Emergency Evacuation:

- Notify diver and dive team of emergency and abort dive.
- Evacuate all unnecessary personnel.
- Decompress the diver (if required) and recover. If decompression is not possible, follow omitted decompression procedures.

ATTACHMENT 4

EMERGENCY PROCEDURES

SCUBA EMERGENCY PROCEDURES

1. **Buddy Separation** – Make a 360-degree check, above and below; if your buddy is not found, surface immediately. Check the surface for bubbles and notify the Diving Supervisor/ Lead Diver immediately.
2. **Lost Diver** – The first stage of a lost diver is when communications have been lost and emergency recall has failed.
   - Initiate diver recall.
   - Wait 1 minute for response.
   - Deploy lost diver buoy.
   - Deploy standby diver (Dive Supervisor's/ Lead Diver's discretion); follow bubblesor conduct expanding circle line search from last known position.
   - Notify ships/ boats in the area to look out for lost diver and request assistancefrom the Coast Guard Rescue Center, if necessary.
3. **Loss of Air/Equipment Malfunction (SCUBA)**
   - Signal buddy/surface and abort dive.
   - Buddy breath/activate reserve/breath from emergency air supply.
   - Exhale to the surface.
4. **Mechanical Injury:**
   - Signal buddy/surface and abort dive.
   - Inform DS.
   - Rule out possible decompression sickness.
   - If immediate treatment required, recall all divers and transport to hospital.
5. **Fouled/Trapped Diver:**
   - Don't panic, stop and think!
   - Notify your buddy diver or topside, if possible (2-2-2 fouled and need assistance,or 3-3-3 fouled and can clear myself).
   - Carefully and calmly try to work yourself free of the entanglement.
   - If required, ditch your equipment and make a buoyant ascent to the surface.
   - If the diver is trapped, the buddy diver should mark the position of the trapped diver with a circle line, his tending line or any available method of marking the trapped diver's position, and then surface and report to the Diving Supervisor.
   - The Diving Supervisor/ Lead Diver will formulate a rescue plan, while the diver delivers additional air to the trapped diver.
   - The DS will then brief the rescue plan to the dive teamand execute the rescue.

ATTACHMENT 4

EMERGENCY PROCEDURES

SURFACE-SUPPLIED AIR EMERGENCY PROCEDURES

1. Loss of Breathing Media

- Re-establish breathing media supply:
    - o Activate topside secondary breathing media supply
    - o Diver initiate emergency procedure using bailout bottle.
    - o **<u>ONLY AS A LAST RESORT</u>** – Pressurize the diver's pneumofathometer hose (135 PSI) and have the diver insert the hose into his/her helmet or mask.
- Alert standby diver.
- Have stricken diver go to bell, stage, or ladder.
- If required, send standby diver to assist.
- Terminate dive.

2. Loss of Communications

- Attempt to establish communications with line pull signals.
- Put constant air to the diver's pneumofathometer.
- Alert standby diver.
- If communications are established using line pull signals, abort dive, and decompress if required.
- If communications are not established, send stand-by diver to diver's assistance, abort dive, and decompress if required.

3. Fouled or Trapped Diver

- Avoid panic and ensure diver does NOT ditch equipment.
- Diver informs topside — gives a detailed report.
- Alert standby diver.
- Diver determines the extent of entrapment.
- Diver attempts to free yourself.
- If required, deploy standby for assistance.
- Abort dive and decompress if required

4. Injury in the Water

- Diver informs topside of injury and extent — gives a detailed report.
- Alert standby diver.

- If required, deploy standby diver to assist stricken diver.
- Abort dive and follow decompression protocol unless injury indicates a greater risk than omitted decompression. Check surface decompression tables for alternate protocol.
- Request required medical assistance.

5. Severance of Divers Air Supply

- Diver initiates emergency procedure using bailout bottle.
- **If pneumofathometer hose intact and then ONLY AS A LAST RESORT**— Pressurize the diver's pneumofathometer hose (135 PSI) and have the diver insert the hose into his helmet or mask.
- Alert standby diver.
- Abort dive and decompress.
- Deploy standby diver with more air and/or assist stricken diver if required.

6. Severance of Complete Umbilical

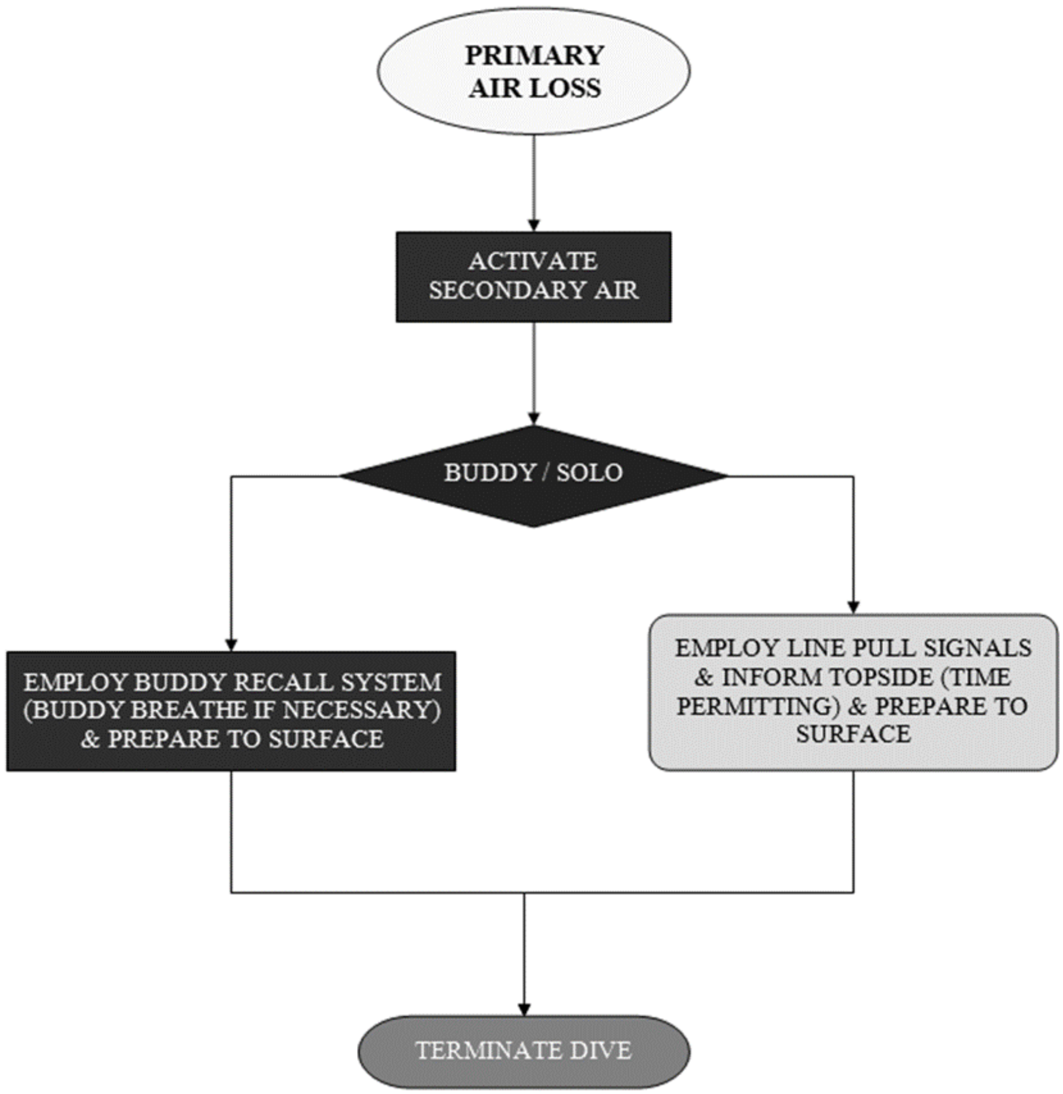
- Diver initiates emergency procedure using bailout bottle.
- Topside alerts standby diver.
- Deploy standby diver down stage line, diver's umbilical (if visible), or descent linewith additional air supply (pneumofathometer, if necessary) to assist stricken diverand inform topside of conditions.
- Abort dive and decompress. Check surface decompression tables for shorter water time.

ATTACHMENT 4

EMERGENCY PROCEDURES

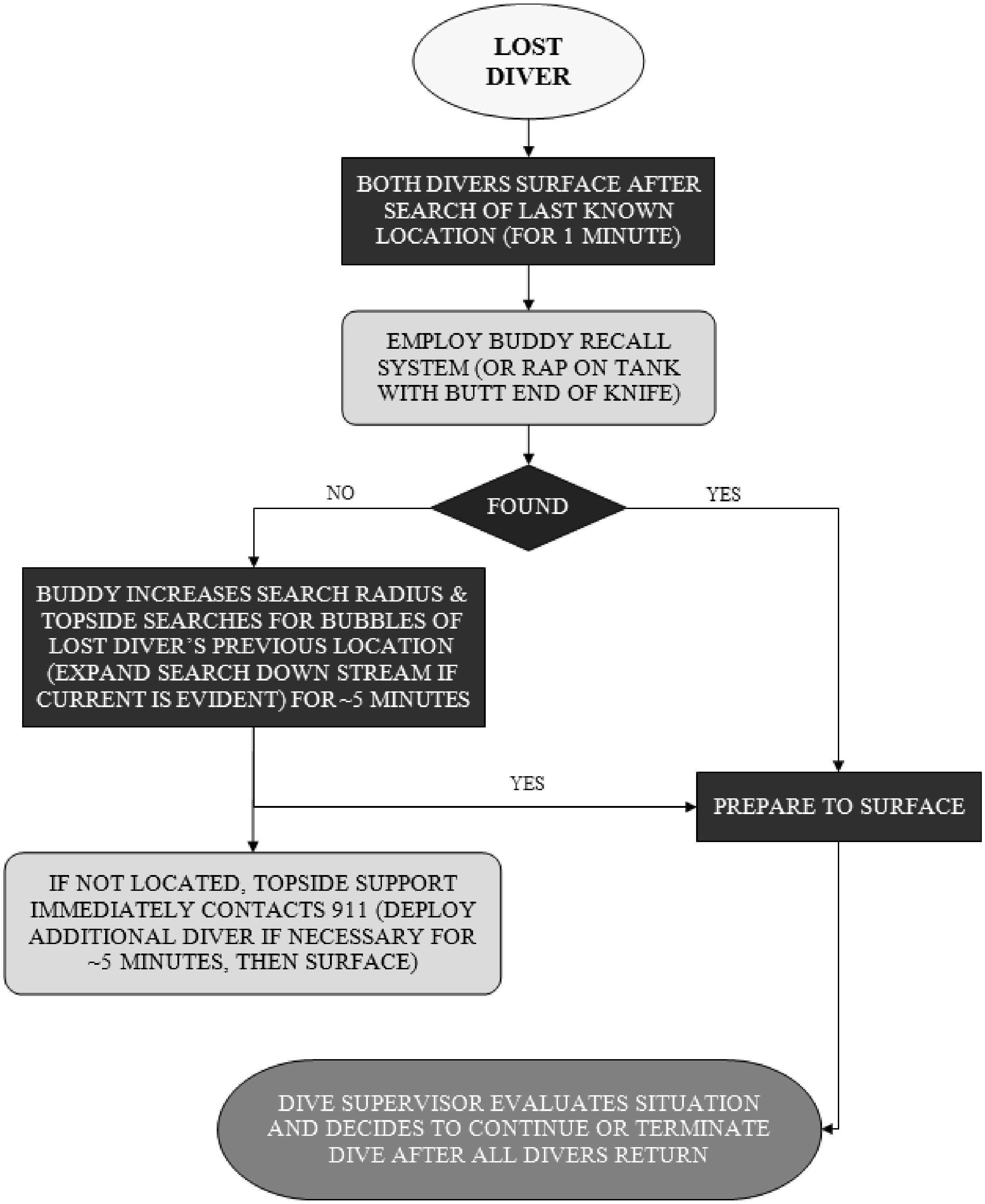
DIVING EMERGENCY DECISION FLOW CHARTS

SCUBA EMERGENCY PROCEDURES



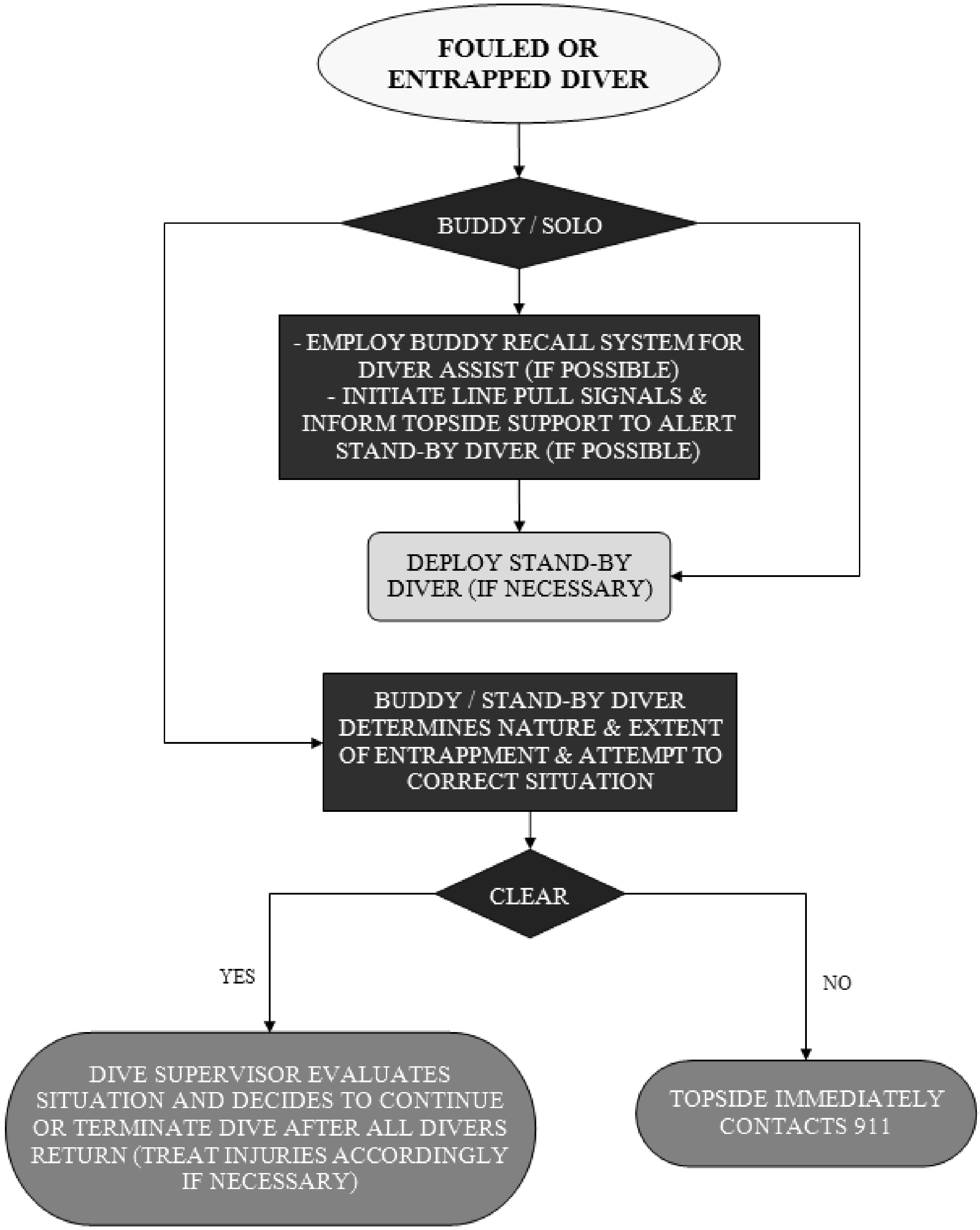
ATTACHMENT 4

EMERGENCY PROCEDURES



ATTACHMENT 4

EMERGENCY PROCEDURES



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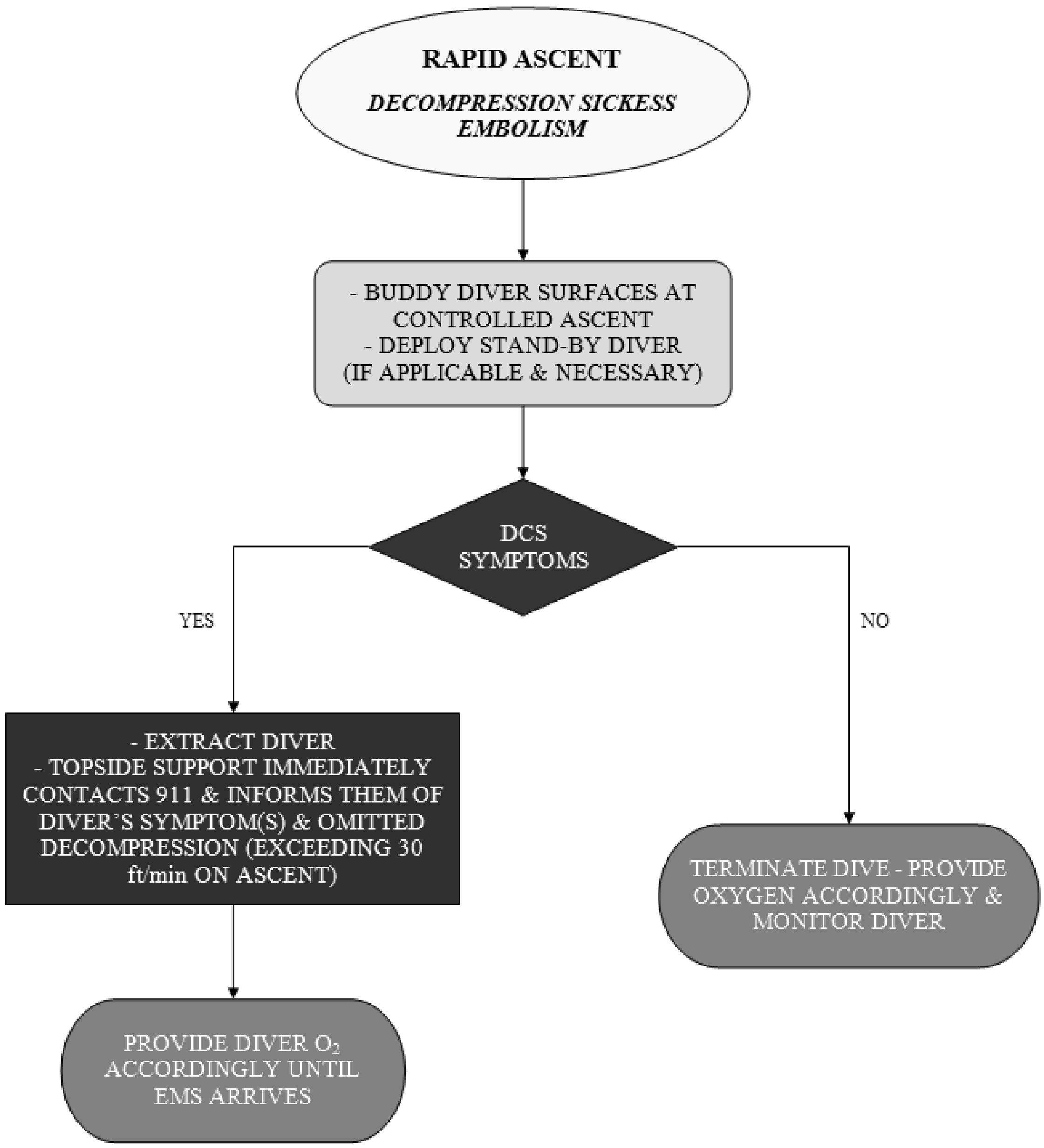
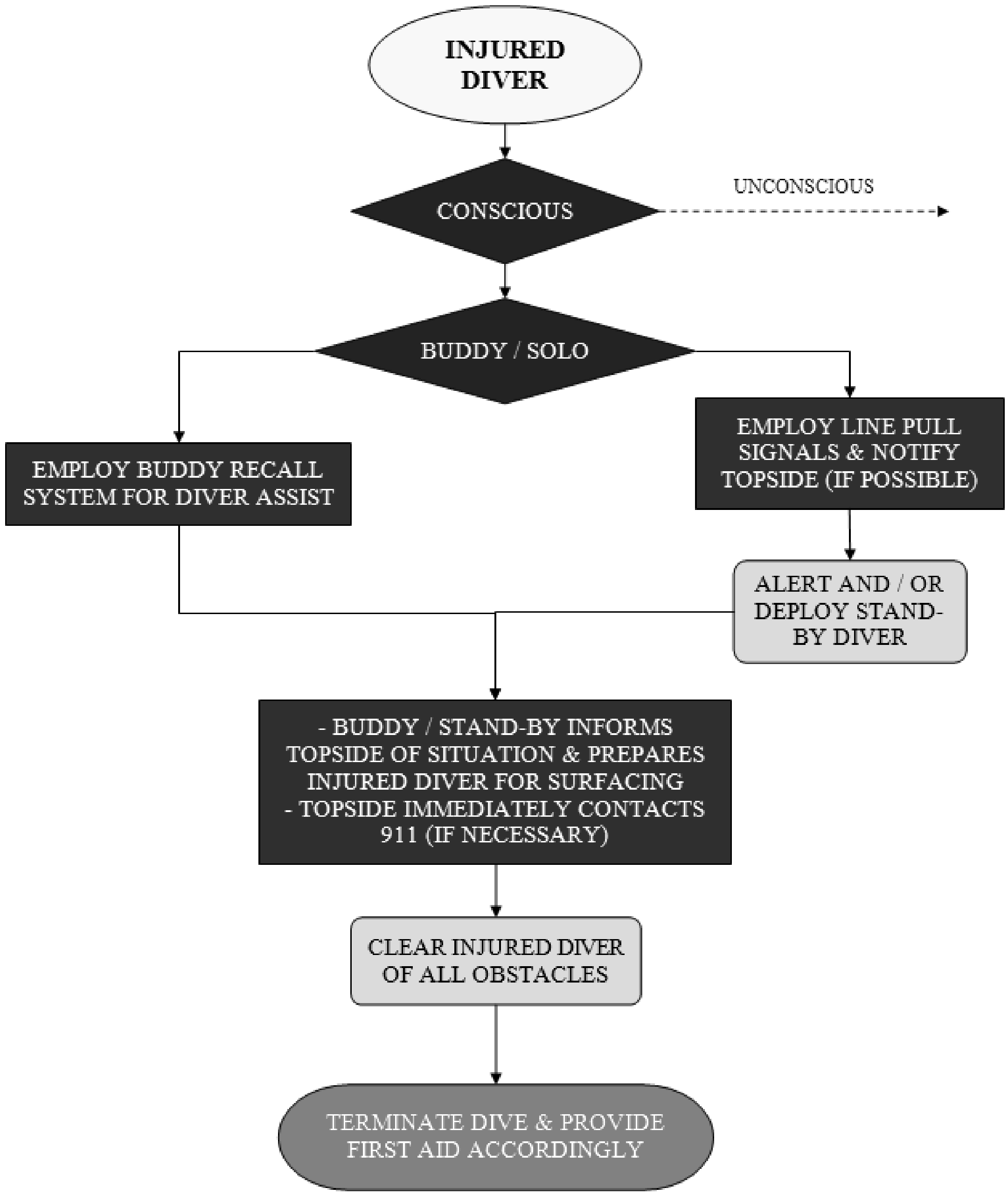


ATTACHMENT 4
EMERGENCY PROCEDURES



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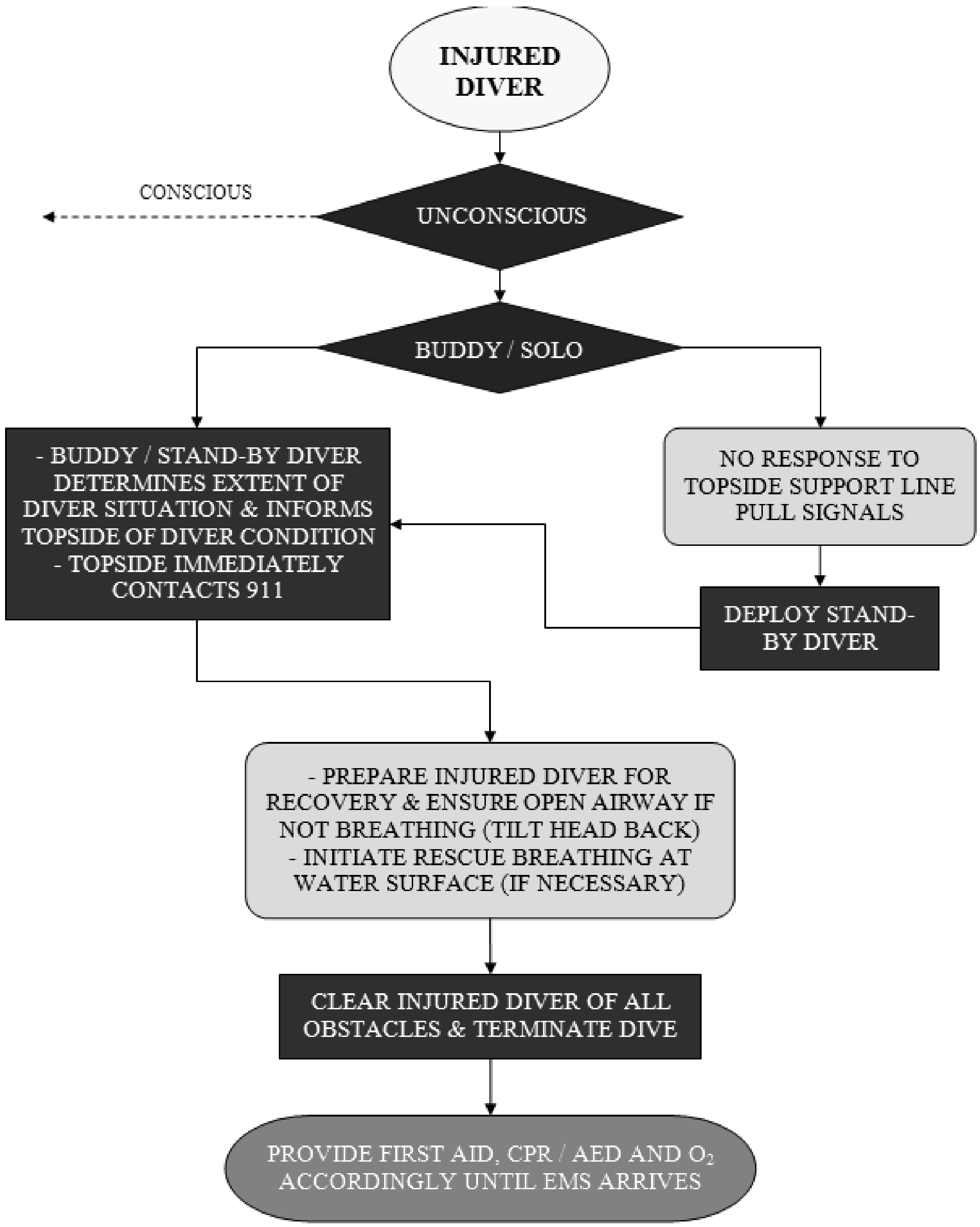
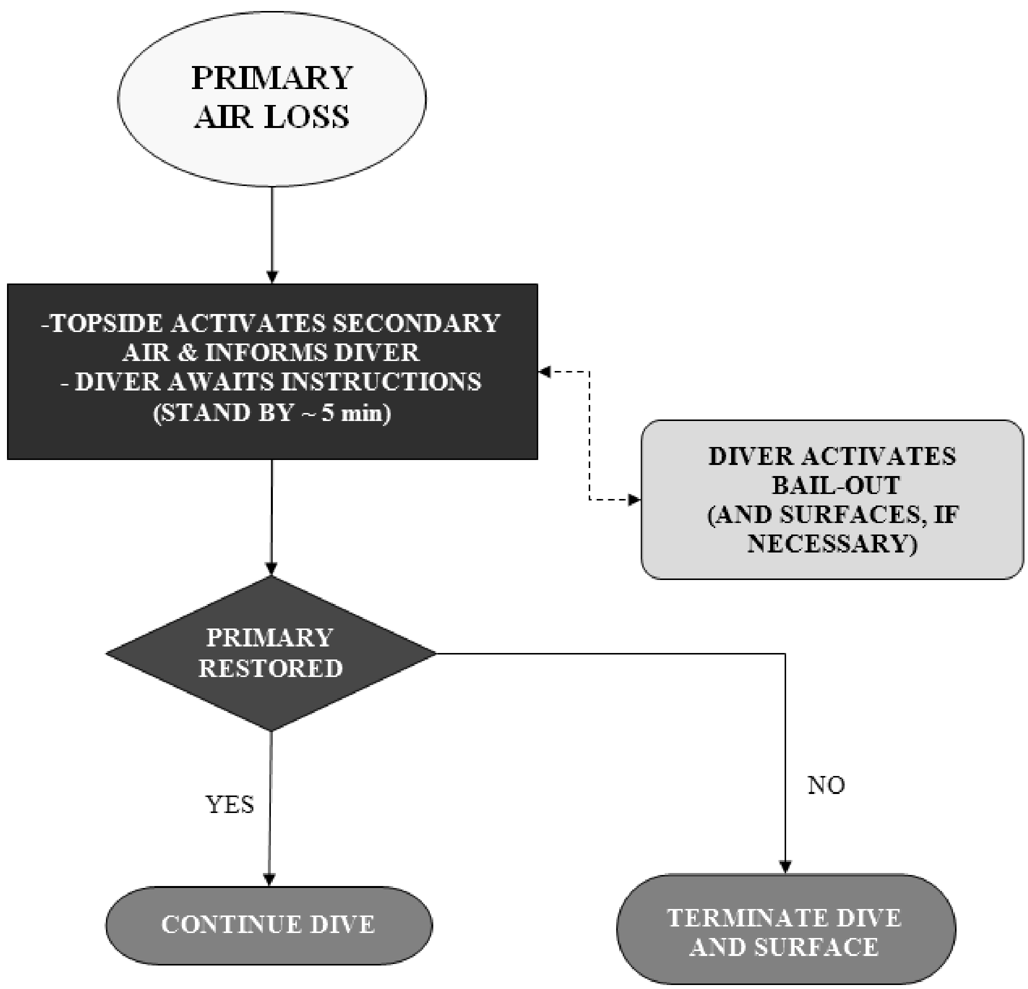
EMERGENCY PROCEDURES



ATTACHMENT 4
EMERGENCY PROCEDURES

SURFACE SUPPLIED EMERGENCY PROCEDURES



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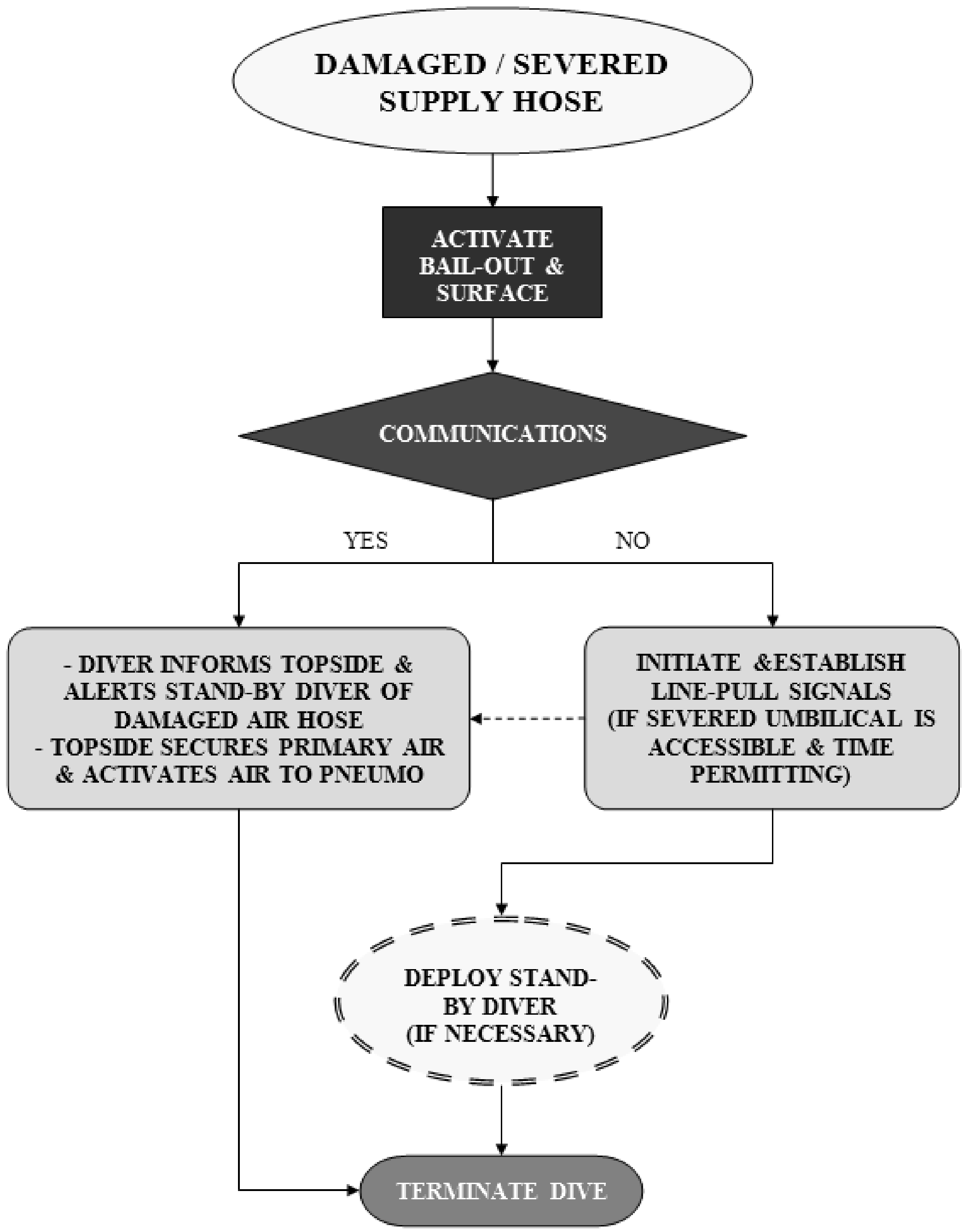
EMERGENCY PROCEDURES



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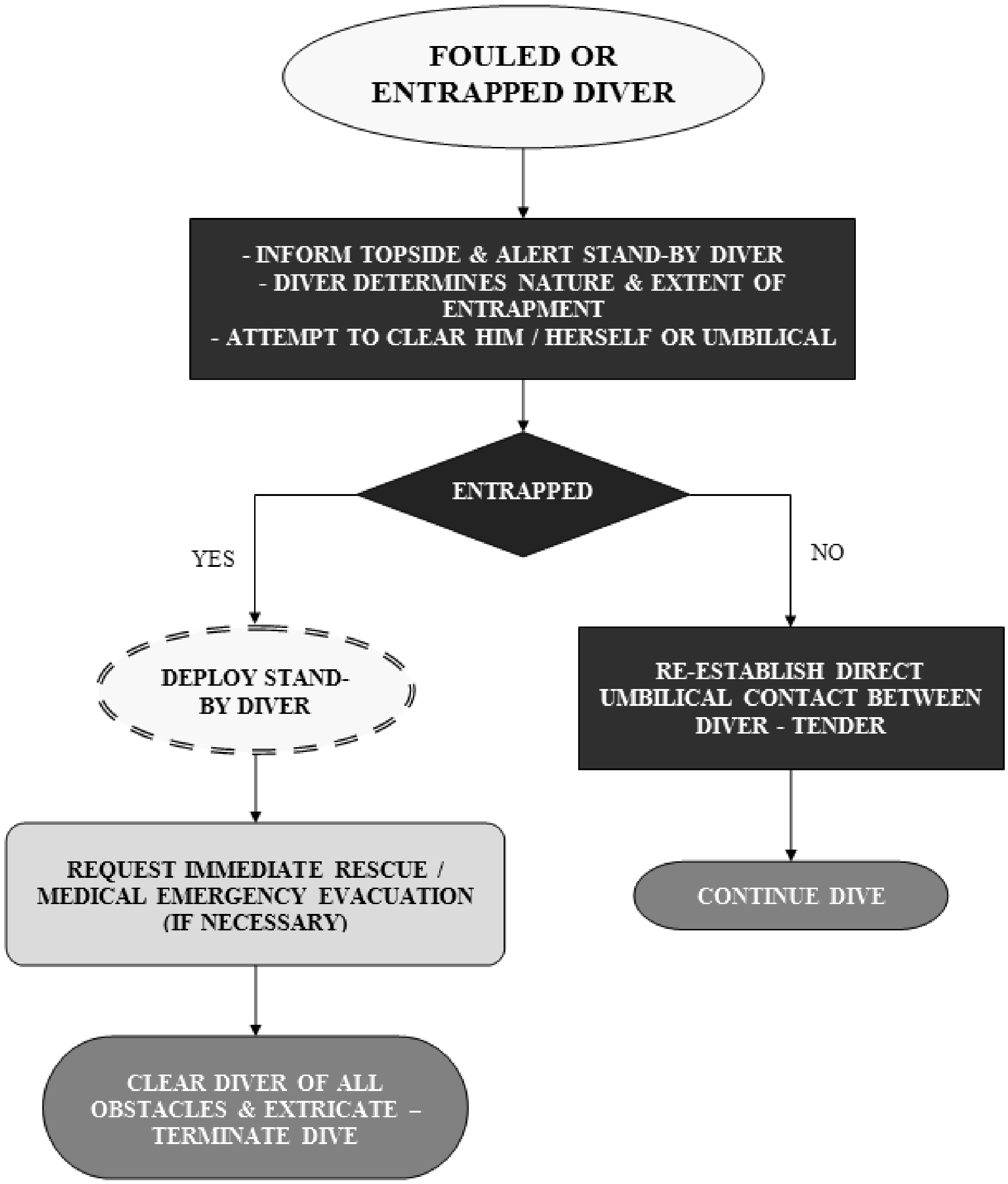
EMERGENCY PROCEDURES



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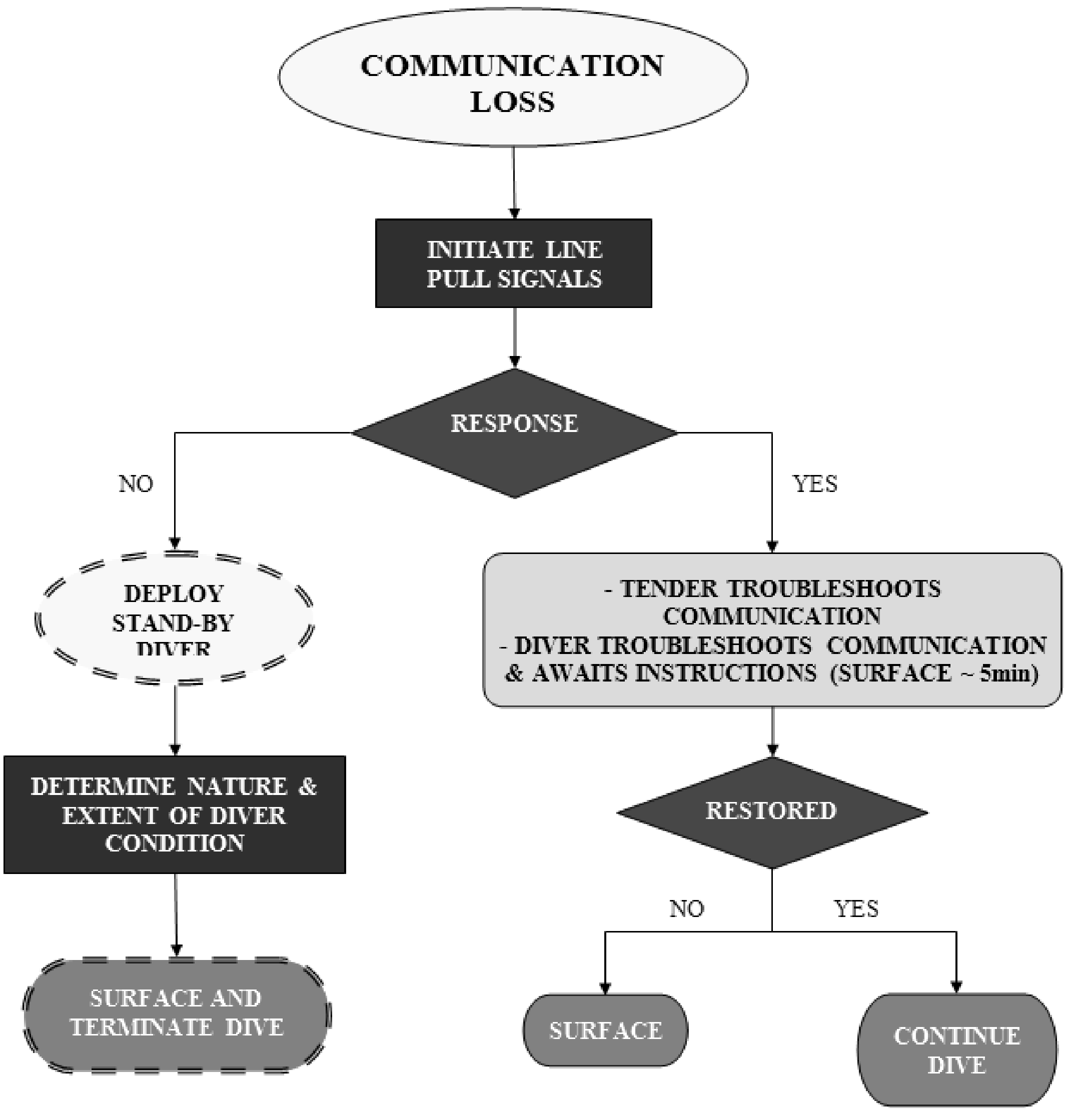
EMERGENCY PROCEDURES



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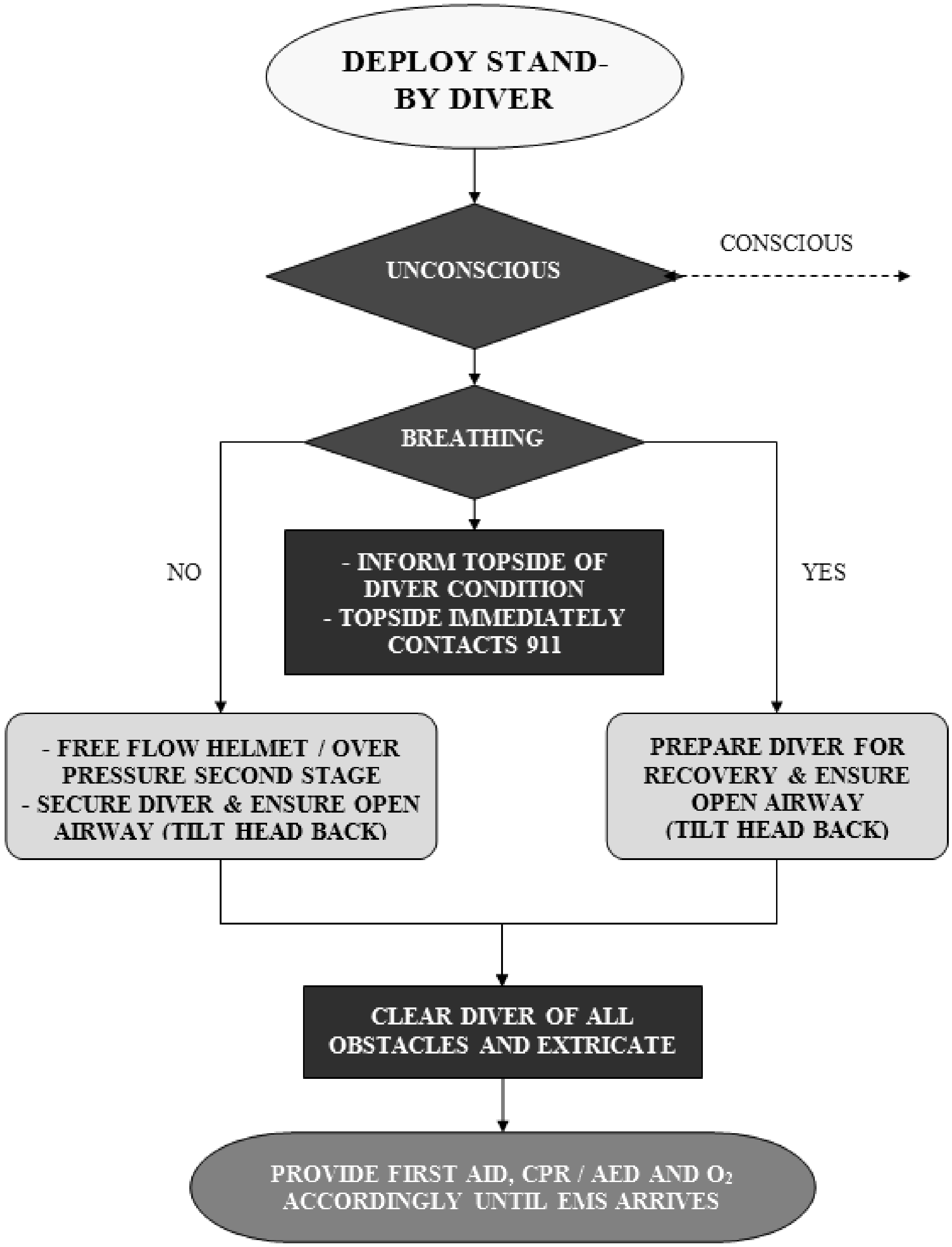

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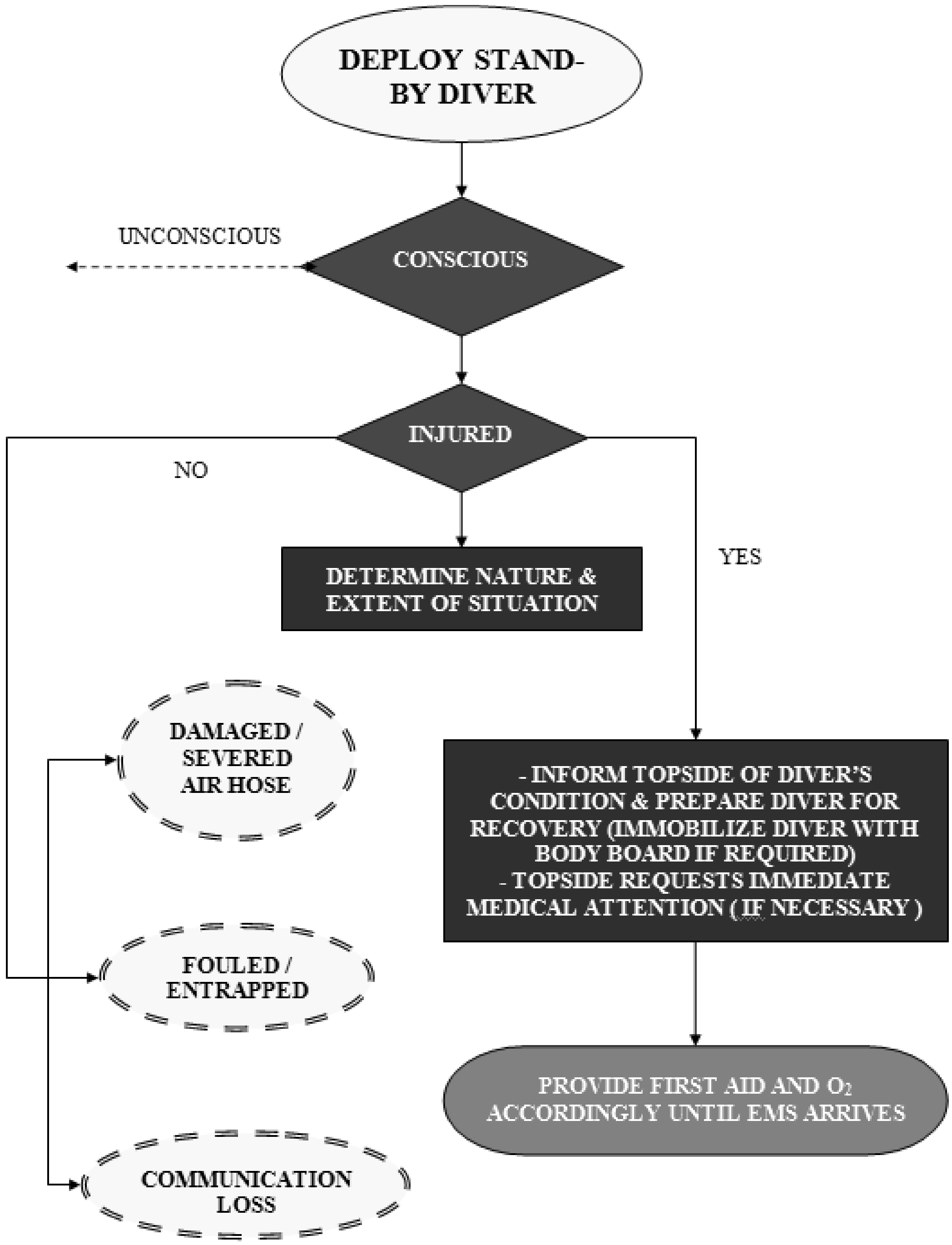

ATTACHMENT 5

EMERGENCY PHONE NUMBERS CHECKLIST

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ATTACHMENT 5

EMERGENCY PHONE NUMBERS CHECKLIST

PROJECT NAME/NUMBER:____

RECOMPRESSION CHAMBER:

ADDRESS/ LAT-LONG ____________________________________

PHONE NUMBER: ______________________________________

POC: ____

RESPONSE TIME: _____________________________________

HOSPITAL:

ADDRESS/ LAT-LONG ____________________________________

PHONE NUMBER: ______________________________________

POC: ____

RESPONSE TIME: _____________________________________

AIR TRANSPORTATION:

ADDRESS/ LAT-LONG ____________________________________

PHONE NUMBER: ______________________________________

POC: ____

RESPONSE TIME: _____________________________________

SEA TRANSPORTATION:

ADDRESS/ LAT-LONG ____________________________________

PHONE NUMBER: ______________________________________

POC: ____

RESPONSE TIME: _____________________________________

ATTACHMENT 5

EMERGENCY PHONE NUMBERS CHECKLIST

PROJECT NAME/NUMBER:____

AMBULANCE:

ADDRESS/ LAT-LONG ____

PHONE NUMBER: ____

POC: ____

RESPONSE TIME: ____

PHYSICIAN:

ADDRESS/LAT-LONG ____

PHONE NUMBER: ____

POC: ____

RESPONSE TIME: ____

COMMUNICATIONS:

ADDRESS/ LAT-LONG ____

PHONE NUMBER: ____

POC: ____

RESPONSE TIME: ____

USCG RESCUE:

ADDRESS/ LAT-LONG ____

PHONE NUMBER: ____

POC: ____

RESPONSE TIME: ____

NOTE – THIS CHECKLIST WILL BE PROMINENTLY POSTED AT THE DIVE SITE AND BE PLACED IN ALL BOATS AND RESPONSE VEHICLES.

ATTACHMENT 6

WORKING DIVE LOG

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ATTACHMENT 6

WORKING DIVE LOG

1. All TMR dives will be recorded on this attachment during field operationseach dive day.

2. The information on these working Dive Logs will be then transferred/ recorded on the TMR Dive Smooth Log by the Dive Supervisor/ or designee and forwarded to the Project Managerfor the official project files. A copy will be further forwarded to the Chairman of the TMR Diving Review Board.

   For scientific divers, a copy will also be sent to the TMR Diving Safety Officer. The Chairman of the Diving Review Board will retain this log for 1 year, except where there has been an injury or incident of decompression sickness and then the record will be retained for 5 years.

3. Definitions:

   a. <u>Old Group</u> – Repetitive group designation from previous dive. Leave blank if this is the first dive.

   b. <u>Surface Interval</u> – The time, which a diver has spent on the surface following a dive. It begins as soon as the diver surfaces and ends as soon as the diver starts his/her next descent. Not required for first dive.

   c. <u>RNT – RESIDUAL NITROGEN TIME</u> – Time, in minutes, which must be added to the bottom time of a repetitive dive to compensate for the nitrogen still in solution in a diver's tissues from a previous dive.

   d. <u>Depth</u> – Depth of current dive.

   e. <u>Bottom Time</u> – The total elapsed time from when the divers leave the surface to thetime (rounded up to the next whole minute) they begin their ascent from the bottom.

   f. <u>Decompression time</u> – Decompression schedule/decompression time.

   g. <u>Equivalent Single Dive Time</u> – RNT plus actual bottom time.

   h. <u>New Group</u> – REPETITIVE GROUP DESIGNATION – A letter, which is used to relate directly to the amount of residual nitrogen remaining in a diver's body.

4. <u>RNT Exception Rule</u> – If performing a repetitive dive to the same depth or deeper, and the RNT is greater than the bottom time of the previous dive, use the bottom time of the previous dive as the RNT.

5. See Attachment 10 for the required U.S. Navy Dive Tables needed to complete these logs.

ATTACHMENT 6

WORKING DIVE LOG

PROJECT NAME/NUMBER:____**DATE:** _________________________

NAME	LS	RS	TBT	DEPTH	TDT	RNT	ESDT	T/S	REPET GROUP	SI
DIVE SUPERVISOR					STBY DIVER					

ATTACHMENT 7

DIVE SMOOTH LOG

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ATTACHMENT 7

DIVE SMOOTH LOG

PROJECT NAME/ NUMBER: ____

1. All TMR dives will be recorded on this attachment and be the final legal record concerning a diver's hyperbaric exposure during operations.

2. Upon completion of the project or weekly, all working Dive Logs from Attachment 6 will be recordedon this Dive Smooth Log by the Dive Supervisor/ Lead Diver and forwarded to the Project Managerfor the Project files and the Chairman Diving Review Board. For science divers, a copy will also besent to the TMR Diving Safety Officer. The Chairman of the Diving Review Board will retain thislog for 1 year, except where there has been an injury or incident of decompression sickness and then the record will be retained for 5 years.

3. Data field definitions:

    a. Date – Date of the diving operation.
    b. Project Name – Name of the Project that dive operations are supporting.
    c. Project Number – Associated Project number.
    d. Location – General Project Location.
    e. Platform – Platform from which the dive operations are conducted.
    f. Gas Source – Source of diver's breathing medium.
    g. Apparatus – The diving mode and equipment used during the operation.
    h. Dress – The exposure protection used by the diver(s).
    i. Project Location – The specific location in the project location that the dive is conducted.
    j. Air Temp – The ambient air temperature at the project dive site.
    k. Current – The observed or reported current at the dive site.
    l. Visibility – The observed underwater visibility reported by the diver(s) at depth.
    m. Altitude – The observed altitude recorded at the dive site.
    n. Water Temp – The observed underwater temperature reported by the diver(s) at depth.
    o. Wave Ht. – The observed wave height recorded at the dive site.
    p. Bottom Type – The observed bottom type reported by the diver(s) at depth.
    q. Tools Used – The tools used for the specific Project task during the dive.
    r. Divers Name – Self-explanatory.
    s. Left Surface (LS) – The recorded time that the diver(s) left the surface (begin descent)
    t. Left Bottom (LB) – the recorded time that the diver(s) left the bottom. (begin ascent)
    u. Total Bottom Time (TBT) – the recorded bottom time (From when diver LS to diver LB).
    v. Total Decompression Time (TDT) – The recorded time of ascent (to include

PROJECT NAME/ NUMBER: ____

anydecompression stops or delays) from when diver LB to diver RS.

w. Reach Surface (RS) – The recorded time that the diver(s) reach the surface.

x. Total Time of Dive (TTD) – The recorded time from when the diver(s) LS to when the diver(s) RS.

y. Depth – The deepest depth recorded of the reported dive.

z. Surface Interval (SI) – The time, that a diver has spent on the surface following a dive. It begins as soon as the diver surfaces and ends as soon as the diver starts his/her next descent. Not required for first dive.

aa. Residual Nitrogen Time (RNT) – Time, in minutes, which must be added to the bottom time of a repetitive dive to compensate for the nitrogen still in solution in a diver's tissues from a previous dive.

bb. Equivalent Single Dive Time (ESDT) – A diver's RNT time plus total bottom time. Used to measure remaining time and new schedule for repetitive dives

cc. Table and Schedule (T/S) – The Table and Schedule used to measure a diver's hyperbaric exposure for a recorded dive.

dd. Repetitive Group (RG) – Repetitive group designation from previous dive and used for repetitive and final dive calculations. Leave blank if this is the diver's first dive.

4. RNT Exception Rule – If performing a repetitive dive to the same depth or deeper, and the RNT is greater than the bottom time of the previous dive, use the bottom time of the previous dive as the RNT.

5. Repetitive Group Designation – A final letter designation, which is used to relate directly to the amount of residual nitrogen remaining in a diver's body after that dive.

6. Use the applicable U.S. Navy Dive Tables located in Attachment 10. These tables are required to complete this log.

DIVE LOG

TETRA TECH

Project

Date: ______ Project Name: ______ Location: ______
Project Number: ______

Equipment

Platform: ______ Gas Source: ______ Apparatus: ______ Dress: ______

Environment

Project Location: ______ Altitude: ______ Tools Used: ______
Air Temp: ______ Water Temp: ______
Current: ______ Wave Ht. ______
Visibility: ______ Bottom Type: ______

Dive Data

Diver (Last, First MI)	LS	LB	TBT	TDT	RS	TTD	Depth	SI	RNT	ESDT	T/S	RG	NOTES

Dive Description

Purpose: ______

Description: ______

Approval

Signature: ______ Date: ______
Dive Supervisor: ______

ATTACHMENT 8

USN DIVING LINE PULL AND HAND SIGNALS

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ATTACHMENT 8
USN Diving Line Pull and Hand Signals

From Tender to Diver		From Diver to Tender	
1 Pull	Are you all right? When diver is descending, 1 pull means STOP.	1 Pull	I am all right. When diver is descending, 1 pull means I am on the bottom.
2 Pulls	Leave surface; Go down.	2 Pulls	Give me slack.
3 Pulls	Standby to come up.	3 Pulls	Take up my slack.
4 Pulls	Come up.	4 Pulls	Haul me up.
7 Pulls	On/Off search signals.	7 Pulls	On/Off search signals.
1 Pull	Stop and search where you are at.	2-1 Pull	I understand, Talk to me.
2 Pulls	Move directly away from the tender if given slack; Move towards the tender if strain is taken.	3-2 Pulls	More air.
3 Pulls	Face umbilical, take a strain, and move RIGHT.	4-3 Pulls	Less air.
4 Pulls	Face umbilical, take a strain, and move LEFT.	1-2-3 Pulls	Send me a square mark.
2-1 Pull	I understand, talk to me.	2-1-2 Pulls	Send me a slate.
3-2 Pulls	Ventilate rig.	5 Pulls	Send me a line.
4-3 Pulls	Circulate rig.	5-5 Pulls	Reacquired anomaly *(for UXO tasking only).*

EMERGENCY—From Diver to Tender	
2-2-2 Pulls	I am fouled and need assistance ("I need you").
3-3-3 Pulls	I am fouled but can clear myself ("I need me").
4-4-4 Pulls	Haul me up immediately.

ATTACHMENT 8
USN Diving Line Pull and Hand Signals

	Meaning/Signal	Comment
	**STOP** Clenched fist.	
	**SOMETHING IS WRONG** Hand flat, fingers together, palm out, thumb down then hand rocking back and forth on axis of forearm.	This is the opposite of Okay. The signal does not indicate an emergency.
	**I AM OKAY or ARE YOU OKAY?** Thumb and forefinger making a circle with three remaining fingers extended (if possible).	Divers wearing mittens may not be able to extend three remaining fingers distinctly. Short range use.
	**OKAY ON THE SURFACE (CLOSE)** Right hand raised overhead giving Okay signal with fingers. **OKAY ON THE SURFACE (DISTANT)** Both hands touching overhead with both arms bent at 45° angle.	Given when diver is close to pickup boat. Given when diver is at a distance from the pickup boat.
	**DISTRESS or HELP or PICK ME UP** Hand waving overhead (diver may also thrash hand in water).	Indicates immediate aid is required.
	**WHAT TIME? or WHAT DEPTH?** Diver points to either watch or depth gauge.	When indicating time, this signal is commonly used for bottom time remaining.
	**GO DOWN or GOING DOWN** Two fingers up, two fingers and thumb against palm.	
	**GO UP or GOING UP** Four fingers pointing up, thumb against palm.	
	**I'M OUT OF AIR** Hand slashing or chopping at throat. **I NEED TO BUDDY BREATHE** Fingers pointing to mouth or regulator.	Indicates signaler is out of air. Signaler's regulator may be in or out of mouth.

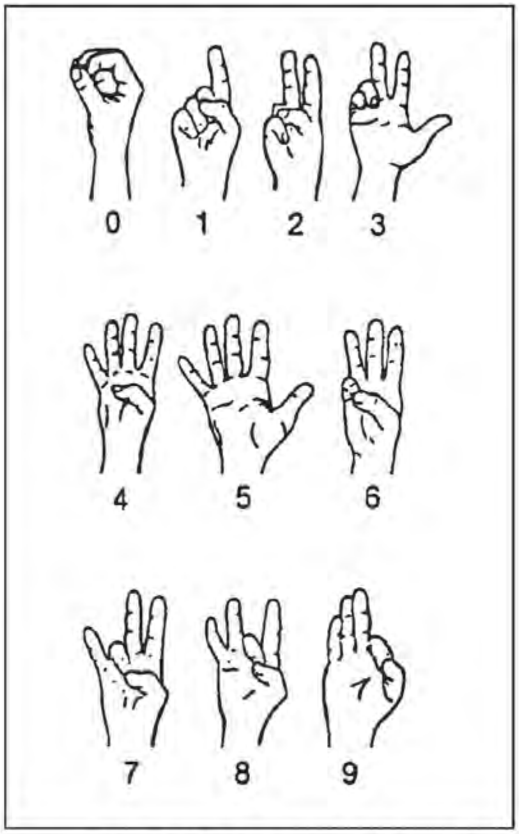
Figure 7-9. SCUBA Hand Signals (page 1 of 3).

ATTACHMENT 8
USN Diving Line Pull and Hand Signals

	Meaning/Signal	Comment
	**COME HERE** Hand to chest, repeated.	
	**ME or WATCH ME** Finger to chest, repeated.	
	**OVER, UNDER, or AROUND** Fingers together and arm moving in and over, under, or around movement.	Diver signals intention to move over, under, or around an object.
	**LEVEL OFF or HOW DEEP?** Fingers and thumb spread out and hand moving back and forth in a level position.	
	**GO THAT WAY** Fist clenched with thumb pointing up, down, right, or left.	Indicates which direction to swim.
	**WHICH DIRECTION?** Fingers clenched, thumb and hand rotating right and left.	
	**EAR TROUBLE** Diver pointing to either ear.	Divers should ascend a few feet. If problem continues, both divers must surface.
	**I'M COLD** Both arms crossed over chest.	
	**TAKE IT EASY OR SLOW DOWN** Hand extended, palm down, in short up-and-down motion.	
	**YOU LEAD, I'LL FOLLOW** Index fingers extended, one hand forward of the other.	

Figure 7-9. SCUBA Hand Signals (page 2 of 3).

ATTACHMENT 8
USN Diving Line Pull and Hand Signals



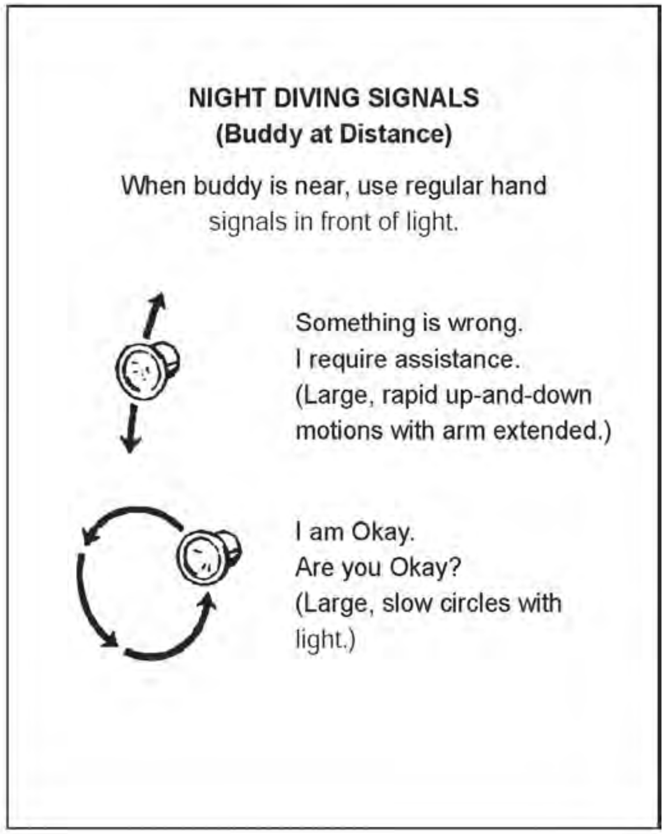


Figure 7-9. SCUBA Hand Signals (page 3 of 3).

ATTACHMENT 9

COLD WATER CONSIDERATIONS AND SAFETY PRECAUTIONS

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ATTACHMENT 9

COLD WATER CONSIDERATIONS AND SAFETY PRECAUTIONS

UNDER ICE DIVING

Diving under the ice requires extremely specialized training and equipment and will not be performed by TMR employees unless approved by the Diving Review Board.

COLD WATER DIVING

In addition to decompression, thermal problems arising from exposure to cold water pose the major consideration when planning operational dives and selecting equipment. The working diver commonly experiences heat loss during immersion and often expects to be uncomfortably chilled at the end of a dive. Bottom time limits may be determined by the diver's cold tolerance rather than by decompression considerations.

An individual thoroughly conditioned physically can be transported from warm climates into cold climates and immediately begin diving without harmful effects. However, individuals differ in how well suited they are for cold weather operations. At least half of the diving team should have previous experience in ice or cold water diving operations and should be well qualified to train the less experienced.

Personnel scheduled to go to Polar Regions should be instructed in cold weather physiology and the prevention of cold injuries. To prevent injury, any techniques that aid heat balance, protection, and basic metabolism should be used.

Cold water immersion may also cause excessive urination, severely dehydrating the diver. This in turn reduces performance and may increase the risk of developing decompression sickness. A diver who is dehydrated may appear normal in the water. However, exiting the water combined with warming of the skin may cause pooling of the blood in the extremities leading to fainting. This means that divers who have been in cold water for any period and who appear cold should be assisted from the water and sit or lie down and take fluids until they are sure they can stand without problems.

Vertigo is caused by cold water stimulating the balance mechanism of the inner ear.

In repetitive diving with cold exposure, the operation should be planned so that the diver is re-warmed to the point of sweating before diving again. If cold water exposures are severe and if more than a 30-minute duration, then consideration should be given to requiring an overnight rest between exposures. The diver must also have sufficient non-caffeine beverages to replace the excessive body fluid loss from cold water induced urination.

The support equipment required for ice and cold water diving must be carefully evaluated for effectiveness and suitability.

Maintaining proper body temperature is particularly difficult for a diver working underwater. The principal temperature control problem encountered by divers involves keeping the body warm. The high thermal conductivity of water, coupled with the normally cool-to-cold waters in which divers operate, can result in rapid and excessive heat loss. At extremely low temperatures or with prolonged immersion, body heat loss will reach a point at which death will occur. Appropriate dress can greatly reduce the effects of heat loss, and a diver with proper dress can work in very cold water for reasonable periods of time.

ATTACHMENT 9

COLD WATER CONSIDERATIONS AND SAFETY PRECAUTIONS

In very cold water, the wet suit is only a marginally effective thermal protective measure, and its use exposes the diver to hypothermia and restricts available bottom time. The use of alternative thermal protective equipment should be considered in these circumstances.

The variable volume dry suit and hot water suit are effective means of thermal protection for cold water diving. Wet suits made of incompressible material are now available. Such suits offer more protection at depth than standard wet suits of the same thickness. Prior to the use of variable volume dry suits and hot water suits in cold and ice-covered waters, divers must be trained in their use and be thoroughly familiar with the operation of these suits.

More weight must be used with a variable volume dry suit than with a wet suit due to the great positive buoyancy of a dry suit. Manufacturer's recommendations should be followed to select starting weight. The additional weight makes use of a weight vest or harness desirable. A shoulder harness is one method of preventing the heavy, awkward belts from slipping down during a dive. A few heavy hip hugger weights are better than several smaller weights.

Both single- and double-hose regulators are used for ice and cold water diving. The single-hose regulator is preferred for buddy breathing, is less bulky, and is easier to maintain than the double-hose; however, it is more subject to freeze-up than the double-hose regulator. Due to the serious nature of the freeze-up problems in single-hose regulators, they should not be allowed to free-flow or be purged for over five seconds at a time. Only regulators having a cold water conversion will be used for ice/cold water diving.

The single-hose regulator should be kept in a warm place before diving. It is important that the divers test the regulator in a warm place, then refrain from breathing it until submerging. When returning to the surface, the regulator should remain submerged, and the diver should refrain from breathing from the regulator until re-submerging. The diver's time on the surface should be kept to a minimum. Once under the water, chances of a freeze-up are reduced. However, if a regulator is allowed to free-flow at depth for as little as 5 seconds, freeze-up may occur. The diver should therefore avoid purging the second stage of the regulator when diving in cold water. If water needs to be purged from the mouthpiece, the diver should do so by exhaling into it.

Where water temperature is at or below 37ºF, a redundant SCUBA system (twin SCUBA bottles, each having a "K" valve and an approved cold water regulator) or twin SCUBA bottles with one common manifold and an approved cold water regulator (with octopus) may be used. When selecting the redundant SCUBA system, maximum depth and bottom time are greatly reduced because the extra SCUBA will be used for emergencies only.

Using surface supplied diving in cold water requires detailed operations planning and extensive logistical support. This includes thermal protection for an elaborate dive station and recompression chamber and hot water heating equipment. In addition, dive equipment may require cold climate modification. Because of logistical considerations, scuba is used in most ice diving situations. However, surface supplied diving may be required because of prolonged bottom times, depth requirements, and complex communications between topside and diver. When diving in cold water that is not ice covered, logistic and equipment support requirements are reduced; however, very cold water poses many of the same dangers to the surface-supplied diver as ice diving.

The diver's mask may show an increased tendency to fog in cold water. An anti-fog solution should be used to prevent this from occurring. Saliva will not prevent this fogging.

HYPOTHERMIA

When diving in cold water, hypothermia may predispose the diver to decompression sickness. Hypothermia is easily diagnosed. The hypothermic diver loses muscle strength, the ability to concentrate, and may become irrational or confused. The victim may shiver violently, or, with severe hypothermia, shivering may be replaced by muscle rigidity. Profound hypothermia may so depress the heartbeat and respiration that the victim appears dead. However, a diver should not be considered dead until the diver has been re-warmed and all resuscitation attempts have been proven to be unsuccessful.

Hypothermia demands immediate treatment and prompt evacuation to a medical facility. A hypothermic diver must not be allowed to walk, i.e., the diver should be transported in a horizontal position. Improper handling of the diver can cause dangerous rhythms of the heart and a drop in the body core temperature, known as after drop. The local/responding medical facility must be notified of the possibility of hypothermia PRIOR to the commencement of diving operations. Emergency re-warming and evacuation plans should be established with their recommendations.

Some of the signs and symptoms of hypothermia are shivering, mental confusion, and loss of memory, speech /sensory impairment, and hallucinations. At approximately 88ºF, all shivering stops, the victim will not recognize familiar people, followed by the victim experiencing muscle rigidity and loss of consciousness

ATTACHMENT 10

U.S. NAVY DIVE TABLES

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ATTACHMENT 10
U.S. NAVY DIVE TABLES

1. All TMR dive logs will use the tables in the attachment to complete the dive logs in Attachment 6 and 7 and when developing any TMR project Health and Safety Dive Plans.

2. **U.S. Navy No-Decompression Table (Table 9-7)** – This table gives the maximum time that can be spent at a given depth without the need for decompression stops during the subsequent ascent to the surface. This table is sometimes called the “no-stop” table. At depthsof 20 feet of seawater (FSW) and shallower, there is no limit on the amount of time that can be spent at depth. Deeper than 20 FSW, the time that can be spent is limited. For example, at 60 FSW, any dive longer than 63 minutes will require decompression stops.

The No-Decompression Table also provides the repetitive group designators for dives that fall within the no-decompression limits. Even though no decompression stops are required during ascent, the diver still surfaces with some residual nitrogen in his tissues. This residual nitrogen needs to be accounted for if a repetitive dive is planned. If a diver exceeds the limits given inthe No-Decompression Table, then the decompression stop requirement must be calculated using U.S Navy Standard Air Table (Table 9-9).

For each depth listed in the No-Decompression Table, the corresponding no decompressionlimit is indicated in the second column. This limit is the maximum bottom time that a diver mayspend at that depth and still return to the surface without taking decompression stops. To findthe no-decompression limit, enter the table at the depth equal to or next greater than the maximum depth of the dive.

Follow that row to the second column to obtain the no-decompression limit. The columns to the right of the no-decompression limit column contain the repetitive group designators for dives with bottom times equal to or shorter than the no-decompression limit. A repetitive groupdesignator must be assigned to a diver after every dive, even a no-decompression dive.

3. **Optional Shallow Water No-Decompression Table (Table 2A-1)** – This table contains an expanded version of Table 9-7 and Table 9-8 covering the depth range of 30–50 FSW in one-foot increments. In this depth range, a small change in the diver’s maximum depth can makea substantial difference in the allowable no-decompression time. For example, at 35 FSW theno-decompression limit is 232 minutes; at 40 FSW it is only 163 minutes, more than an hour less. When the diver’s maximum depth is accurately known at the beginning of the dive, for example in ballast tank dives, or when continuous depth recording is available, for example with a decompression computer, the expanded table can be used to maximize no- decompression time.

These optional tables are most suited to ship husbandry diving, but can be used in other shallow air diving applications as well.

4. **Residual Nitrogen Time Table for Repetitive Air Dives (Figure 9-8)** - The procedures for conducting a repetitive dive are summarized in this table. Upon completing the first dive, the diver is assigned a repetitive group designator from either the Air Decompression Table or the No-Decompression Table. This designator tells the diver how much residual nitrogen he has upon surfacing from the first dive. A diver in Group A has the lowest amount of residual nitrogen; a diver in Group Z has the highest.

As nitrogen passes out of the diver’s body during the surface interval, the repetitive group designation changes to a lower letter group to reflect the lower quantity of residual nitrogen.

The top half of the table allows the repetitive group designator to be determined at any time during the surface interval. The lower half of the table gives the Residual Nitrogen Time (RNT) corresponding to the repetitive group designator at the end of the surface interval and the depth of the repetitive dive. The residual nitrogen time is the time a diver would have had to spend at the depth of the repetitive dive to absorb the amount of nitrogen he has left over from the previous dive. The residual nitrogen time is added to the bottom time of the repetitive dive to obtain the Equivalent Single Dive Time (ESDT).

The decompression schedule for the repetitive dive is obtained by entering either the Air Decompression Table or the No-Decompression Table at the depth of the repetitive dive and the equivalent single dive time.

NOTE: When using the Optional Shallow Water No Decompression Tables above ensure the corresponding Residual Nitrogen Timetable for Repetitive Shallow Water Air Dives (Table 2A- 2) is used for your repetitive dive calculations.

5. **U.S Navy Standard Air Table (Table 9-9)** – This table combines three modes of decompression into one table. These modes are: (1) in-water decompression on air, (2) in- water decompression on air and oxygen, and (3) surface decompression on oxygen.

Refer to reference (b), Chapter 9, when using the Standard Air Tables in any of the above modes when developing HASPs where decompression diving profiles are anticipated.

These tables are to be available to the Dive Supervisor/ Lead Diver on TMR dive sites for emergency procedure in water decompression on planned no decompression dive plans

Table 9-7. *No-Decompression Limits and Repetitive Group Designators for No-Decompression Air Dives.*

Depth (fsw)	No-Stop Limit	Repetitive Group Designation															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
10	Unlimited	57	101	158	245	426	*										
15	Unlimited	36	60	88	121	163	217	297	449	*							
20	Unlimited	26	43	61	82	106	133	165	205	256	330	461	*				
25	1102	20	33	47	62	78	97	117	140	166	198	236	285	354	469	992	1102
30	371	17	27	38	50	62	76	91	107	125	145	167	193	223	260	307	371
35	232	14	23	32	42	52	63	74	87	100	115	131	148	168	190	215	232
40	163	12	20	27	36	44	53	63	73	84	95	108	121	135	151	163	
45	125	11	17	24	31	39	46	55	63	72	82	92	102	114	125		
50	92	9	15	21	28	34	41	48	56	63	71	80	89	92			
55	74	8	14	19	25	31	37	43	50	56	63	71	74				
60	63	7	12	17	22	28	33	39	45	51	57	63					
70	48	6	10	14	19	23	28	32	37	42	47	48					
80	39	5	9	12	16	20	24	28	32	36	39						
90	33	4	7	11	14	17	21	24	28	31	33						
100	25	4	6	9	12	15	18	21	25								
110	20	3	6	8	11	14	16	19	20								
120	15	3	5	7	10	12	15										
130	12	2	4	6	9	11	12										
140	10	2	4	6	8	10											
150	8		3	5	7	8											
160	7		3	5	6	7											
170	6			4	6												
180	6			4	5	6											
190	5			3	5												

* Highest repetitive group that can be achieved at this depth regardless of bottom time.

Table 9-8. Residual Nitrogen Time Table for Repetitive Air Dives.

Locate the diver's repetitive group designation from his previous dive along the diagonal line above the table. Read horizontally to the interval in which the diver's surface interval lies.

Next, read vertically downward to the new repetitive group designation. Continue downward in this same column to the row that represents the depth of the repetitive dive. The time given at the intersection is residual nitrogen time, in minutes, to be applied to the repetitive dive.

* Dives following surface intervals longer than this are not repetitive dives. Use actual bottom times in the Air Decompression Tables to compute decompression for such dives.

Repetitive Group at Beginning of Surface Interval (rows) / **Repetitive Group at the End of the Surface Interval** (columns)

	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
A																:10 2:20 *
B															:10 1:16	1:17 3:36 *
C														:10 :55	:56 2:11	2:12 4:31 *
D													:10 :52	:53 1:47	1:48 3:03	3:04 5:23 *
E												:10 :52	:53 1:44	1:45 2:39	2:40 3:55	3:56 6:15 *
F											:10 :52	:53 1:44	1:45 2:37	2:38 3:31	3:32 4:48	4:49 7:08 *
G										:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:23	4:24 5:40	5:41 8:00 *
H									:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:16	5:17 6:32	6:33 8:52 *
I								:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:08	6:09 7:24	7:25 9:44 *
J							:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 7:00	7:01 8:16	8:17 10:36 *
K						:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:52	7:53 9:09	9:10 11:29 *
L					:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:44	8:45 10:01	10:02 12:21 *
M				:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:37	9:38 10:53	10:54 13:13 *
N			:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:34	9:35 10:29	10:30 11:45	11:46 14:05 *
O		:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:34	9:35 10:27	10:28 11:21	11:22 12:37	12:38 14:58 *
Z	:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:34	9:35 10:27	10:28 11:19	11:20 12:13	12:14 13:30	13:31 15:50 *

Dive Depth	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
10	**	**	**	**	**	**	**	**	**	**	**	427	246	159	101	58
15	**	**	**	**	**	**	**	**	450	298	218	164	122	89	61	37
20	**	**	**	**	**	462	331	257	206	166	134	106	83	62	44	27
25	†	†	470	354	286	237	198	167	141	118	98	79	63	48	34	21
30	372	308	261	224	194	168	146	126	108	92	77	63	51	39	28	18
35	245	216	191	169	149	132	116	101	88	75	64	53	43	33	24	15
40	188	169	152	136	122	109	97	85	74	64	55	45	37	29	21	13
45	154	140	127	115	104	93	83	73	64	56	48	40	32	25	18	12
50	131	120	109	99	90	81	73	65	57	49	42	35	29	23	17	11
55	114	105	96	88	80	72	65	58	51	44	38	32	26	20	15	10
60	101	93	86	79	72	65	58	52	46	40	35	29	24	19	14	9
70	83	77	71	65	59	54	49	44	39	34	29	25	20	16	12	8
80	70	65	60	55	51	46	42	38	33	29	25	22	18	14	10	7
90	61	57	52	48	44	41	37	33	29	26	22	19	16	12	9	6
100	54	50	47	43	40	36	33	30	26	23	20	17	14	11	8	5
110	48	45	42	39	36	33	30	27	24	21	18	16	13	10	8	5
120	44	41	38	35	32	30	27	24	22	19	17	14	12	9	7	5
130	40	37	35	32	30	27	25	22	20	18	15	13	11	9	6	4
140	37	34	32	30	27	25	23	21	19	16	14	12	10	8	6	4
150	34	32	30	28	26	23	21	19	17	15	13	11	9	8	6	4
160	32	30	28	26	24	22	20	18	16	14	13	11	9	7	5	4
170	30	28	26	24	22	21	19	17	15	14	12	10	8	7	5	3
180	28	26	25	23	21	19	18	16	14	13	11	10	8	6	5	3
190	26	25	23	22	20	18	17	15	14	12	11	9	8	6	5	3

Residual Nitrogen Times (Minutes)

** Residual Nitrogen Time cannot be determined using this table (see paragraph 9-9.1 subparagraph 8 for instructions).

† Read vertically downward to the 30 fsw repetitive dive depth. Use the corresponding residual nitrogen times to compute the equivalent single dive time. Decompress using the 30 fsw air decompression table.

Table 2A-1. *No-Decompression Limits and Repetitive Group Designators for Shallow Water Air No-Decompression Dives.*

Depth (fsw)	No-Stop Limit (min)	Repetitive Group Designation															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
30	371	17	27	38	50	62	76	91	107	125	145	167	193	223	260	307	371
31	334	16	26	37	48	60	73	87	102	119	138	158	182	209	242	282	334
32	304	15	25	35	46	58	70	83	98	114	131	150	172	197	226	261	304
33	281	15	24	34	45	56	67	80	94	109	125	143	163	186	212	243	281
34	256	14	23	33	43	54	65	77	90	104	120	137	155	176	200	228	256
35	232	14	23	32	42	52	63	74	87	100	115	131	148	168	190	215	232
36	212	14	22	31	40	50	61	72	84	97	110	125	142	160	180	204	212
37	197	13	21	30	39	49	59	69	81	93	106	120	136	153	172	193	197
38	184	13	21	29	38	47	57	67	78	90	102	116	131	147	164	184	
39	173	12	20	28	37	46	55	65	76	87	99	112	126	141	157	173	
40	163	12	20	27	36	44	53	63	73	84	95	108	121	135	151	163	
41	155	12	19	27	35	43	52	61	71	81	92	104	117	130	145	155	
42	147	11	19	26	34	42	50	59	69	79	89	101	113	126	140	147	
43	140	11	18	25	33	41	49	58	67	76	87	98	109	122	135	140	
44	134	11	18	25	32	40	48	56	65	74	84	95	106	118	130	134	
45	125	11	17	24	31	39	46	55	63	72	82	92	102	114	125		
46	116	10	17	23	30	38	45	53	61	70	79	89	99	110	116		
47	109	10	16	23	30	37	44	52	60	68	77	87	97	107	109		
48	102	10	16	22	29	36	43	51	58	67	75	84	94	102			
49	97	10	16	22	28	35	42	49	57	65	73	82	91	97			
50	92	9	15	21	28	34	41	48	56	63	71	80	89	92			

Table 2A-2. *Residual Nitrogen Time Table for Repetitive Shallow Water Air Dives.*

Locate the diver's repetitive group designation from his previous dive along the diagonal line above the table. Read horizontally to the interval in which the diver's surface interval lies.

Next, read vertically downward to the new repetitive group designation. Continue downward in this same column to the row that represents the depth of the repetitive dive. The time given at the intersection is residual nitrogen time, in minutes, to be applied to the repetitive dive.

* Dives following surface intervals longer than this are not repetitive dives. Use actual bottom times in the Air Decompression Tables to compute decompression for such dives.

Repetitive Group at Beginning of Surface Interval

Repetitive Group at Beginning of Surface Interval	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
A																:10 2:20 *
B															:10 1:16	1:17 3:36 *
C														:10 :55	:56 2:11	2:12 4:31 *
D													:10 :52	:53 1:47	1:48 3:03	3:04 5:23 *
E												:10 :52	:53 1:44	1:45 2:39	2:40 3:55	3:56 6:15 *
F											:10 :52	:53 1:44	1:45 2:37	2:38 3:31	3:32 4:48	4:49 7:08 *
G										:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:23	4:24 5:40	5:41 8:00 *
H									:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:16	5:17 6:32	6:33 8:52 *
I								:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:08	6:09 7:24	7:25 9:44 *
J							:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 7:00	7:01 8:16	8:17 10:36 *
K						:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:52	7:53 9:09	9:10 11:29 *
L					:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:44	8:45 10:01	10:02 12:21 *
M				:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:37	9:38 10:53	10:54 13:13 *
N			:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:34	9:35 10:29	10:30 11:45	11:46 14:05 *
O		:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:34	9:35 10:27	10:28 11:21	11:22 12:37	12:38 14:58 *
Z	:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:34	9:35 10:27	10:28 11:19	11:20 12:13	12:14 13:30	13:31 15:50 *

Repetitive Group at the End of the Surface Interval

Dive Depth	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
30	372	308	261	224	194	168	146	126	108	92	77	63	51	39	28	18
31	334	282	243	210	183	159	139	120	103	88	74	61	49	38	27	17
32	305	262	227	198	173	151	132	115	99	85	71	59	47	36	26	17
33	282	244	213	187	164	144	126	110	95	81	69	57	46	35	25	16
34	262	229	201	177	156	138	121	105	91	78	66	55	44	34	25	16
35	245	216	191	169	149	132	116	101	88	75	64	53	43	33	24	15
36	231	204	181	161	143	126	111	98	85	73	62	51	41	32	23	15
37	218	194	173	154	137	122	107	94	82	70	60	50	40	31	23	14
38	207	185	165	148	132	117	103	91	79	68	58	48	39	30	22	14
39	197	177	158	142	127	113	100	88	77	66	56	47	38	29	21	14
40	188	169	152	136	122	109	97	85	74	64	55	45	37	29	21	13
41	180	163	146	132	118	105	93	82	72	62	53	44	36	28	20	13
42	173	156	141	127	114	102	91	80	70	61	52	43	35	27	20	13
43	166	150	136	123	110	99	88	78	68	59	50	42	34	26	19	12
44	160	145	131	119	107	96	85	75	66	57	49	41	33	26	19	12
45	154	140	127	115	104	93	83	73	64	56	48	40	32	25	18	12
46	149	136	123	111	101	90	81	71	63	54	46	39	32	25	18	12
47	144	131	119	108	98	88	78	70	61	53	45	38	31	24	18	11
48	139	127	116	105	95	85	76	68	60	52	44	37	30	24	17	11
49	135	123	112	102	92	83	74	66	58	51	43	36	30	23	17	11
50	131	120	109	99	90	81	73	65	57	49	42	35	29	23	17	11

Residual Nitrogen Times (Minutes)

Table 9-9. *Air Decompression Table.*

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop									Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
			100	90	80	70	60	50	40	30	20			
30 FSW														
371	1:00	AIR									0	1:00	0	Z
		AIR/O_2									**0**	1:00		
380	0:20	AIR									5	6:00	0.5	Z
		AIR/O_2									**1**	2:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
420	0:20	AIR									22	23:00	0.5	Z
		AIR/O_2									**5**	6:00		
480	0:20	AIR									42	43:00	0.5	
		AIR/O_2									**9**	10:00		
540	0:20	AIR									71	72:00	1	
		AIR/O_2									**14**	15:00		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
600	0:20	AIR									92	93:00	1	
		AIR/O_2									**19**	20:00		
660	0:20	AIR									120	121:00	1	
		AIR/O_2									**22**	23:00		
720	0:20	AIR									158	159:00	1	
		AIR/O_2									**27**	28:00		
35 FSW														
232	1:10	AIR									0	1:10	0	Z
		AIR/O_2									**0**	1:10		
240	0:30	AIR									4	5:10	0.5	Z
		AIR/O_2									**2**	3:10		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
270	0:30	AIR									28	29:10	0.5	Z
		AIR/O_2									**7**	8:10		
300	0:30	AIR									53	54:10	0.5	Z
		AIR/O_2									**13**	14:10		
330	0:30	AIR									71	72:10	1	Z
		AIR/O_2									**18**	19:10		
360	0:30	AIR									88	89:10	1	
		AIR/O_2									**22**	23:10		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
420	0:30	AIR									134	135:10	1.5	
		AIR/O_2									**29**	30:10		
480	0:30	AIR									173	174:10	1.5	
		AIR/O_2									**38**	44:10		
540	0:30	AIR									228	229:10	2	
		AIR/O_2									**45**	51:10		
600	0:30	AIR									277	278:10	2	
		AIR/O_2									**53**	59:10		
660	0:30	AIR									314	315:10	2.5	
		AIR/O_2									**63**	69:10		
720	0:30	AIR									342	343:10	3	
		AIR/O_2									**71**	82:10		

Table 9-9. Air Decompression Table (Continued).

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
40 FSW														
163	1:20	AIR									0	1:20	0	O
		AIR/O_2									**0**	1:20		
170	0:40	AIR									6	7:20	0.5	O
		AIR/O_2									**2**	3:20		
180	0:40	AIR									14	15:20	0.5	Z
		AIR/O_2									**5**	6:20		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
190	0:40	AIR									21	22:20	0.5	Z
		AIR/O_2									**7**	8:20		
200	0:40	AIR									27	28:20	0.5	Z
		AIR/O_2									**9**	10:20		
210	0:40	AIR									39	40:20	0.5	Z
		AIR/O_2									**11**	12:20		
220	0:40	AIR									52	53:20	0.5	Z
		AIR/O_2									**12**	13:20		
230	0:40	AIR									64	65:20	1	Z
		AIR/O_2									**16**	17:20		
240	0:40	AIR									75	76:20	1	Z
		AIR/O_2									**19**	20:20		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
270	0:40	AIR									101	102:20	1	Z
		AIR/O_2									**26**	27:20		
300	0:40	AIR									128	129:20	1.5	
		AIR/O_2									**33**	34:20		
330	0:40	AIR									160	161:20	1.5	
		AIR/O_2									**38**	44:20		
360	0:40	AIR									184	185:20	2	
		AIR/O_2									**44**	50:20		
420	0:40	AIR									248	249:20	2.5	
		AIR/O_2									**56**	62:20		
480	0:40	AIR									321	322:20	2.5	
		AIR/O_2									**68**	79:20		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required---														
540	0:40	AIR									372	373:20	3	
		AIR/O_2									**80**	91:20		
600	0:40	AIR									410	411:20	3.5	
		AIR/O_2									**93**	104:20		
660	0:40	AIR									439	440:20	4	
		AIR/O_2									**103**	119:20		
Exceptional Exposure: SurDO_2 ---														
720	0:40	AIR									461	462:20	4.5	
		AIR/O_2									**112**	128:20		

Table 9-9. *Air Decompression Table (Continued).*

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop									Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
			100	90	80	70	60	50	40	30	20			
45 FSW														
125	1:30	AIR									0	1:30	0	N
		AIR/O_2									**0**	1:30		
130	0:50	AIR									2	3:30	0.5	O
		AIR/O_2									**1**	2:30		
140	0:50	AIR									14	15:30	0.5	O
		AIR/O_2									**5**	6:30		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
150	0:50	AIR									25	26:30	0.5	Z
		AIR/O_2									**8**	9:30		
160	0:50	AIR									34	35:30	0.5	Z
		AIR/O_2									**11**	12:30		
170	0:50	AIR									41	42:30	1	Z
		AIR/O_2									**14**	15:30		
180	0:50	AIR									59	60:30	1	Z
		AIR/O_2									**17**	18:30		
190	0:50	AIR									75	76:30	1	Z
		AIR/O_2									**19**	20:30		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
200	0:50	AIR									89	90:30	1	Z
		AIR/O_2									**23**	24:30		
210	0:50	AIR									101	102:30	1	Z
		AIR/O_2									**27**	28:30		
220	0:50	AIR									112	113:30	1.5	Z
		AIR/O_2									**30**	31:30		
230	0:50	AIR									121	122:30	1.5	Z
		AIR/O_2									**33**	34:30		
240	0:50	AIR									130	131:30	1.5	Z
		AIR/O_2									**37**	43:30		
270	0:50	AIR									173	174:30	2	
		AIR/O_2									**45**	51:30		
300	0:50	AIR									206	207:30	2	
		AIR/O_2									**51**	57:30		
330	0:50	AIR									243	244:30	2.5	
		AIR/O_2									**61**	67:30		
360	0:50	AIR									288	289:30	3	
		AIR/O_2									**69**	80:30		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required--														
420	0:50	AIR									373	374:30	3.5	
		AIR/O_2									**84**	95:30		
480	0:50	AIR									431	432:30	4	
		AIR/O_2									**101**	117:30		
Exceptional Exposure: SurDO_2 --														
540	0:50	AIR									473	474:30	4.5	
		AIR/O_2									**117**	133:30		

Table 9-9. Air Decompression Table (Continued).

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
50 FSW														
92	1:40	AIR									0	1:40	0	M
		AIR/O_2									**0**	1:40		
95	1:00	AIR									2	3:40	0.5	M
		AIR/O_2									**1**	2:40		
100	1:00	AIR									4	5:40	0.5	N
		AIR/O_2									**2**	3:40		
110	1:00	AIR									8	9:40	0.5	O
		AIR/O_2									**4**	5:40		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
120	1:00	AIR									21	22:40	0.5	O
		AIR/O_2									**7**	8:40		
130	1:00	AIR									34	35:40	0.5	Z
		AIR/O_2									**12**	13:40		
140	1:00	AIR									45	46:40	1	Z
		AIR/O_2									**16**	17:40		
150	1:00	AIR									56	57:40	1	Z
		AIR/O_2									**19**	20:40		
160	1:00	AIR									78	79:40	1	Z
		AIR/O_2									**23**	24:40		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
170	1:00	AIR									96	97:40	1	Z
		AIR/O_2									**26**	27:40		
180	1:00	AIR									111	112:40	1.5	Z
		AIR/O_2									**30**	31:40		
190	1:00	AIR									125	126:40	1.5	Z
		AIR/O_2									**35**	36:40		
200	1:00	AIR									136	137:40	1.5	Z
		AIR/O_2									**39**	45:40		
210	1:00	AIR									147	148:40	2	
		AIR/O_2									**43**	49:40		
220	1:00	AIR									166	167:40	2	
		AIR/O_2									**47**	53:40		
230	1:00	AIR									183	184:40	2	
		AIR/O_2									**50**	56:40		
240	1:00	AIR									198	199:40	2	
		AIR/O_2									**53**	59:40		
270	1:00	AIR									236	237:40	2.5	
		AIR/O_2									**62**	68:40		
300	1:00	AIR									285	286:40	3	
		AIR/O_2									**74**	85:40		
Exceptional Exposure: In-Water Air/O_2 Decompression ------------- SurDO_2 Required---														
330	1:00	AIR									345	346:40	3.5	
		AIR/O_2									**83**	94:40		
360	1:00	AIR									393	394:40	3.5	
		AIR/O_2									**92**	103:40		
Exceptional Exposure: SurDO_2 ---														
420	1:00	AIR									464	465:40	4.5	
		AIR/O_2									**113**	129:40		

Table 9-9. Air Decompression Table (Continued).
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
55 FSW														
74	1:50	AIR									0	1:50	0	L
		AIR/O_2									**0**	1:50		
75	1:10	AIR									1	2:50	0.5	L
		AIR/O_2									**1**	2:50		
80	1:10	AIR									4	5:50	0.5	M
		AIR/O_2									**2**	3:50		
90	1:10	AIR									10	11:50	0.5	N
		AIR/O_2									**5**	6:50		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
100	1:10	AIR									17	18:50	0.5	O
		AIR/O_2									**8**	9:50		
110	1:10	AIR									34	35:50	0.5	O
		AIR/O_2									**12**	13:50		
120	1:10	AIR									48	49:50	1	Z
		AIR/O_2									**17**	18:50		
130	1:10	AIR									59	60:50	1	Z
		AIR/O_2									**22**	23:50		
140	1:10	AIR									84	85:50	1	Z
		AIR/O_2									**26**	27:50		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
150	1:10	AIR									105	106:50	1.5	Z
		AIR/O_2									**30**	31:50		
160	1:10	AIR									123	124:50	1.5	Z
		AIR/O_2									**34**	35:50		
170	1:10	AIR									138	139:50	1.5	Z
		AIR/O_2									**40**	46:50		
180	1:10	AIR									151	152:50	2	Z
		AIR/O_2									**45**	51:50		
190	1:10	AIR									169	170:50	2	
		AIR/O_2									**50**	56:50		
200	1:10	AIR									190	191:50	2	
		AIR/O_2									**54**	60:50		
210	1:10	AIR									208	209:50	2.5	
		AIR/O_2									**58**	64:50		
220	1:10	AIR									224	225:50	2.5	
		AIR/O_2									**62**	68:50		
230	1:10	AIR									239	240:50	2.5	
		AIR/O_2									**66**	77:50		
240	1:10	AIR									254	255:50	3	
		AIR/O_2									**69**	80:50		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required---														
270	1:10	AIR									313	314:50	3.5	
		AIR/O_2									**83**	94:50		
300	1:10	AIR									380	381:50	3.5	
		AIR/O_2									**94**	105:50		
330	1:10	AIR									432	433:50	4	
		AIR/O_2									**106**	122:50		
Exceptional Exposure: SurDO_2 ---														
360	1:10	AIR									474	475:50	4.5	
		AIR/O_2									**118**	134:50		

Table 9-9. Air Decompression Table (Continued).

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
60 FSW														
63	2:00	AIR									0	2:00	0	K
		AIR/O_2									**0**	2:00		
65	1:20	AIR									2	4:00	0.5	L
		AIR/O_2									**1**	3:00		
70	1:20	AIR									7	9:00	0.5	L
		AIR/O_2									**4**	6:00		
80	1:20	AIR									14	16:00	0.5	N
		AIR/O_2									**7**	9:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
90	1:20	AIR									23	25:00	0.5	O
		AIR/O_2									**10**	12:00		
100	1:20	AIR									42	44:00	1	Z
		AIR/O_2									**15**	17:00		
110	1:20	AIR									57	59:00	1	Z
		AIR/O_2									**21**	23:00		
120	1:20	AIR									75	77:00	1	Z
		AIR/O_2									**26**	28:00		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
130	1:20	AIR									102	104:00	1.5	Z
		AIR/O_2									**31**	33:00		
140	1:20	AIR									124	126:00	1.5	Z
		AIR/O_2									**35**	37:00		
150	1:20	AIR									143	145:00	2	Z
		AIR/O_2									**41**	48:00		
160	1:20	AIR									158	160:00	2	Z
		AIR/O_2									**48**	55:00		
170	1:20	AIR									178	180:00	2	
		AIR/O_2									**53**	60:00		
180	1:20	AIR									201	203:00	2.5	
		AIR/O_2									**59**	66:00		
190	1:20	AIR									222	224:00	2.5	
		AIR/O_2									**64**	71:00		
200	1:20	AIR									240	242:00	2.5	
		AIR/O_2									**68**	80:00		
210	1:20	AIR									256	258:00	3	
		AIR/O_2									**73**	85:00		
220	1:20	AIR									278	280:00	3	
		AIR/O_2									**77**	89:00		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required--														
230	1:20	AIR									300	302:00	3.5	
		AIR/O_2									**82**	94:00		
240	1:20	AIR									321	323:00	3.5	
		AIR/O_2									**88**	100:00		
270	1:20	AIR									398	400:00	4	
		AIR/O_2									**102**	119:00		
Exceptional Exposure: SurDO_2 --														
300	1:20	AIR									456	458:00	4.5	
		AIR/O_2									**115**	132:00		

Table 9-9. Air Decompression Table (Continued).
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
70 FSW														
48	2:20	AIR									0	2:20	0	K
		AIR/O_2									**0**	2:20		
50	1:40	AIR									2	4:20	0.5	K
		AIR/O_2									**1**	3:20		
55	1:40	AIR									9	11:20	0.5	L
		AIR/O_2									**5**	7:20		
60	1:40	AIR									14	16:20	0.5	M
		AIR/O_2									**8**	10:20		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
70	1:40	AIR									24	26:20	0.5	N
		AIR/O_2									**13**	15:20		
80	1:40	AIR									44	46:20	1	O
		AIR/O_2									**17**	19:20		
90	1:40	AIR									64	66:20	1	Z
		AIR/O_2									**24**	26:20		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
100	1:40	AIR									88	90:20	1.5	Z
		AIR/O_2									**31**	33:20		
110	1:40	AIR									120	122:20	1.5	Z
		AIR/O_2									**38**	45:20		
120	1:40	AIR									145	147:20	2	Z
		AIR/O_2									**44**	51:20		
130	1:40	AIR									167	169:20	2	Z
		AIR/O_2									**51**	58:20		
140	1:40	AIR									189	191:20	2.5	
		AIR/O_2									**59**	66:20		
150	1:40	AIR									219	221:20	2.5	
		AIR/O_2									**66**	78:20		
160	1:20	AIR								1	244	247:00	3	
		AIR/O_2								**1**	**72**	85:00		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required--														
170	1:20	AIR								2	265	269:00	3	
		AIR/O_2								**1**	**78**	91:00		
180	1:20	AIR								4	289	295:00	3.5	
		AIR/O_2								**2**	**83**	97:00		
190	1:20	AIR								5	316	323:00	3.5	
		AIR/O_2								**3**	**88**	103:00		
200	1:20	AIR								9	345	356:00	4	
		AIR/O_2								**5**	**93**	115:00		
210	1:20	AIR								13	378	393:00	4	
		AIR/O_2								**7**	**98**	122:00		
Exceptional Exposure: SurDO_2 ---														
240	1:20	AIR								25	454	481:00	5	
		AIR/O_2								**13**	**110**	140:00		

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
80 FSW														
39	2:40	AIR									0	2:40	0	J
		AIR/O_2									**0**	2:40		
40	2:00	AIR									1	3:40	0.5	J
		AIR/O_2									**1**	3:40		
45	2:00	AIR									10	12:40	0.5	K
		AIR/O_2									**5**	7:40		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
50	2:00	AIR									17	19:40	0.5	M
		AIR/O_2									**9**	11:40		
55	2:00	AIR									24	26:40	0.5	M
		AIR/O_2									**13**	15:40		
60	2:00	AIR									30	32:40	1	N
		AIR/O_2									**16**	18:40		
70	2:00	AIR									54	56:40	1	O
		AIR/O_2									**22**	24:40		
80	2:00	AIR									77	79:40	1.5	Z
		AIR/O_2									**30**	32:40		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
90	2:00	AIR									114	116:40	1.5	Z
		AIR/O_2									**39**	46:40		
100	1:40	AIR								1	147	150:20	2	Z
		AIR/O_2								**1**	**46**	54:20		
110	1:40	AIR								6	171	179:20	2	Z
		AIR/O_2								**3**	**51**	61:20		
120	1:40	AIR								10	200	212:20	2.5	
		AIR/O_2								**5**	**59**	71:20		
130	1:40	AIR								14	232	248:20	3	
		AIR/O_2								**7**	**67**	86:20		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required---														
140	1:40	AIR								17	258	277:20	3.5	
		AIR/O_2								**9**	**73**	94:20		
150	1:40	AIR								19	285	306:20	3.5	
		AIR/O_2								**10**	**80**	102:20		
160	1:40	AIR								21	318	341:20	4	
		AIR/O_2								**11**	**86**	114:20		
170	1:40	AIR								27	354	383:20	4	
		AIR/O_2								**14**	**90**	121:20		
Exceptional Exposure: SurDO_2 ---														
180	1:40	AIR								33	391	426:20	4.5	
		AIR/O_2								**17**	**96**	130:20		
210	1:40	AIR								51	473	526:20	5	
		AIR/O_2								**26**	**110**	158:20		

Table 9-9. Air Decompression Table (Continued).

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop									Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
			100	90	80	70	60	50	40	30	20			
90 FSW														
33	3:00	AIR									0	3:00	0	J
		AIR/O_2									**0**	3:00		
35	2:20	AIR									4	7:00	0.5	J
		AIR/O_2									**2**	5:00		
40	2:20	AIR									14	17:00	0.5	L
		AIR/O_2									**7**	10:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended ---														
45	2:20	AIR									23	26:00	0.5	M
		AIR/O_2									**12**	15:00		
50	2:20	AIR									31	34:00	1	N
		AIR/O_2									**17**	20:00		
55	2:20	AIR									39	42:00	1	O
		AIR/O_2									**21**	24:00		
60	2:20	AIR									56	59:00	1	O
		AIR/O_2									**24**	27:00		
70	2:20	AIR									83	86:00	1.5	Z
		AIR/O_2									**32**	35:00		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
80	2:00	AIR								5	125	132:40	2	Z
		AIR/O_2								**3**	**40**	50:40		
90	2:00	AIR								13	158	173:40	2	Z
		AIR/O_2								**7**	**46**	60:40		
100	2:00	AIR								19	185	206:40	2.5	
		AIR/O_2								**10**	**53**	70:40		
110	2:00	AIR								25	224	251:40	3	
		AIR/O_2								**13**	**61**	86:40		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required--														
120	1:40	AIR							2	28	256	288:20	3.5	
		AIR/O_2							2	**14**	**70**	98:40		
130	1:40	AIR							5	28	291	326:20	3.5	
		AIR/O_2							5	**14**	**79**	110:40		
140	1:40	AIR							8	28	330	368:20	4	
		AIR/O_2							8	**14**	**87**	126:40		
Exceptional Exposure: SurDO_2 ---														
150	1:40	AIR							11	34	378	425:20	4.5	
		AIR/O_2							11	**17**	**94**	139:40		
160	1:40	AIR							13	40	418	473:20	4.5	
		AIR/O_2							13	**20**	**101**	151:40		
170	1:40	AIR							15	45	451	513:20	5	
		AIR/O_2							15	**23**	**106**	166:40		
180	1:40	AIR							16	51	479	548:20	5.5	
		AIR/O_2							16	**26**	**112**	176:40		
240	1:40	AIR							42	68	592	704:20	7.5	
		AIR/O_2							42	**34**	**159**	267:40		

__Table 9-9.__ Air Decompression Table (Continued).
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
100 FSW														
25	3:20	AIR									0	3:20	0	H
		AIR/O_2									**0**	3:20		
30	2:40	AIR									3	6:20	0.5	J
		AIR/O_2									**2**	5:20		
35	2:40	AIR									15	18:20	0.5	L
		AIR/O_2									**8**	11:20		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
40	2:40	AIR									26	29:20	1	M
		AIR/O_2									**14**	17:20		
45	2:40	AIR									36	39:20	1	N
		AIR/O_2									**19**	22:20		
50	2:40	AIR									47	50:20	1	O
		AIR/O_2									**24**	27:20		
55	2:40	AIR									65	68:20	1.5	Z
		AIR/O_2									**28**	31:20		
60	2:40	AIR									81	84:20	1.5	Z
		AIR/O_2									**33**	36:20		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
70	2:20	AIR								11	124	138:00	2	Z
		AIR/O_2								**6**	**39**	53:00		
80	2:20	AIR								21	160	184:00	2.5	Z
		AIR/O_2								**11**	**45**	64:00		
90	2:00	AIR							2	28	196	228:40	2.5	
		AIR/O_2							2	**14**	**53**	82:00		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required--														
100	2:00	AIR							9	28	241	280:40	3	
		AIR/O_2							9	**14**	**66**	102:00		
110	2:00	AIR							14	28	278	322:40	3.5	
		AIR/O_2							14	**14**	**76**	117:00		
120	2:00	AIR							19	28	324	373:40	4	
		AIR/O_2							19	**14**	**85**	136:00		
Exceptional Exposure: SurDO_2 --														
150	1:40	AIR						3	26	46	461	538:20	5	
		AIR/O_2						3	26	**23**	**109**	183:40		

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop									Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
			100	**90**	**80**	**70**	**60**	**50**	**40**	**30**	**20**			
110 FSW														
20	3:40	AIR									0	3:40	0	H
		AIR/O_2									**0**	3:40		
25	3:00	AIR									5	8:40	0.5	I
		AIR/O_2									**3**	6:40		
30	3:00	AIR									14	17:40	0.5	K
		AIR/O_2									**7**	10:40		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
35	3:00	AIR									27	30:40	1	M
		AIR/O_2									**14**	17:40		
40	3:00	AIR									39	42:40	1	N
		AIR/O_2									**20**	23:40		
45	3:00	AIR									50	53:40	1	O
		AIR/O_2									**26**	29:40		
50	3:00	AIR									71	74:40	1.5	Z
		AIR/O_2									**32**	35:40		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
55	2:40	AIR								5	85	93:20	1.5	Z
		AIR/O_2								**3**	**33**	44:20		
60	2:40	AIR								13	111	127:20	2	Z
		AIR/O_2								**7**	**36**	51:20		
70	2:40	AIR								26	155	184:20	2.5	Z
		AIR/O_2								**14**	**42**	64:20		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required---														
80	2:20	AIR							9	28	200	240:00	2.5	
		AIR/O_2							9	**14**	**54**	90:20		
90	2:20	AIR							18	28	249	298:00	3.5	
		AIR/O_2							18	**14**	**68**	113:20		
100	2:20	AIR							25	28	295	351:00	3.5	
		AIR/O_2							25	**14**	**79**	131:20		
110	2:00	AIR						5	26	28	353	414:40	4	
		AIR/O_2						5	26	**14**	**91**	154:00		
Exceptional Exposure: SurDO_2 ---														
120	2:00	AIR						10	26	35	413	486:40	4.5	
		AIR/O_2						10	26	**18**	**101**	173:00		
180	1:40	AIR					3	23	47	68	593	736:20	7.5	
		AIR/O_2					3	23	47	**34**	**159**	298:40		

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

			DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop											
Bottom Time (min)	**Time to First Stop (M:S)**	**Gas Mix**	**100**	**90**	**80**	**70**	**60**	**50**	**40**	**30**	**20**	**Total Ascent Time (M:S)**	**Chamber O_2 Periods**	**Repet Group**
120 FSW														
15	4:00	AIR									0	4:00	0	F
		AIR/O_2									**0**	4:00		
20	3:20	AIR									4	8:00	0.5	H
		AIR/O_2									**2**	6:00		
25	3:20	AIR									9	13:00	0.5	J
		AIR/O_2									**5**	9:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
30	3:20	AIR									24	28:00	0.5	L
		AIR/O_2									**13**	17:00		
35	3:20	AIR									38	42:00	1	N
		AIR/O_2									**20**	24:00		
40	3:00	AIR								2	49	54:40	1	O
		AIR/O_2								**1**	**26**	30:40		
45	3:00	AIR								3	71	77:40	1.5	Z
		AIR/O_2								**2**	**31**	36:40		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
50	3:00	AIR								10	85	98:40	1.5	Z
		AIR/O_2								**5**	**33**	46:40		
55	3:00	AIR								19	116	138:40	2	Z
		AIR/O_2								**10**	**35**	53:40		
60	3:00	AIR								27	142	172:40	2	Z
		AIR/O_2								**14**	**39**	61:40		
70	2:40	AIR							13	28	190	234:20	2.5	
		AIR/O_2							13	**14**	**51**	86:40		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required---														
80	2:40	AIR							24	28	246	301:20	3	
		AIR/O_2							24	**14**	**67**	118:40		
90	2:20	AIR						7	26	28	303	367:00	3.5	
		AIR/O_2						7	26	**14**	**80**	140:20		
100	2:20	AIR						15	25	28	372	443:00	4	
		AIR/O_2						15	25	**14**	**95**	167:20		
Exceptional Exposure: SurDO_2 ---														
110	2:20	AIR						21	25	38	433	520:00	5	
		AIR/O_2						21	25	**19**	**105**	188:20		
120	2:00	AIR					3	23	25	47	480	580:40	5.5	
		AIR/O_2					3	23	25	**24**	**113**	211:00		

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
130 FSW														
12	4:20	AIR									0	4:20	0	F
		AIR/O_2									**0**	4:20		
15	3:40	AIR									3	7:20	0.5	G
		AIR/O_2									**2**	6:20		
20	3:40	AIR									8	12:20	0.5	I
		AIR/O_2									**5**	9:20		
In-Water Air/O_2 Decompression or SurDO_2 Recommended ---														
25	3:40	AIR									17	21:20	0.5	K
		AIR/O_2									**9**	13:20		
30	3:20	AIR								2	32	38:00	1	M
		AIR/O_2								1	**17**	22:00		
35	3:20	AIR								5	44	53:00	1	O
		AIR/O_2								**3**	**23**	30:00		
40	3:20	AIR								6	66	76:00	1.5	Z
		AIR/O_2								**3**	**30**	37:00		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
45	3:00	AIR							1	11	84	99:40	1.5	Z
		AIR/O_2							1	**6**	**33**	49:00		
50	3:00	AIR							2	20	118	143:40	2	Z
		AIR/O_2							2	**10**	**36**	57:00		
55	3:00	AIR							4	28	146	181:40	2	Z
		AIR/O_2							4	**14**	**40**	67:00		
60	3:00	AIR							12	28	170	213:40	2.5	Z
		AIR/O_2							12	**14**	**46**	81:00		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required--														
70	2:40	AIR						1	26	28	235	293:20	3	
		AIR/O_2						1	26	**14**	**63**	117:40		
80	2:40	AIR						12	26	28	297	366:20	3.5	
		AIR/O_2						12	26	**14**	**79**	144:40		
90	2:40	AIR						22	25	28	375	453:20	4	
		AIR/O_2						22	25	**14**	**95**	174:40		
Exceptional Exposure: SurDO_2 ---														
100	2:20	AIR					6	23	26	38	444	540:00	5	
		AIR/O_2					6	23	26	**20**	**106**	204:20		
120	2:20	AIR					17	24	27	57	534	662:00	6	
		AIR/O_2					17	24	27	**29**	**130**	255:20		
180	2:00	AIR				13	21	45	57	94	658	890:40	9	
		AIR/O_2				13	21	45	57	**46**	**198**	418:00		

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
140 FSW														
10	4:40	AIR									0	4:40	0	E
		AIR/O_2									**0**	4:40		
15	4:00	AIR									5	9:40	0.5	H
		AIR/O_2									**3**	7:40		
20	4:00	AIR									13	17:40	0.5	J
		AIR/O_2									**7**	11:40		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
25	3:40	AIR								3	24	31:20	1	L
		AIR/O_2								**2**	**12**	18:20		
30	3:40	AIR								7	37	48:20	1	N
		AIR/O_2								**4**	**19**	27:20		
35	3:20	AIR							2	7	58	71:00	1.5	O
		AIR/O_2							2	**4**	**26**	36:20		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
40	3:20	AIR							4	7	82	97:00	1.5	Z
		AIR/O_2							4	**4**	**33**	50:20		
45	3:20	AIR							5	18	114	141:00	2	Z
		AIR/O_2							5	**9**	**36**	59:20		
50	3:20	AIR							8	27	145	184:00	2	Z
		AIR/O_2							8	**14**	**39**	70:20		
55	3:00	AIR						1	15	29	171	219:40	2.5	Z
		AIR/O_2						1	15	**15**	**45**	85:00		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required--														
60	3:00	AIR						2	23	28	209	265:40	3	
		AIR/O_2						2	23	**14**	**56**	109:00		
70	3:00	AIR						14	25	29	276	347:40	3.5	
		AIR/O_2						14	25	**15**	**74**	142:00		
80	2:40	AIR					2	24	25	29	362	445:20	4	
		AIR/O_2					2	24	25	**15**	**91**	175:40		
Exceptional Exposure: SurDO_2 ---														
90	2:40	AIR					12	23	26	38	443	545:20	5	
		AIR/O_2					12	23	26	**19**	**107**	210:40		

Table 9-9. *Air Decompression Table (Continued).*

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
150 FSW														
8	5:00	AIR									0	5:00	0	E
		AIR/O_2									**0**	5:00		
10	4:20	AIR									2	7:00	0.5	F
		AIR/O_2									**1**	6:00		
15	4:20	AIR									8	13:00	0.5	H
		AIR/O_2									**5**	10:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
20	4:00	AIR								2	15	21:40	0.5	K
		AIR/O_2								1	**8**	13:40		
25	4:00	AIR								7	29	40:40	1	M
		AIR/O_2								**4**	**14**	22:40		
30	3:40	AIR							4	7	45	60:20	1.5	O
		AIR/O_2							4	**4**	**22**	34:40		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
35	3:40	AIR							6	7	74	91:20	1.5	Z
		AIR/O_2							6	**4**	**30**	44:40		
40	3:20	AIR						2	6	14	106	132:00	2	Z
		AIR/O_2						2	6	**7**	**35**	59:20		
45	3:20	AIR						3	8	24	142	181:00	2	Z
		AIR/O_2						3	8	**12**	**40**	72:20		
50	3:20	AIR						4	14	28	170	220:00	2.5	Z
		AIR/O_2						4	14	**14**	**46**	87:20		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required--														
55	3:20	AIR						7	21	28	212	272:00	3	
		AIR/O_2						7	21	**14**	**57**	113:20		
60	3:20	AIR						11	26	28	248	317:00	3	
		AIR/O_2						11	26	**14**	**67**	132:20		
70	3:00	AIR					3	24	25	28	330	413:40	4	
		AIR/O_2					3	24	25	**14**	**85**	170:00		
Exceptional Exposure: SurDO_2 --														
80	3:00	AIR					15	23	26	35	430	532:40	4.5	
		AIR/O_2					15	23	26	**18**	**104**	205:00		
90	2:40	AIR				3	22	23	26	47	496	620:20	5.5	
		AIR/O_2				3	22	23	26	**24**	**118**	239:40		
120	2:20	AIR			3	20	22	23	50	75	608	804:00	8	
		AIR/O_2			3	20	22	23	50	**37**	**168**	356:20		
180	2:00	AIR		2	19	20	42	48	79	121	694	1027:40	10.5	
		AIR/O_2		2	19	20	42	48	79	**58**	**222**	538:00		

Table 9-9. Air Decompression Table (Continued).

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop									Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
			100	90	80	70	60	50	40	30	20			
160 FSW														
7	5:20	AIR									0	5:20	0	E
		AIR/O_2									**0**	5:20		
10	4:40	AIR									4	9:20	0.5	F
		AIR/O_2									**2**	7:20		
15	4:20	AIR								2	10	17:00	0.5	I
		AIR/O_2								**1**	**6**	12:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
20	4:00	AIR							1	4	19	28:40	0.5	L
		AIR/O_2							1	**2**	**10**	18:00		
25	4:00	AIR							4	7	35	50:40	1	N
		AIR/O_2							4	**4**	**17**	30:00		
30	3:40	AIR						2	6	7	62	81:20	1.5	Z
		AIR/O_2						2	6	**4**	**26**	42:40		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
35	3:40	AIR						4	6	8	89	111:20	1.5	Z
		AIR/O_2						4	6	**4**	**34**	57:40		
40	3:40	AIR						6	6	21	134	171:20	2	Z
		AIR/O_2						6	6	**11**	**38**	70:40		
45	3:20	AIR					2	5	11	28	166	216:00	2.5	Z
		AIR/O_2					2	5	11	**14**	**45**	86:20		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required--														
50	3:20	AIR					2	8	19	28	207	268:00	3	
		AIR/O_2					2	8	19	**15**	**55**	113:20		
55	3:20	AIR					3	11	26	28	248	320:00	3	
		AIR/O_2					3	11	26	**14**	**67**	135:20		
60	3:20	AIR					6	17	25	29	291	372:00	3.5	
		AIR/O_2					6	17	25	**15**	**77**	154:20		
Exceptional Exposure: SurDO_2 --														
70	3:20	AIR					15	23	26	29	399	496:00	4.5	
		AIR/O_2					15	23	26	**15**	**99**	197:20		
80	3:00	AIR				6	21	24	25	44	482	605:40	5.5	
		AIR/O_2				6	21	24	25	**23**	**114**	237:00		

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
170 FSW														
6	5:40	AIR									0	5:40	0	D
		AIR/O_2									**0**	5:40		
10	5:00	AIR									6	11:40	0.5	G
		AIR/O_2									**3**	8:40		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
15	4:40	AIR								3	13	21:20	0.5	J
		AIR/O_2								2	**6**	13:20		
20	4:20	AIR							3	6	24	38:00	1	M
		AIR/O_2							3	**3**	**12**	23:20		
25	4:00	AIR						1	7	7	41	60:40	1	O
		AIR/O_2						1	7	**4**	**20**	37:00		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
30	4:00	AIR						5	7	7	77	100:40	1.5	Z
		AIR/O_2						5	7	**3**	**30**	50:00		
35	3:40	AIR					2	6	6	15	120	153:20	2	Z
		AIR/O_2					2	6	6	**8**	**37**	68:40		
40	3:40	AIR					4	6	9	25	158	206:20	2.5	Z
		AIR/O_2					4	6	9	**12**	**44**	84:40		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required---														
45	3:40	AIR					5	7	16	28	197	257:20	2.5	Z
		AIR/O_2					5	7	16	**14**	**53**	109:40		
50	3:20	AIR				1	5	11	23	28	244	316:00	3	
		AIR/O_2				1	5	11	23	**14**	**66**	134:20		
55	3:20	AIR				2	7	16	26	28	289	372:00	3.5	
		AIR/O_2				2	7	16	26	**14**	**77**	156:20		
60	3:20	AIR				2	11	21	26	28	344	436:00	4	
		AIR/O_2				2	11	21	26	**14**	**88**	181:20		
Exceptional Exposure: SurDO_2 --														
70	3:20	AIR				7	19	24	25	39	454	572:00	5	
		AIR/O_2				7	19	24	25	**20**	**109**	228:20		
80	3:20	AIR				17	22	23	26	53	525	670:00	6	
		AIR/O_2				17	22	23	26	**27**	**128**	267:20		
90	3:00	AIR			8	19	22	23	37	66	574	752:40	7	
		AIR/O_2			8	19	22	23	37	**33**	**148**	319:00		
120	2:40	AIR		9	19	20	22	42	60	94	659	928:20	9	
		AIR/O_2		9	19	20	22	42	60	**46**	**198**	454:40		
180	2:20	AIR	10	18	19	40	43	70	97	156	703	1159:00	11.5	
		AIR/O_2	10	18	19	40	43	70	97	**74**	**229**	648:00		

Table 9-9. Air Decompression Table (Continued).

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
180 FSW														
6	6:00	AIR									0	6:00	0	E
		AIR/O_2									**0**	6:00		
10	5:20	AIR									8	14:00	0.5	G
		AIR/O_2									**4**	10:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
15	4:40	AIR							2	3	14	24:20	0.5	K
		AIR/O_2							2	**2**	**7**	16:40		
20	4:20	AIR						1	5	7	29	47:00	1	M
		AIR/O_2						1	5	**3**	**15**	29:20		
25	4:20	AIR						5	6	7	57	80:00	1.5	O
		AIR/O_2						5	6	**4**	**24**	44:20		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
30	4:00	AIR					3	6	6	7	95	121:40	1.5	Z
		AIR/O_2					3	6	6	**4**	**34**	63:00		
35	3:40	AIR				1	5	6	6	22	144	188:20	2	Z
		AIR/O_2				1	5	6	6	**11**	**41**	79:40		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required---														
40	3:40	AIR				2	6	5	13	28	178	236:20	2.5	
		AIR/O_2				2	6	5	13	**14**	**48**	97:40		
45	3:40	AIR				4	5	10	20	28	235	306:20	3	
		AIR/O_2				4	5	10	20	**14**	**63**	130:40		
50	3:40	AIR				4	8	13	25	29	277	360:20	3.5	
		AIR/O_2				4	8	13	25	**15**	**75**	154:40		
55	3:40	AIR				5	11	19	26	28	336	429:20	4	
		AIR/O_2				5	11	19	26	**14**	**87**	181:40		
Exceptional Exposure: SurDO_2 --														
60	3:20	AIR			1	8	13	23	25	31	406	511:00	4.5	
		AIR/O_2			1	8	13	23	25	**16**	**100**	205:20		
70	3:20	AIR			4	12	21	24	25	48	499	637:00	5.5	
		AIR/O_2			4	12	21	24	25	**24**	**119**	253:20		

Table 9-9. *Air Decompression Table (Continued).*

(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
190 FSW														
5	6:20	AIR									0	6:20	0	D
		AIR/O_2									**0**	6:20		
10	5:20	AIR								2	8	16:00	0.5	H
		AIR/O_2								1	**4**	11:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended --														
15	4:40	AIR						1	3	3	16	28:20	0.5	K
		AIR/O_2						1	3	**2**	**8**	19:40		
20	4:20	AIR					1	2	6	7	34	55:00	1	N
		AIR/O_2					1	2	6	**4**	**17**	35:20		
Exceptional Exposure: In-Water Air Decompression ------------- In-Water Air/O_2 Decompression or SurDO_2 Required -----------														
25	4:20	AIR					2	6	7	7	72	99:00	1.5	Z
		AIR/O_2					2	6	7	**3**	**28**	51:20		
30	4:00	AIR				1	6	5	7	13	122	158:40	2	Z
		AIR/O_2				1	6	5	7	**7**	**38**	74:00		
Exceptional Exposure: In-Water Air/0_2 Decompression ------------- SurDO_2 Required--														
35	4:00	AIR				4	5	6	8	26	165	218:40	2.5	Z
		AIR/O_2				4	5	6	8	**13**	**45**	91:00		
40	3:40	AIR			1	5	5	8	17	28	217	285:20	3	
		AIR/O_2			1	5	5	8	17	**15**	**58**	123:40		
45	3:40	AIR			2	5	6	12	24	29	264	346:20	3.5	
		AIR/O_2			2	5	6	12	24	**15**	**71**	149:40		
50	3:40	AIR			3	5	10	17	26	28	324	417:20	4	
		AIR/O_2			3	5	10	17	26	**14**	**85**	179:40		
Exceptional Exposure: SurDO2 --														
55	3:40	AIR			4	8	10	24	25	30	397	502:20	4.5	
		AIR/O_2			4	8	10	24	25	**15**	**99**	204:40		
60	3:40	AIR			5	10	16	24	25	40	454	578:20	5	
		AIR/O_2			5	10	16	24	25	**20**	**109**	233:40		
90	3:20	AIR		11	19	20	21	28	51	83	626	863:00	8.5	
		AIR/O_2		11	19	20	21	28	51	**41**	**178**	408:20		
120	3:00	AIR	15	17	19	20	37	46	79	113	691	1040:40	10.5	
		AIR/O_2	15	17	19	20	37	46	79	**55**	**219**	551:00		

***Table 9-9.** Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

200 FSW

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
Exceptional Exposure ----------														
5	6:40	AIR									0	6:40	0	E
		AIR/O_2									**0**	6:40		
10	5:40	AIR								3	8	17:20	0.5	H
		AIR/O_2								**2**	**4**	12:20		
15	5:00	AIR						2	3	5	19	34:40	0.5	L
		AIR/O_2						2	3	**3**	**9**	23:00		
20	4:40	AIR					2	4	6	7	43	67:20	1	O
		AIR/O_2					2	4	6	**4**	**20**	41:40		
25	4:20	AIR				1	5	6	6	7	85	115:00	1.5	Z
		AIR/O_2				1	5	6	6	**4**	**32**	64:20		
30	4:20	AIR				4	6	5	7	19	145	191:00	2	Z
		AIR/O_2				4	6	5	7	**10**	**42**	84:20		
35	4:00	AIR			2	5	5	6	13	28	188	251:40	2.5	
		AIR/O_2			2	5	5	6	13	**14**	**51**	106:00		
40	4:00	AIR			4	5	5	11	21	28	249	327:40	3.5	
		AIR/O_2			4	5	5	11	21	**14**	**68**	143:00		
45	3:40	AIR		1	4	5	10	14	25	28	306	397:20	3.5	
		AIR/O_2		1	4	5	10	14	25	**14**	**81**	168:40		
50	3:40	AIR		2	4	8	10	21	26	28	382	485:20	4.5	
		AIR/O_2		2	4	8	10	21	26	**14**	**97**	201:40		

210 FSW

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
Exceptional Exposure ----------														
4	7:00	AIR									0	7:00	0	D
		AIR/O_2									**0**	7:00		
5	6:20	AIR									2	9:00	0.5	E
		AIR/O_2									**1**	8:00		
10	5:40	AIR							2	3	9	20:20	0.5	I
		AIR/O_2							2	**2**	**4**	14:40		
15	5:00	AIR					1	3	3	6	24	42:40	1	M
		AIR/O_2					1	3	3	**3**	**12**	28:00		
20	4:40	AIR				1	3	5	6	7	57	84:20	1	O
		AIR/O_2				1	3	5	6	**4**	**23**	47:40		
25	4:40	AIR				3	6	5	7	8	110	144:20	2	Z
		AIR/O_2				3	6	5	7	**4**	**38**	73:40		
30	4:20	AIR			2	5	6	6	6	26	163	219:00	2.5	Z
		AIR/O_2			2	5	6	6	6	**13**	**45**	93:20		
35	4:00	AIR		1	4	5	6	7	18	28	223	296:40	3	
		AIR/O_2		1	4	5	6	7	18	**14**	**60**	130:00		
40	4:00	AIR		2	5	5	7	11	26	28	278	366:40	3.5	
		AIR/O_2		2	5	5	7	11	26	**14**	**76**	161:00		
45	4:00	AIR		4	4	6	11	18	26	28	355	456:40	4	
		AIR/O_2		4	4	6	11	18	26	**14**	**91**	194:00		
50	3:40	AIR	1	4	5	10	12	23	26	36	432	553:20	5	
		AIR/O_2	1	4	5	10	12	23	26	**18**	**105**	223:40		

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop												Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
			130	120	110	100	90	80	70	60	50	40	30	20			
220 FSW																	
Exceptional Exposure																	
4	7:20	AIR												0	7:20	0	E
		AIR/O_2												**0**	7:20		
5	6:40	AIR												3	10:20	0.5	E
		AIR/O_2												**2**	9:20		
10	6:00	AIR										3	4	10	23:40	0.5	J
		AIR/O_2										3	**2**	**5**	17:00		
15	5:20	AIR								3	2	4	7	28	50:00	1	N
		AIR/O_2								3	2	4	**4**	**14**	33:20		
20	5:00	AIR							2	4	6	6	7	70	100:40	1.5	Z
		AIR/O_2							2	4	6	6	**4**	**26**	54:00		
25	4:40	AIR						1	5	6	6	6	14	133	176:20	2	Z
		AIR/O_2						1	5	6	6	6	**7**	**41**	82:40		
30	4:20	AIR					1	4	5	6	6	10	28	183	248:00	2.5	
		AIR/O_2					1	4	5	6	6	10	**14**	**50**	106:20		
35	4:20	AIR					3	5	5	5	10	22	28	251	334:00	3.5	
		AIR/O_2					3	5	5	5	10	22	**14**	**68**	147:20		
40	4:00	AIR				1	4	5	5	9	15	26	28	319	416:40	4	
		AIR/O_2				1	4	5	5	9	15	26	**14**	**84**	183:00		
250 FSW																	
Exceptional Exposure																	
4	7:40	AIR												4	12:20	0.5	F
		AIR/O_2												**2**	10:20		
5	7:40	AIR												7	15:20	0.5	G
		AIR/O_2												**4**	12:20		
10	6:20	AIR								2	2	4	3	15	33:00	0.5	L
		AIR/O_2								2	2	4	**2**	**7**	24:20		
15	5:40	AIR						2	2	3	4	6	7	53	83:20	1	O
		AIR/O_2						2	2	3	4	6	**4**	**22**	49:40		
20	5:20	AIR					2	2	4	6	6	6	11	125	168:00	2	Z
		AIR/O_2					2	2	4	6	6	6	**6**	**39**	82:20		
25	5:00	AIR				1	4	4	5	6	6	10	28	189	258:40	2.5	
		AIR/O_2				1	4	4	5	6	6	10	**14**	**51**	112:00		
30	4:40	AIR			1	4	4	4	5	6	9	25	28	267	358:20	3.5	
		AIR/O_2			1	4	4	4	5	6	9	25	**15**	**72**	160:40		
35	4:40	AIR			3	4	4	5	5	10	19	26	28	363	472:20	4	
		AIR/O_2			3	4	4	5	5	10	19	26	**14**	**93**	203:40		

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop												Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
			130	120	110	100	90	80	70	60	50	40	30	20			

300 FSW

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	130	120	110	100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
Exceptional Exposure																	
4	9:00	AIR											3	7	19:40	0.5	G
		AIR/O_2											**2**	**4**	15:40		
5	8:40	AIR										3	3	8	23:20	0.5	I
		AIR/O_2										3	**2**	**4**	18:40		
10	7:20	AIR						2	3	2	3	4	7	35	64:00	1	N
		AIR/O_2						2	3	2	3	4	**4**	**18**	44:20		
15	6:20	AIR			1	2	2	3	3	5	6	7	11	125	172:00	2	Z
		AIR/O_2			1	2	2	3	3	5	6	7	**6**	**39**	86:20		
20	6:00	AIR		2	2	2	4	5	5	5	6	16	28	219	300:40	3	
		AIR/O_2		2	2	2	4	5	5	5	6	16	**14**	**59**	137:00		
25	5:40	AIR	1	3	4	4	4	5	5	5	18	26	28	324	433:20	4	
		AIR/O_2	1	3	4	4	4	5	5	5	18	26	**14**	**85**	195:40		

ATTACHMENT 11

EQUIPMENT CHECKLISTS

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ATTACHMENT 11

EQUIPMENT CHECKLISTS

PROJECT NAME: ____________________________________ DATE: ____________________

GENERAL DIVE EQUIPMENT LOADOUT

General Dive Equipment

Item	Quantity	Inspected for operation and loaded
DIVE FLAG (CIVILIAN AND CODE ALPHA)		
LOST DIVER BUOY		
TENDING LINES AND HARNESSES		
HANDHELD GPS		
BUDDY LINES		
DIVE SYSTEM(S)		
AIR SUPPLY/ BOTTLES		
CELLULAR PHONE (ON AND CHARGED)		
VHF RADIO		
DRINKING WATER		
PERSONAL DIVE GEAR		
DIVE OPS WORK PLAN		
DIVE SAFE PRACTICES MANUAL		
U.S. NAVY DIVE MANUAL		
EMERGENCY CONTACT LIST (POSTED)		
REQUIRED LINES, BUOYS, ANCHORS		

ATTACHMENT 11

EQUIPMENT CHECKLISTS

PROJECT NAME: ______________________________________ DATE: _____________________

GENERAL DIVE EQUIPMENT LOADOUT

Medical Equipment

Item	Quantity	Inspected for operation and loaded	
FIRST AID KIT/ TRAUMA KIT			
EMERGENCY OXYGEN SYSTEM		**PSIG**	**PSIG**
STRETCHER OR BACKBOARD			

Tools, UXO Related Equipment, Explosive Materials

Item	Quantity	Inspected for operation and loaded

Loadout Checked (Name)

Signature

Diving Supervisor Name

Diving Supervisor Signature

ATTACHMENT 11

EQUIPMENT CHECKLISTS

BOAT PRE-OPERATION CHECKLIST

Project Description:	Date:
Project Location:	**Job#:**

Step No.	Description	Check Completed (Initials)
1	**Inspect exterior of vessel** ☐ Inspect for visible damage ☐ Boat registration ☐ POL leaks ☐ Hull plugs in place ☐ Maintenance issues	
2	**Inspect propulsion system** ☐ a. Engine (propeller, oil, fuel level and extra fuel on board, hours since last maintenance, functional, and adequately secured to vessel) ☐ b. Steering system (functional, forward/reverse gears) ☐ c. Batteries (charged, water in cells, contacts clean)	
3	**Inspect all communication equipment** ☐ a. Perform VHF radio check with a base station ☐ b. Perform cellular phone check with a base station ☐ c. Perform dive communication check with radio and dive hats ☐ d. Have spare batteries charged and within reach of all comm. equip.	
4	**Inspect electrical systems and all other communication equipment** Ensure the following are on board and in work order ☐ a. Dive flags (Alpha and Recreational) and pole ☐ b. Sound signaling device (vessel horn, hand horn, whistle) ☐ c. Flares (rocket/parachute, hand held, smoke) ☐ d. Water dye canister, flash light, signaling mirror, EPIRB, and strobe lights for PFDs ☐ e. Deck and Navigation lighting (port, starboard, fore/aft, search, and cabin) ☐ f. Bilge pump	
5	**Inspect mooring systems** ☐ a. Anchor secured to line/chain and functional ☐ b. Line/chain in working order and ready for use ☐ c. Fenders secure and ready for use ☐ d. Extra line available for use	
6	**Ensure navigational equipment is functioning** ☐ a. GPS (locked on 4 satellites, correct datum, power source) ☐ b. Compass and binoculars ☐ c. Charts / maps	
7	**Place copies of the following in cabin near helm** ☐ a. Emergency procedures plan ☐ b. Safe diving practices and operations manual ☐ c. Air decompression tables	

ATTACHMENT 11

EQUIPMENT CHECKLISTS

BOAT PRE-OPERATION CHECKLIST

Step No.	Description	Check Completed (Initials)
8	**Inspect lifesaving equipment** ☐ a. Ensure 1 PFD per person and 1 throw ring (USCG approved, in working order and properly fitted with strobe, whistle and knife attached) ☐ b. First aid kit (stocked, non-expired contents), First aid book, back board ☐ c. Fire extinguisher (charged, current inspection, accessible)	
9	**Inspect toolbox** ☐ a. Spare parts for engine and other vessel systems ☐ b. Tools (clean and in working order) for repairing vessel systems and dive equipment	
10	**Alternate propulsion systems** ☐ a. Hand paddles (2) ☐ b. Spare outboard engine (complete, working, with spare fuel source)	
11	**Personal comfort equipment** ☐ a. Water ☐ b. Food ☐ c. Sunscreen/motion sickness medicine ☐ d. Clothing as required by conditions/locations (hard hat, sunglasses, ballcap, extreme weather, steel toed boots, change of clothes)	

NOTES:

1. File completed checklist in daily job log.
2. Record any maintenance issues in vessel log and report to Project Manager.
3. Complete dive boat safety checklist after completing this checklist.

ATTACHMENT 11
EQUIPMENT CHECKLISTS
SCUBA EQUIPMENT INSPECTION

Cylinders				FFMs/ Regulators/ Gauges		Buoyancy Compensators	
Primary		Emergency Bail-Out					
Pre-Dive	Post Dive	Pre-Dive	Post Dive	Pre-Dive	Post Dive	Pre-Dive	Post Dive
Serial # Inspect	Clean and Charge (PSIG)	Serial # Inspect	Clean and Charge (PSIG)	Serial # Inspect /Test	Clean and Inspect	Serial # Inspect /Test	Clean/Inspect

Notes:

1. Fill-in and initial each block prior to and after each dive. Place PSI level in block as indicated.
2. Ensure cylinders are gauged at minimum 90% capacity (2700 PSI) following charge. (NOTE: Gauge after bottles are cool).

Specific Pre-Dive Procedures:

FFM
- Inspect – Nose pad/ one-way/ comms/ purge/ ABV/ seal/ straps/ test breathe

Specific Post Dive Procedures:

Cylinders
- Rinse cylinders with fresh water.
- Leak check cylinders during charging.

Buoyancy Compensators
- Rinse with fresh water and clean BC.
- Inspect BC inflation and dump valves.
- Empty any water in BC, Inflate and leave overnight for drying and leak check

Masks / Regulators / Gauges
- Rinse with fresh water and sterilize masks and regulators (Note: see DOP concerning COVID-19 protocols).
- Inspect mask, regulator and hoses.
- Rinse & inspect gauges.

Diving Supervisor Name

Diving Supervisor Signature

ATTACHMENT 11

EQUIPMENT CHECKLISTS

SCUBA CHECKLIST

ALL ITEMS WILL BE CHECKED IN APPROPRIATE BLOCKS AS FOLLOWS:

1. **ALL PERSONNEL MUST WEAR SAFETY GLASSES WHEN WORKING WITH HP AIR**
2. **Initial for each completed and satisfactory check.**
3. **When completed, person completing the checks will sign as appropriate (blocks 1 thru 4) and then turn in to the Diving Supervisor for his checks, review and signature.**

Set Number	Diver Signature	Dive Supervisor Signature

Initial	Procedure	Remarks
Air Cylinders		
	Cylinders – inspect for current hydro and visual	
	O ring and valve – inspect condition	
	Pressure – adequate for days operations	
	Bail-Out Bottles - *Repeat above steps	
Buoyancy Compensator (BC)		
	Straps / Buckles / Harness – inspect condition and adjust for fit	
	Air bladder – leak check	
	Cylinder and bail-out – mount securely	
	Inflator fitting and hose – inspect condition	
	Dump valves – check for proper function	
Regulator(s)		
	Hoses / Connectors – inspect condition	
	1st and 2nd stages – inspect condition	
	Cylinder yoke assembly – secure	
	Bail-out regulator(s) – repeat above checks	
	Regulator assemblies – attach to cylinders	
	Inflation whip – attach to BC	
	Valves – open / leak check cylinder O ring	
	Pressure gauge – reading properly	
	Dive Computer – inspect, check batt, function	
	BC inflation – check proper function	
	Primary regulator / bail-out regulator - test	
	Fittings - Check for leaks	
	FFM – Nose pad/ one-way valves / comms/ pp/ ABV**/** seal/straps	
Notes:		

ATTACHMENT 11

EQUIPMENT CHECKLISTS

SCUBA CHECKLIST

ALL ITEMS WILL BE CHECKED IN APPROPRIATE BLOCKS AS FOLLOWS:

1. **ALL PERSONNEL MUST WEAR SAFETY GLASSES WHEN WORKING WITH HP AIR**
2. **Initial for each completed and satisfactory check.**
3. **When completed, person completing the checks will sign as appropriate (blocks 1 THRU 3) and then turn in to the Diving Supervisor for checks, review, and signature.**

Mask/ Type	Serial No.	Diver Signature	Dive Supervisor Signature
1.			
2.			
3.			
4.			
5.			

Initial	Procedure	Remarks
	Check SADS float inflation level	
	Check SADS for holes, tears, or air bladder leaks.	
	Check Umbilical condition and correctly secured to SADS float assembly.	
	Ensure SADS air bottles (primary and EGS are properly secured to SADS float assembly).	
	Attach Primary and EGS regulators to bottles	
	Check divers harness assembly (Configure as required)	
	Connect FFM to primary LP hose (replace second stage)	
	Inspect Full Face Mask (FFM) - Nose pad/ one-way/ comms/ pp/ ABV (if installed)/ seal / straps	
	Open main bottle slowly; record pressure	PSIG: (min 90% @ 2700 psig)
	Open EGS bottle slowly; record pressure	PSIG: (min 90% @ 2700 psig)
	Check air to FFM; test breathe	
	Check air to EGS; test breathe	
	Check comms – DV to/from SUPE (during in water checks)	

Notes:

ATTACHMENT 11

EQUIPMENT CHECKLISTS

SCUBA CHECKLIST

ALL ITEMS WILL BE CHECKED IN APPROPRIATE BLOCKS AS FOLLOWS:

1. **ALL PERSONNEL MUST WEAR SAFETY GLASSES WHEN WORKING WITH HP AIR**
2. **Initial for each completed and satisfactory check.**
3. **When completed, person completing the checks will sign as appropriate (blocks 1 or 2) and then turn in to the Diving Supervisor for checks, review, and signature.**

Mask/ Type	Serial No.	Diver Signature	Dive Supervisor Signature
1.			
2.			
3.			
4.			
5.			

Initial	Procedure	Remarks
	Secure primary and EGS air; bleed down system	
	Disconnect FFM	
	Check FFM for damage	
	Check SADS for holes, tears, or air bladder leaks.	
	Check umbilical condition and still correctly secured to SADS float assembly.	
	Remove primary and EGS first stages from bottles	
	Inspect harness	
	Cap all open fittings on umbilical	** Use dummy plugs/ tape connector.*
	Disinfect FFM and EGS 2nd stage with disinfectant solution/ wipes	*Note: See DOP for COVID-19 protocols*
	Wash all components with soap and water. Hang dry.	
	Stow SADS system	

Notes:

ATTACHMENT 11

EQUIPMENT CHECKLISTS

PRE-DIVE: SSA SYSTEM

PROJECT NAME/NUMBER:________________________________DATE:__________________
TENDER/DIVER: ____

NOTE: ALL ITEMS WILL BE CHECKED IN APPROPRIATE BLOCKS AS FOLLOWS:

1. **An initial for each completed and satisfactory check.**
2. **An N/A for each item not applicable to the Dive Helmet being pre-dove.**
3. **An "R" for any repairs made. A brief description in the remarks section. If more space required use the "notes" section for continuation.**
4. **When completed, person completing the checks will sign as appropriate and then turn in to the Diving Supervisor for his checks, review, and signature.**

Helmet/Mask Type	Serial No.	Checked By:	Signature	Dive Supe Signature
1.				
2.				

	Procedure	Remarks					
1	Ensure HP Air Bottles secured; Check cylinder pressures; Record cylinder pressures	#1:	#2:	#3:	#4:	#5:	#6:
2	Ensure ACS on solid surface and secured						
3	Inspect ACS condition						
4	Check Umbilical condition and secured						
5	Ensure all ACS valves are SECURED (closed);regulator valve low pressure (*all the way counterclockwise*)						
6	Attach HP whips to bottles						
7	Open bottles slowly; record HP Supply Pressure	PSIG #1:			PSIG #2:		
8	Attach Divers supply/ pneumo hoses/ comm wires and mic to ACS						
9	Open 1 HP supply (slowly)						
10	Set required OB pressure on ACS	OB PSIG:					

	Procedure	1	2	Remarks
11	Test non-return valve (suck and blow)			
12	Check helmet for damage / deterioration			
13	Check neck dam seal (lube if required)			
14	Check oral nasal mask			
15	Check side block assembly – ensure secure			
16	Check 2nd stage regulator			
17	Check inhalation diaphragm			
18	Check exhaust valve			
19	Check neck dam for damage			
20	Check neck dam assembly			
21	Check locking mechanism			
22	Check to ensure flow restrictor in place			*Mandatory if inflator hose used for dry suit
23	Ensure flow restrictor plug in place or stowed in safe place			*If inflator hose not used.
24	Check 1st stage assembly			
25	Check HP and LP hoses			

ATTACHMENT 11

EQUIPMENT CHECKLISTS

PRE-DIVE: SSA SYSTEM

	Procedure	1	2	Remarks	
26	**Check face plate secure and not damaged** (*DO NOT use screwdriver*)				
27	**Check harness assembly**				
28	**Check bailout bottle PSIG** *(90% or 2700 minimum)*			PSIG 1:	PSIG 2:
29	**Check air spread OPs completed**				
30	**Remove hose plugs; blow down system**				
31	**Connect hoses; snoop all fittings**				
32	**Adjust dial-a-breath**				
33	**Check free-flow**				
34	**Check purge**				
35	**Check EGS valve**				
36	**Check communications OK**				

Notes:

ATTACHMENT 11

EQUIPMENT CHECKLISTS

POST-DIVE: SSA SYSTEM

PROJECT NAME/NUMBER:__________________________________DATE:___________________
TENDER/DIVER: ____

NOTE: ALL ITEMS WILL BE CHECKED IN APPROPRIATE BLOCKS AS FOLLOWS:

1. **An initial for each completed and satisfactory check.**
2. **An N/A for each item not applicable to the Dive Helmet being pre-dove.**
3. **An "R" for any repairs made. A brief description in the remarks section. If more space required use the "notes" section for continuation.**
4. **When completed, person completing the checks will sign as appropriate (blocks 1 or 2) and then turn in to the DivingSupervisor for his checks, review and signature.**

Helmet/Mask Type	Serial No.	Checked By:	Signature	Dive Supe Signature
1.				
2.				

	Procedure	1	2	Remarks
1	Secure ACS			
2	Bleed and disconnect hoses			
3	Make sure flow restrictor remains on helmet when using dry suit inflator whip			
4	Install flow restrictor plug			
5	Disconnect comms: 2-wire or MM plug			
6	Cap helmet and umbilical fittings			
7	Check helmet for damage			
8	Check neck dam O-ring for damage (lube)			
9	Check neck dam assembly for damage			
10	Check locking mechanisms for damage			
11	Remove head liner			
12	Check oral nasal mask			
13	Check side block assembly - secured			
14	Check 2nd stage regulator			
15	Check inhalation diaphragm			
16	Check LP and HP hoses (1st stage)			
17	Check face plate secure and not damaged *(DO NOT use screwdriver)*			
18	Wash with soap and water. Then dry.			
19	Disinfect using COVID-19 protocols outlined in DOP			
20	Open all valves – back of ¼ turn			
21	Remove covers from ear speakers / comms pod			

Notes:
Number of dives:

ATTACHMENT 11

EQUIPMENT CHECKLISTS

PRE-DIVE: SURFACE SUPPLIED AIR w/ FFM

PROJECT NAME/NUMBER:________________________________DATE:__________________
TENDER/DIVER: ____

ALL ITEMS WILL BE CHECKED IN APPROPRIATE BLOCKS AS FOLLOWS:

1. **ALL PERSONNEL MUST WEAR SAFETY GLASSES WHEN WORKING WITH HP AIR**
2. **Initial for each completed and satisfactory check.**
3. **When completed, person completing the checks will sign as appropriate (blocks 1 THRU 3) and then turn in to the Diving Supervisor for his checks, review and signature.**

Mask/ Type	Serial No.	Diver Signature	Dive Supervisor Signature
1.			
2.			
3.			

Initial	Procedure	Remarks					
	Ensure HP Air Bottles secured; Check cylinder pressures; Record cylinder pressures	#1:	#2:	#3:	#4:	#5:	#6:
	Ensure ACS on solid surface and secured						
	Inspect ACS condition						
	Check Umbilical condition and secured						
	Ensure all ACS valves are SECURED (closed); regulator valve low pressure (*all the way counterclockwise*)						
	Attach HP whips to bottles						
	Open bottles slowly; record HP Supply Pressure	1 HP PSIG:				2 HP PSIG:	
	Attach Divers supply/ pneumo hoses/ comm wires and mic to ACS						
	Open 1 HP supply (slowly)						
	Set required OB pressure on ACS	OB PSIG:				* *Initial set @ 135 PSIG*	
	Check harness assembly						
	Check bailout bottle PSIG (90% @ min 2700)	PSIG DVR:				PSIG STBY:	
	Attach bailout first stage to pony bottle				* *Attach QD (first stage to KM block)*		
	Check KM Manifold Block (*Suck and blow*)						
	Blow down diver's umbilical's						
	Connect umbilical hose to KM blocks						
	Connect comms (Hi-use connector)			* *Secure dummy plugs/ tape connector*			
	Inspect Full Face Mask (FFM) - Nose pad/ one-way/ comms/ pp/ ABV/ seal / straps						
	Connect FFM to Block						
	Air to Masks						
	Check air to FFM; purge mask						
	Check comms – DV to console; DV to DV						
	Check pneumo for both umbilical's						
	Check all air spread OPs completed						

Notes:

ATTACHMENT 11

EQUIPMENT CHECKLISTS

POST-DIVE: SURFACE SUPPLIED AIR w/ FFM

PROJECT NAME/NUMBER:_________________________________DATE:___________________
TENDER/DIVER: ____

ALL ITEMS WILL BE CHECKED IN APPROPRIATE BLOCKS AS FOLLOWS:

1. **ALL PERSONNEL MUST WEAR SAFETY GLASSES WHEN WORKING WITH HP AIR**
2. **Initial for each completed and satisfactory check.**
3. **When completed, person completing the checks will sign as appropriate (blocks 1 or 2) and then turn in to the Diving Supervisor for his checks, review and signature.**

Mask/ Type	Serial No.	Diver Signature	Dive Supervisor Signature
1.			
2.			
3.			

Initial	Procedure	Remarks
	Secure HP air; bleed down all HP whips and umbilical's	
	Disconnect FFM air / comms	
	Check FFM for damage/ post dive	
	Disinfect with antibacterial wipes	*Note: See DOP for COVID-19 protocols.*
	Wash with soap and water. Then dry.	
	Bleed down EGS; Disconnect QD	
	Remove B/O first stage from pony	
	Bleed and disconnect hoses from KM block, inspect block and harness	
	Cap all fittings on block and umbilical	** Use dummy plugs/ tape connector.*
	Remove umbilicals from ACS/ stow	
	Cap all fittings on umbilical and ACS	
	Remove mic from ACS/ stow	
	Ensure all air system fittings capped and valves are secured; regulator valve backed out; ACS power OFF	
	Place ACS on charge or stow	

Notes:

APPENDIX B

DIVING RELATED ACTIVITY HAZARD ANALYSIS (AHAs) and BOATING INSTRUCTION HSE 1-10

Activity Hazard Analysis (AHA) #2

A draft AHA for this task is included below. This AHA will be reviewed by the SHM and the USACE as part of planning during development and finalization of the APP. The draft AHA will be finalized prior to initiation of this phase of field work by the staff performing the work and will be submitted for final approval by the SHM and the USACE prior to the preparatory phase inspection. Any modifications to the approved AHA that results in a higher RAC than the approved AHA will also be reviewed by the USACE and SHM. The AHA will be maintained by the staff performing the work, under SUXOS/DS and UXOSO oversight to keep it current to the work being performed and the hazards presented by the work as a living document.

Activity/Work Task: Boat Operations	**Overall Risk Assessment Code (RAC) (Use highest code)**						**M**
Project Location: Military Munitions Investigation Nashua River Former Ft. Devens	**Risk Assessment Code (RAC) Matrix**						
Contract Number: W912DR-21-D-0002, Task Order W912DR22F0121	**Severity**	**Probability**					
Date Prepared: July 2022		Frequent	Likely	Occasional	Seldom	Unlikely	
Prepared by: Jennifer Harlan, PMP	Catastrophic	**E**	**E**	**H**	**H**	**M**	
	Critical	**E**	**H**	**H**	**M**	**L**	
Reviewed by: Jeffrey (Jim) Streib, CIH, CSP, CHMM, CQA Director, Health, Safety and Environmental	Marginal	**H**	**M**	**M**	**L**	**L**	
	Negligible	**M**	**L**	**L**	**L**	**L**	
Notes: (Field Notes, Review Comments, etc.) In addition to the information listed in this AHA, all field personnel must review and be familiar with all provisions of the approved APP/SSHP. EM 385-1-1 will also be available on site for personnel to review specific materials and mitigation measures associated with this project. PPE for this AHA will consist of a PFD, appropriate footwear, safety glasses with side shields, a standard work uniform (long pants, tee shirt), hearing protection (as required), work gloves worn when indicated, , and other PPE described in this AHA. First Aid-/CPR-Qualified Persons: SUXOS/DS- Don Schwalback UXOSO- Patrick Oberley	Step 1: Review each **"Hazard"** with identified safety **"Controls"** and determine RAC (see above).						
	"Probability" is the likelihood to cause an incident, near miss, or accident and is identified as Frequent, Likely, Occasional, Seldom, or Unlikely.				**RAC Chart**		
	"Severity" is the outcome/degree if an incident, near miss, or accident did occur and is identified as Catastrophic, Critical, Marginal, or Negligible.				**E = Extremely High Risk** **H = High Risk**		
	Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on the AHA. Annotate the overall highest RAC at the top of the AHA.				**M = Moderate Risk** **L = Low Risk**		

AHA#2 - Boat Operations

Job Steps	Hazards	Controls	RAC
1. Boating	Boats & Skiffs could cause injury or death.	• Follow the requirements of EM 385-1-1 and using the inspection checklist provided in the dive safety procedure manual (DSPM). • All boat operators are qualified and trained in boat use and procedures. • Boat will be equipped with rescue equipment to handle a man overboard situation (such as life ring with rope, or similar equipment), and personnel trained in its use. • Ensure boat passengers have been briefed on the location, use, and inspection of emergency equipment onboard and the procedures to follow in the event of a shipboard emergency. • Practice drills will be done prior to or during first deployment for situations such as man overboard, fires and explosions, and abandon ship.	M
	Fueling of boat – potential for fire, environmental release. Run out of fuel when operating.	• No smoking or other sources of ignition when fueling. • Engine must be off. • There must be a fire extinguisher available. • Refuel in a manner to prevent any spills, especially spills into the water. If there is any sheen in the water the spill must be reported. • Check for fuel leaks in the boat, if fuel lines are in the boat. • Ensure there is enough fuel supply for the trip and the return to dock plus 1/3 in reserve.	M
	Boat could malfunction and drift into open water if engine does not work.	• Have anchor and enough line to deploy in the event of motor/engine malfunction. Ensure that a Float Plan is filed in accordance with the APP using the example Coast Guard Float Plan in the APP. • File this plan daily with the PM or designee before leaving the dock and notify them of your return. • Perform military munitions avoidance by avoiding operating the boat in shallow waters in which the boats hull, outdrives or jet-drives impact the sea floor. • Boat Operator will ensure that boat is well maintained and in good condition prior to taking on passengers. • Emergency radios will be in operating condition prior to leaving the wharf. There will be a primary and alternate means of communication, and extra batteries will be available. • Directions for contacting the Coast Guard and hospital will be posted with each radio and cell phone.	M
	Grounding	• Use caution in the shallow areas. • Use depth meter and spotting to avoid striking the bottom or grounding.	M
	Slip, trips, and falls	• Personnel should use appropriate footwear (sturdy leather deck shoes) to ensure that there is enough tread on the soles to minimize slipping. • Identify and remove trip hazards.	L

AHA#2 - Boat Operations			
Job Steps	**Hazards**	**Controls**	**RAC**
		• Those hazards that cannot be removed must be marked. When climbing up or down or on and off boats, always ensure three points of contact. • Good housekeeping standards will be enforced. Cargo will be properly staged on the boat to prevent tripping hazards. • Personnel will remain seated while boat is in motion and keep all extremities inside the boat.	
	Contracting or spreading coronavirus.	• Monitor yourself for coronavirus symptoms. • Wash hands regularly.	M
	Worker exposure to extreme temperatures and sunburn.	• Properly dress for the weather. Such as a full brim hat. • UXOSO to monitor weather and implement heat stress and cold stress controls as specified in the APP. • Provide breaks for personnel to get either into cool (heat stress) or warm (cold stress) environment. • Encourage a steady work pace. • Ensure adequate potable drinking water is available. • Know the signs and symptoms of exposure and keep an eye on your partner. • Boat occupants will be prepared with raingear and a change of clothing in the event they get wet and chilled. • SSHO to implement SWP 05-15 Heat Illness Prevention and Monitoring or SWP 05-16 Cold Stress.	L
	Severe weather can cause dangerous seas and hazardous boating conditions.	• Monitor the local and national weather service broadcasts prior to mobilization by boat and during the day. • Local weather will be monitored, and boat operations will be terminated during an approaching storm or should sea conditions make it unsafe to continue. • Monitor actual water conditions for dangerous wave or ground swell action. • Follow provisions in the APP for severe weather. • All personnel will wear personal flotation devices while boat is in transit and during inclement weather. At all other times, a personal flotation device should be readily available and accessible.	M
	Boat could be struck by other boats in area.	• Boat operator oversees situational awareness while on the water. • Boat operator will not be doing other tasks while boat is being moved. • Monitor Channel 16 and U.S. Coast Guard rules for lighting and other vessel operations. • Use air horn in the event of a boat coming close.	M

AHA#2 - Boat Operations		
Equipment to be Used	**Training Requirements/Competent or Qualified Personnel Name(s)**	**Inspection Requirements**
PPE: • Footwear with rubber soles to prevent slipping. Safety toe footwear required near heavy diving equipment (SCUBA cylinders) • Type II or better PFD to be worn in transit • Back braces (optional) • Appropriate clothing and PPE (to include personal flotation device, puncture resistant or leather work gloves, safety sunglasses and cap). Hearing protection will be required if noise from boat engine reaches hazardous levels. • Chemical-resistant gloves for use when handling MPPEH/military munitions and in fueling operation	PPE requirements training	• PPE inspected daily prior to use by user with additional random inspections by UXOSO.
Boat/s: • Shark Marine Underwater Navigation (SM) system • HERO Underwater camera • Fuel spill kit • Boat tool kit • Fuel container	• Site specific military munitions training will be presented to all site personnel • Equipment familiarity training • Site-specific training, slip/fall hazards • Site-specific training/lifting and carrying techniques • Current HAZWOPER training • Site-specific training in use of equipment and tools	• UXOSO will ensure that all controls are being followed, all equipment is being correctly utilized, and all personnel have received appropriate training. • Equipment inspected daily prior to use by user and UXOSO. • Daily serviceability check of magnetometers by user and UXOQCS. • UXOQCS to check SM and RTK each day prior to operations.
Emergency Gear: • Communications equipment • First Aid Kit • Fire extinguishers • Vessel rescue equipment (hook, rope, life ring) • WBGT monitor	• Emergency response procedures • Heat stress symptoms/first aid • Site-specific biological hazards to include first aid • Equipment familiarity training	• Communications equipment checked daily prior to use by UXOSO. • First Aid Kits checked daily and inspected weekly by the UXSO. • Fire extinguishers checked daily and inspected weekly by the UXOSO. • Equipment inspected daily prior to use by user and UXOSO.

Abbreviations and Acronyms:
APP – Accident Prevention Plan
CSP- Certified Safety Professional
CIH- Certified Industrial Hygienist
CHMM- Certified Hazardous Materials Manager
DEET – 33% diethyl-meta- toluamide
HSE – Health Safety, and Environmental
GFCI – Ground-fault circuit interrupter
OSHA – Occupational Safety and Health Administration
UXOSO – UXO Safety Officer
PPE – Personal protective equipment
PFD- Personal flotation device
SSHP – Site Safety and Health Plan
SUXOS/DS – Senior UXO Supervisor
USACE – U.S. Army Corps of Engineers
UXO – Unexploded ordnance

AHA Signature Sheet **AHA#2 - Boat Operations**

I have reviewed the above AHA and acknowledge the hazards involved with this work task and the controls that will help to minimize illness or injury during the tasks.

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Activity Hazard Analysis (AHA) #3

A draft AHA for this task is included below. This AHA will be reviewed by the SHM and the USACE as part of planning during development and finalization of the APP. The draft AHA will be finalized prior to initiation of this phase of field work by the staff performing the work and will be submitted for final approval by the SHM and the USACE prior to the preparatory phase inspection. Any modifications to the approved AHA that results in a higher RAC than the approved AHA will also be reviewed by the USACE and SHM. The AHA will be maintained by the staff performing the work, under SUXOS/DS and UXOSO oversight to keep it current to the work being performed and the hazards presented by the work as a living document.

<table>
<tr><td>Activity/Work Task: Diving Operations and Intrusive Investigation</td><td colspan="5">Overall Risk Assessment Code (RAC) (Use highest code)</td><td>M</td></tr>
<tr><td>Project Location: Military Munitions Investigation Nashua River Former Ft. Devens</td><td colspan="6">Risk Assessment Code (RAC) Matrix</td></tr>
<tr><td>Contract Number: W912DR-21-D-0002, Task Order W912DR22F0121</td><td rowspan="2">Severity</td><td colspan="5">Probability</td></tr>
<tr><td>Date Prepared: July 2022</td><td>Frequent</td><td>Likely</td><td>Occasional</td><td>Seldom</td><td>Unlikely</td></tr>
<tr><td rowspan="2">Prepared by: Jennifer Harlan, PMP</td><td>Catastrophic</td><td>E</td><td>E</td><td>H</td><td>H</td><td>M</td></tr>
<tr><td>Critical</td><td>E</td><td>H</td><td>H</td><td>M</td><td>L</td></tr>
<tr><td rowspan="2">Reviewed by: Jeffrey (Jim) Streib, CIH, CSP, CHMM, CQA
Director, Health, Safety and Environmental</td><td>Marginal</td><td>H</td><td>M</td><td>M</td><td>L</td><td>L</td></tr>
<tr><td>Negligible</td><td>M</td><td>L</td><td>L</td><td>L</td><td>L</td></tr>
<tr><td rowspan="6">Notes: (Field Notes, Review Comments, etc.)
In addition to the information listed in this AHA, all field personnel must review and be familiar with all provisions of the approved APP/SSHP. EM 385-1-1 will also be available on site for personnel to review specific materials and mitigation measures associated with this project. PPE for this AHA will consist of a PFD, appropriate footwear, safety glasses with side shields, a standard work uniform (long pants, tee shirt), hearing protection (as required), work gloves worn when indicated, , and other PPE described in this AHA.

First Aid-/CPR-Qualified Persons:
SUXOS/DS- Don Schwalback
UXOSO- Patrick Oberley</td><td colspan="6">Step 1: Review each “Hazard” with identified safety “Controls” and determine RAC (see above).</td></tr>
<tr><td colspan="4">“Probability” is the likelihood to cause an incident, near miss, or accident and is identified as Frequent, Likely, Occasional, Seldom, or Unlikely.</td><td colspan="2">RAC Chart</td></tr>
<tr><td colspan="4" rowspan="2">“Severity” is the outcome/degree if an incident, near miss, or accident did occur and is identified as Catastrophic, Critical, Marginal, or Negligible.</td><td colspan="2">E = Extremely High Risk</td></tr>
<tr><td colspan="2">H = High Risk</td></tr>
<tr><td colspan="4" rowspan="2">Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each “Hazard” on the AHA. Annotate the overall highest RAC at the top of the AHA.</td><td colspan="2">M = Moderate Risk</td></tr>
<tr><td colspan="2">L = Low Risk</td></tr>
</table>

AHA # 3 - Diving Operations & Intrusive investigation			
Job Steps	**Hazards**	**Controls**	**RAC**
1.Pre-Dive Safety Brief 2. Dress out divers and conduct surface and in water equipment checks Deploy and recover divers to/from water. 3. Deploy and recover divers to/from water. Deploy underwater waypoints, transects and grids 4.Diver(s) navigate to targets and perform underwater intrusive investigation. survey 5.Diver(s) excavate targets anomalies 6.Diver(s) identify and photograph MEC/MPPEH. Diver consults with SUXOS/DV and receives acceptable to move determination. 7. Diver recovers MEC/MPPEH and transfers MEC/MPPEH to the surface team. and process MEC/ MPPEH 8..Diver(s) are recovered and observed on the surface for 10 min. and dive team extraction 9.Dive Team and equipment transit to staging area. 10.Equipment transit and maintenance	Vessel Traffic	• Display Commercial Dive Alpha Flag • Display Recreational Dive Flag Topside Personnel Aware of Boat Traffic	L
	Slip, trips, & Falls	• Personnel should use appropriate footwear (sturdy leather deck shoes) to ensure that there is enough tread on the soles to minimize slipping. • Identify and remove trip hazards. • Those hazards that cannot be removed must be marked. When climbing up or down or on and off boats, always ensure three points of contact. • Good housekeeping standards will be enforced. Cargo will be properly staged on the boat to prevent tripping hazards.	L
	Fall from ladder	• Verify water depth prior to entry • Proper entrance ladder or walk-in entry only • Ladder extends minimum of 3 feet below water surface • Maintain three points of contact to ladder. • Sweep for submerged objects	L
	Contracting or spreading coronavirus.	• Monitor yourself for coronavirus symptoms. • Wash hands regularly.	M
	Primary Air Supply Failure/ Loss of Air	• Failure of the primary air supply - Diver switch over to the emergency air source. • If breathing resistance occurs on the bottom, surface immediately, using controlled ascent. • If out of air completely, go onto emergency air from bail-out bottle. • Divers will surface when primary air reaches 500 PSIG. • Alternative method is to "Buddy Breath" with dive partner. • Adhere to No D tables to prevent decompression sickness. • Dive operations will be terminated.	L
	Loss of Communications	• Initiate diver locator system- lost diver buoy • Attempt to establish visual contact • Initiate diver recall system • Topside actions for lost diver: Initiate emergency recall. Identify GPS coordinates of the last known location of the diver. Mark last known location with anchor and buoy. • Dive team surface	L

AHA # 3 - Diving Operations & Intrusive investigation			
Job Steps	**Hazards**	**Controls**	**RAC**
	Fouled or entrapped Diver	• Diver must always be aware of his surroundings and avoid any hazardous situations if identified. • All hazardous situations will be communicated to the dive supervisor or team leader immediately. • Request Stand-by Diver to assist if any problems	L
	Hazardous Marine Life	• Wear Protective Outer-Garments (wet/ skin suits or coveralls) • Determine types of hazardous aquatic life found in this location from local marine or harbor police or lifeguard headquarters. Training in biological hazards avoidance. • Wear protective gloves • Avoid hazards • Terminate dive operations on any imminent threats	L
	Biological hazards – hazardous sea life, bees, wasps, centipedes, mosquitoes, spiders, and rodents	• Training in biological hazards avoidance • Workers will apply DEET to work clothing following manufacturer's instructions as a preventative measure for biting insects as required. • Tuck in pant legs to socks and tuck in shirt to pants. • Wear long sleeves.	L
	Line entanglement	• Diver will assess the situation and attempt self-extraction by removing or cutting the line. • Standby diver will be at the ready when diver(s) are in the water and will be deployed to assist if directed by the Diving Supervisor.	M
	MEC hazards	• On-site MEC Training • Perform MEC operations using approved methods and techniques. • Divers will not investigate targets unless there is suitable visibility. • Dive team to maintain neutral buoyancy as much as possible to remain above riverbed/seabed. • Divers plan to approach target from down-current side to prevent unintended contact. • Target will be investigated using hand tools, without moving the MEC until it can be identified and inspected • MEC operations will cease if unauthorized watercraft/personnel enter the area. Personnel will be informed of the site hazards and of the fact that they are not authorized to be near the site operations and will be asked to leave.	M
	Pinch points	• No divers between boats or objects and boats • Do not place hands, feet or legs in between boats or boats and docks	L

Abbreviations and Acronyms:

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HSE – Health Safety, and Environmental
GFCI – Ground-fault circuit interrupter
MEC – Munitions and Explosives of Concern
OSHA – Occupational Safety and Health Administration
UXOSO – UXO Safety Officer
PPE – Personal protective equipment
PFD- Personal flotation device
SSHP – Site Safety and Health Plan
SUXOS/DS – Senior UXO Supervisor
USACE – U.S. Army Corps of Engineers
UXO – Unexploded ordnance

AHA Signature Sheet **AHA # 3 - Diving Operations & Intrusive Investigation**

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Status:	Approved	**Approved By:**	M.W.D. Mark W. Dollar, President
Version Date:	09/08/2021	**Title:**	HSE 1-10, Boating
Revision #:	Rev. 2	**Original Issue Date:**	03/31/2020
Category:	Procedure	**Sections:**	Safety
Reference Driver:	CFR 33/EM 385-1-1	**Document Type:**	Procedure
Keyword Index:	Boating/Health, Safety and Environmental	**Document Owner:**	Scot Wilson

1.0 PURPOSE AND SCOPE

The purpose of this procedure is to establish the minimum requirements for boating safety. This procedure applies to all Tetra Tech Munitions Response (TMR) project sites and activities, including subcontractor activities.

2.0 DEFINITIONS

Definitions are provided to understand their intent as they pertain to a procedure and projects requiring quality program planning.

A Master List of Definitions is located in the Corporate Reference Library on the intranet (https://tetratechinc.sharepoint.com/sites/OU-TMR). In addition, the following definitions are specific to this procedure.

Inshore/Nearshore- For the purposes of TMR boating operations, inshore operations typically consist of the use of a boat less than 26 feet (Class A or Class I) that will not operate more than 1 mile from the nearest land.

Offshore- For the purposes of TMR boating operations, offshore operations typically consist of the use of a boat greater than 26 feet (Class II, Class III, or greater) that will operate more than 1 mile from the nearest land.

Boat – Any powered or non-powered watercraft utilized for the transport of personnel on a body of water.

Class	**Description**
Class A	Less than 16 feet (4.8 meters) length overall
Class I	16 feet (4.8 meters) to less than 26 feet (8 meters) length overall
Class II	26 feet (8 meters) to less than 40 feet (12 meters) length overall
Class III	40 to 65 feet (12 to 20 meters) length overall
Small Research Vessel (SRV)	Greater than 65 feet (20 meters) length overall but less than 300 gross tons
Diving Support Vessel (DSV)	Greater than 65 feet (20 meters) length overall but less than 300 gross tons

3.0 PROCEDURE

3.1 Responsibilities

3.1.1 Line Management

Project manager (PM) is responsible for coordinating with the dive program safety officer to implement the requirements of this procedure. The PM shall provide the necessary management support and allocate enough project resources to enable project personnel to operate boats in a safe manner.

Site managers (SMs) and supervisors are responsible for implementation of this boating safety program in the field.

3.1.2 HSE Personnel

The Health, Safety, and Environmental (HSE) director shall ensure that the requirements of this program are incorporated into site HSE plans.

3.1.3 Boat Captain

The captain of the boat is responsible for the overall health and safety of those on the boat. The boat captain shall ensure that all persons on the boat are given a safety orientation regarding emergency procedures. The boat captain shall also ensure that safety requirements in the applicable safety plan governing the work, such as the use of personal protective equipment, are implemented. The captain is also responsible for the inspection of the boat being used and for having the proper safety equipment, in good working order, on the boat. The captain of the boat will have the final say concerning safety, specifically concerning that of the personnel and craft during operations.

3.2 General Requirements

3.2.1 Boating Towing and Launching

Those TMR personnel who will tow a boat on a trailer to the launching site will be experienced in this capacity and be responsible for reviewing the Boat Pre-Operation Checklist prior to departure. This person will ensure that the boat is not loaded with project equipment, which will overload the bearings and axle weight capacity. Overweight equipment should be carried in another vehicle or the towing vehicle.

The PM must designate a person experienced in towing a boat, launching, or piloting a vessel. This person must have attended a nationally recognized boating safety class (i.e., United States Coast Guard [USCG] Auxiliary or Power Squad). Pre-launch checks will be done before the boat is backed into the water. This includes checking the engine oil and/or fuel mixtures in the tanks. Any mixing of fuel and oil will be done in a separate Underwriters Laboratory (UL) approved flammable liquid storage container prior to filling the vessel tanks. This will ensure the gas/oil mixture is correct.

Whenever possible, perform fuel mixing and transfer in an environmentally safe area where spills can be easily cleaned.

To launch the vessel, back part of the way down the boat ramp, remove the rear tie down straps to the trailer, ensure the boat plug is installed, and continue backing into the water's edge. Place the fenders/bumpers on the side that will be in contact with the pier, to prevent damage. Ensure that the bow and stern lines are being handled by personnel on the pier as the vessel is backed further into the water—until the vessel is floating freely. An alternative plan is to have the coxswain in the boat lower the engine and start it when the rear is in the water and floating free from the trailer. Carefully back the boat with the engine clear of the trailer. Pull the truck and trailer forward and park and secure. Secure the bow and stern lines to the dock and load additional equipment. Lower the engine/out drive, if applicable, and start the engine. Once warm, check all indicators and gauges to ensure that the motor is working properly.

For vessel recovery, reverse the process listed above. Back the truck and trailer down the ramp and place the truck in park with the emergency brake on. Keep the bow winch connected to the vessel until the vessel is out of the water and onto the trailer. Raise the motor/outdrive and secure in the up position. Once the vessel is trailered, remove additional equipment as necessary to reduce weight; and secure the vessel to the trailer with bow and stern straps and the safety chain near the winch. The vessel is not to be towed with a person in the vessel.

3.2.2 Boat Operators

Only designated TMR personnel who meet appropriate Federal, State or local training requirements shall operate a boat during a project. These requirements are a valid USCG license for vessels over 40 feet (12 meters) or any USCG recognized training such as the USCG Auxiliary Boating Skills and Seamanship Training for vessels less than 40 feet (12 meters).

Boat operators must possess basic knowledge to troubleshoot common mechanical problems that can occur on the boat. The boat operator shall be responsible for all personnel's safety on board the boat and for the integrity of all boat and safety equipment.

Each designated boat operator shall give a safety briefing to boat occupants prior to leaving shore. **Boats are to be occupied during use by not less than one qualified operator plus one additional person.** If the "additional person" is not a qualified operator, a basic safety and operations demonstration will be conducted before launching.

3.3 Logbook

Boat captains shall maintain a logbook for each vessel. The logbook will be used to note weather, tides, maintenance issues, equipment status, and to record completion of the safety orientation given to each day's passengers. Captains will make notes of any additional observations regarding the boat and its safe operation. This logbook will be kept with the vessel.

3.4 Float Plan

A Float Plan shall be filled out by the boat captain, unexploded ordnance (UXO) safety officer (UXOSO) or field operations lead (FOL) for all trips made by boat using the USCG Float Plan (Attachment 2). The UXOSO or FOL shall always be aware of the location of all project boats and designated use personnel. If several boats and crews are involved in the work or are traveling to remote areas, each designated boat operator shall file a written USCG Float Plan or equivalent with the UXOSO or SM/FOL. This plan can be filed electronically, via email or text message, if necessary. The Float Plan shall include the following:

- The names of the boat operator and passengers.
- A description and registration numbers of the boat.
- Radio call sign or cellular telephone number if boat is so equipped.
- A trip itinerary with expected time and location of return.
- Steps the UXOSO or SM/FOL will take to initiate a search response if the expected time of return is exceeded.

A Float Plan shall be prepared by each designated boat operator and approved by the PM, UXOSO, and/or qualified person prior to the activity. For boats that are operated with one crew, the Float Plan shall be developed that ensures the boat returns to the dock in no more than 12 hours.

3.5 Boat Registration and Numbering

The UXOSO or SM/FOL shall ensure that all project boats meet USCG or state boat registration and numbering requirements. The USCG requires that all motorized boats be numbered in the state of principal use. Many states also require that certain non-motorized boats be numbered (sailboats, rafts, and dinghies). A valid certificate or number showing the numbers issued to the boat is required to be on board the boat whenever the boat is in use. Boat registration numbers are required to be painted or permanently attached to the outside of each side of the forward half of the boat. Boat registration must be updated annually or as required by the registering state.

3.6 USCG -Approved Equipment

All TMR project boats will meet or exceed USCG requirements for safety equipment. These requirements are summarized below for small craft (less than 40 feet or 12 meters in length). The UXOSO or SM/FOL shall consult with the HSE director if larger craft are required.

3.6.1 Flame Arresters

All gasoline engines, except outboard motors, installed in a boat must have an approved flame arrestor (backfire preventer) fitted to the carburetor/intake.

3.6.2 Sound Signaling Devices

Although not required for small craft, all TMR boats shall carry at least one air horn or similar sound-signaling device.

3.6.3 Personal Flotation Devices

All TMR personnel and passengers shall always wear an approved personal flotation device (PFD) when operating or being transported in a boat. A positively buoyant wet suit may be substituted for a PFD. PFDs shall be Type III or higher (capable of turning its wearer in a vertical or slightly backward position in the water). Automatic inflating PFDs can be used providing that they are approved in the HSE Plan, and Activity Hazards Analysis addresses its use. For persons less than 90 pounds, a child PDF must be used. PDFs shall be inspected, maintained, and stored in accordance with the manufacturer's instruction. In addition, each boat up to 26 feet (8 meters) in length shall be equipped with at least one Type IV PFD ring buoy, 24 inches (6 meters) in diameter with 90 feet (27 meters) of buoyant line attached, designed to be thrown to a person in the water, grasped and held by the user until rescued.

A buoyant boat cushion equipped with straps and a float ring are two common examples of additional types of life rings that can qualify as a Type IV PFD and help in a rescue.

For boat operations in cold water environments, immersion/exposure suits will be required for each person on board based on the location of boat operations listed below.

AREA OF OPERATION	VSL TYPE	DEVICE
Seaward of the Boundary Line, north of 32ºN, or south of 32ºS, and Lake Superior.	Documented	Immersion Suit/Exposure Suit
Coastal Waters on the West Coast of the U.S. north of Pt. Reyes, CA; Beyond coastal waters, cold waters; and Lake Superior	All	Immersion Suit/Exposure Suit

3.6.4 Fire Extinguishers

Each boat used by TMR personnel less than 26 feet (8 meters) shall carry at least one Type 1-A:10-B:C fire extinguisher (for use in gasoline, oil, and grease fires) approved by UL. Motorboats or skiffs over 26 feet (8 meters) will have a minimum of two 1-A:10BC fire extinguishers available. Larger craft will have additional requirements. Each fire extinguisher shall be inspected by the UXOSO or SM/FOL at least once every week to ensure that it is sufficiently charged and that the nozzles are free and clear. Discharged fire extinguishers shall be replaced or recharged immediately. The number and sizes of extinguishers required will depend on the vessel size and applicable regulations.

3.6.5 Navigation Lights

All TMR project boats shall be equipped with navigation lights. These lights shall always be utilized when operating between sunset and sunrise. Navigational lighting shall meet all USCG requirements. Boats shall be operated at reduced speeds at night and when visibility is reduced.

3.6.6 Visual Distress Signals

All TMR boats shall carry a selection of pyrotechnic and non-pyrotechnic visual distress signals. Pyrotechnic visual distress signals include red flares, orange smoke (day use only), and aerial red meteor or parachute flares. No pyrotechnic visual distress signals include an orange distress flag (day use only) and a flashlight or other electric distress light (night use only). No single signaling device is ideal under all conditions and for all purposes. Pyrotechnic visual distress signals shall not be used past the expiration date.

3.6.7 Pollution Control

The Refuse Act of 1899 prohibits the throwing, discharging, or depositing of any refuse matter of any kind (including trash, garbage, oil, and other liquid pollutants) into the waters of the United States (U.S.). The Federal Water Pollution Control Act prohibits the discharge of oil or hazardous substances in quantities that may be harmful into U.S. navigable waters. No person may intentionally drain oil or oily wastes from any source into the bilge of any vessel. Vessels 26 feet (8 meters) and greater in length, with machinery spaces, must display a placard fixed in a conspicuous place in the machinery spaces, or at the bilge pump control station stating the rules of the Federal Water Pollution Control Act governing the discharge of oil or oily waste to the water (see Reference No. 3). Pumping of bilge water without using an oily-water separator should be undertaken with caution. Any vessels equipped with toilet facilities must be equipped with a USCG-approved marine sanitation device and shall observe all no-discharge areas shown on National Oceanic and Atmospheric Administration (NOAA) charts.

TMR employees shall report any significant oil spills to water to the HSE director who must report the spill to the USCG or other applicable regulatory agency. The procedure for incident reporting and investigation shall be followed when reporting the spill. (See Tetra Tech Safety Manual, DCN 02-02, Incident Reporting & Investigation Program)

3.7 Weather

A daily weather check shall be conducted prior to any boating operation. If severe weather is forecast, work should be delayed or cancelled. All HSE plans covering boating operations shall address the hazards that weather poses to boating operations, and specific actions to be taken to avoid these hazards. The field supervisor in consultation with the boat captain, site safety and health officer and PM shall establish maximum sea state or go/no-go criteria, ensuring compliance with the applicable project safety plans, prior to the beginning of operations.

3.8 Load Capacity

Boats less than 20 feet shall not be loaded (passengers and gear) beyond the weight capacity printed on the USCG capacity plate attached to the stern. For boats without capacity plates, the licensed captain/trained operator shall evaluate the safe loading of crew, cargo, and equipment on a trip-by-trip basis. Several factors must be considered when loading a boat: distribute the load evenly; keep the load low; do not stand up in a small boat or canoe; and do not overload the boat.

3.9 Tool Kit

All TMR motorized boats shall carry a tool kit with enough tools for the boat operator to troubleshoot common mechanical problems such as fouled spark plugs, flooded carburetor, electrical shorts, etc. Boats operated in remote areas shall also carry appropriate spare parts (e.g., propellers, shear pins, patch kits, air pumps). The tool kit shall be maintained by the boat operator, with supplies replaced immediately upon use.

3.10 Survival Kit/Ditch Bag

All TMR boats utilized in remote areas shall carry a survival kit. The survival kit shall contain, at a minimum: a first aid kit; high-energy canned or preserved foods; drinking water; blankets; a heat source; signaling devices; waterproof matches; and other items as necessary to ensure survival for a minimum of 24 hours for the entire crew. For offshore work, a “ditch bag” consisting of an Emergency Position-Indicating Radio Beacon (EPIRB); handheld very high frequency (submersible) signaling devices – visual and audible; and/or strobe light or light stick may be required. The ditch bag should be waterproof, float and preferably be high visibility in color. Survival suits may be required by the HSE plans for operations in cold environments.

3.11 Communications

All TMR boats operated in remote areas shall carry a two-way radio or cellular telephone that enables communication back to the field camp or other pre-established location. Exceptions to this requirement must be negotiated with the HSE director. Additional communication and locating methods may be utilized such as SPOT Messenger, global positioning system, EPIRB, and satellite telephones.

3.12 Boating Accident Report

The USCG requires filing a boating accident report within 24 hours of an accident (death, disappearance overboard, medical treatment beyond first aid, property damage > $2000, or if the boat is destroyed).

TMR personnel involved in a boating accident shall follow the procedure outlined in HSE plans and Tetra Tech's Safety Manual, Incident Reporting and Investigation Program (DCN 02-02), for accident and injury reporting. This procedure will provide for proper notification of the USCG.

3.13 Good Housekeeping

TMR personnel using a boat shall properly stow and secure all gear and equipment against unexpected shifts when underway. Decks and open spaces must be kept clear and free from clutter and trash to minimize slip, trip, and fall hazards.

3.14 Fuel Management

TMR personnel shall utilize the "one-third rule" in boating fuel management. Use one-third of the fuel to get to the destination, one-third to return, and keep one-third in reserve.

3.15 Training

Boat operators shall be trained on, and pass the test of, a nationally recognized boating safety organization such as the USCG Auxiliary or Power Squadron. All operators and passengers shall be trained on the requirements of this program. Training records shall be maintained in accordance with the Tetra Tech Safety Manual, DCN 01-04, Recordkeeping and Reporting Requirements.

3.16 Operations

Operations of motorboats/skiffs can be hazardous to personnel considering other boaters, weather conditions, the task assigned, and the condition of the boat/skiff you are operating. Ensure Boat Pre-Operation Checklist is completed before departing the launch area. The boat captain or designee must utilize and fill out the checklist each day the vessel is used (use is defined as being launched from the trailer or departing the dock or moorage) and submit it to the UXOSO or FOL. This checklist can be filed electronically, via email or text message, if necessary.

When operating in restricted waters, near shipping channels, in rough fast flowing water, or near obstacles that could damage or capsize the boat, plan for emergency rescue in case the boat motor fails, or you become incapacitated from operating the boat and you are in personal danger. Consideration would be for a second motor or a safety boat operating in the area or other rescue capability available.

4.0 REFERENCES

CFR Title 33, Navigation and Navigable Waters, Chapter I - Coast Guard, Department of Homeland Security (Parts 1-199), Subchapter S, Boating Safety (Parts 173-199), Retrieved from https://www.gpo.gov/fdsys/granule/CFR-2010-title33-vol2/CFR-2010-title33-vol2-chapI-subchapS

USACE EM 385-1-1 (November 30, 2014), Safety and Health Requirements Manual. Retrieved from https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_385-1-1.pdf

Title 33 USC. Chapter 9 Protection of Navigable Waters and of Harbor and River Improvements. Subchapter I - In General. 407 - Deposit of refuse in navigable waters generally. (pp. 46). Retrieved from https://www.gpo.gov/fdsys/pkg/USCODE-2011-title33/pdf/USCODE-2011-title33-chap9-subchapI.pdf

Tetra Tech Safety Manual, Incident Reporting and Investigation Program, DCN 02-02.[1]

Tetra Tech Safety Manual, Recordkeeping and Reporting Requirements, DCN 01-04.[2]

U.S Department of Homeland Security. United States Coast Guard Auxiliary (2015 v.10.2). USCG Float Plan. Retrieved from http://www.floatplancentral.org

DOC NOAA. Office of Marine & Aviation Operations. NOAA Small Boat Standards and Procedures Manual (April 30, 2018, 4.1 Edition), Retrieved from https://www.omao.noaa.gov/sites/default/files/documents/2018%200430%20SBS%26PM%204.1.pdf.

5.0 RECORDS

Records associated with the awareness and recognition programs will be retained in the appropriate project or office files.

6.0 GUIDELINES

HSE-25 Boat Pre-Operation Checklist

HSE-26 Float Plan Template

7.0 APPLICABLE ISO17025 CLAUSES

None.

[1] https://tetratechinc.sharepoint.com/:b:/r/sites/Health-Safety/Health%20%20Safety%20Manual/02_General%20Health%20and%20Safety%20Programs/DCN%2002-02%20Incident%20Reporting%20and%20Investigation%20Program.pdf

[2] https://tetratechinc.sharepoint.com/:b:/r/sites/Health-Safety/Health%20%20Safety%20Manual/01_Health%20and%20Safety%20Program%20Administration/DCN%2001-04%20Recordkeeping%20and%20Reporting%20Requirements.pdf

APPENDIX C

DIVE TEAM MEMBERS AND QUALIFICATIONS

(*Names, designations, qualifications, and certifications will be submitted separately from this Dive Operations Plan to the DDC and will be maintained on-site in the diver qualification files by the UXOSO*)

APPENDIX F
Explosives Site Plan

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DEPARTMENT OF THE ARMY
DEFENSE AMMUNITION CENTER
1 C TREE ROAD
MCALESTER OK 74501-9053

ATCL-ACE (385-10b) 6 September 2022

MEMORANDUM FOR U.S. Army Corps of Engineers, Engineering and Support Center, Huntsville, CEHNC-EMM, P.O. Box 1600, Huntsville, Alabama 35807-4301

SUBJECT: Department of Defense Explosive Safety Board (DDESB) Final Approval for Base Realignment and Closure (BRAC), Area of Potential Interest (AOPI), Nashua River, Former Fort Devens, Devens, MA (File Number M22-0047)

1. References:

a. DDESB, DDESB-PE memorandum (DDESB Approval of Explosives Site Plan, Base Realignment and Closure (BRAC), Area of Potential Interest, Nashua River, Former Fort Devens, Devens, MA [USATCES MEC File Number M22-0047]), 3 August 2022 (Enclosure 1).

b. U.S. Army Technical Center for Explosives Safety, ATCL-ACE memorandum (Request DDESB Final Approval for the Explosives Site Plan (ESP) Base Realignment and Closure (BRAC), Area of Potential Interest (AOPI), Nashua River, Former Fort Devens, Devens, Massachusetts, May 2022. (File Number 22-0047)), 21 July 2022 (Enclosure 2).

2. The enclosed DDESB and Army correspondence (enclosure 1 and 2) provides final approval for Area of Potential Interest (AOPI), Nashua River, Former Fort Devens, Devens, Massachusetts. This approval is limited by the constraints applied in the attached correspondence.

3. A complete copy of your site submission and this document must be retained on permanent file at the installation and available for future review.

4. Primary point of contact (POC) is Mr. Randy Smith, (918) 420-8334, DSN 956-8334, randy.w.smith2.civ@army.mil. The alternate POC is Robin Jett, (918) 420-8002, DSN 956-8002, robin.e.jett4.civ@army.mil. Please refer to our file number when corresponding with this office.

FIEFFER.LAURA.A.1230375727 Digitally signed by FIEFFER.LAURA.A.1230375727 Date: 2022.09.06 11:01:55 -05'00'

Encls

LAURA A. FIEFFER
Acting Director, U.S. Army Technical Center for Explosives Safety

CF: (wo/encls)
DACS-SF (Mr. Patton)

EXPLOSIVES SITE PLAN (ESP)

Base Realignment and Closure (BRAC)

Area of Potential Interest (AOPI)

Nashua River

Former Fort Devens

Devens, MA

May 2022

Prepared by:
U.S. Army Corps of Engineers, Baltimore District
2 Hopkins Plaza
Baltimore,
MD 21201

TABLE OF CONTENTS

1. Site:

- **a.** Name: Nashua River, Former Fort Devens
- **b.** State**:** Massachusetts

2. **Anticipated Dates**:

- **a.** Start: Late spring 2022

3. Purpose:

This requirement is for munitions response services to complete a Munitions and Explosives of Concern (MEC) investigation to address Areas of Potential Interest (AOPIs) along a 3 mile stretch of the Nashua River near Former Fort Devens.

4. Site Background and Current Conditions:

The Nashua River runs through a portion of former Fort Devens. The former Fort Devens was active from 1917 to 1996. The river flows in a northern direction and is slow moving, with a river bottom composed of heavy layers of silt and sand. The project area defined in Section 1.0 includes the following four bridges from south to north: State Route 2, Jackson Road, Hospital Road, and West Main Street, see **Figure 2**. The river is primarily used by recreational users (i.e., canoeing, kayaking, fishing), with trails along some of its banks used for hiking. Massachusetts Department of Transportation (DoT) divers perform bridge inspections and associated maintenance along the Nashua River. The Nashua River is also known to have an infestation of water chestnut, a non-native, invasive aquatic plant. Active management of this invasive species has been performed by volunteers with the Nashua River Watershed Association (NRWA) since 2014.

Military munitions were recovered from the Nashua River in three distinct events. Two related to magnetic fishing on the river in July and August of 2020 and one associated with an inspection of the State Route 2 bridge by Massachusetts DOT divers in March 2021.

5. Executing Agencies:

- **a.** US Army Corps of Engineers New England District (CENAE)
- **b.** US Army Corps of Engineers Baltimore District (CENAB)
- **c.** Base Realignment and Closure (BRAC)

6. Scope of Investigative Action:

An underwater investigation to determine the nature and extent of MEC/MPPEH in a 3 mile stretch of the Nashua River along portions of the Former Fort Devens area.

7. Safety Criteria:

a. The MGFD for the AOPI is identified in Table 7-1. If munitions of explosive concern (MEC) with a greater fragmentation distance are encountered during the course of this investigation, the Minimum Separation Distances (MSD) will be adjusted in accordance with DDESB Technical Paper 16 and the Fragmentation Data Review Forms. The work will continue with an ESP amendment submitted and the quantity distance (QD) arcs will be adjusted accordingly.

b. See Appendix B for Fragmentation Data Review Forms.

c. See Table 7-1 for Minimum Separation Distances.

d. Any occupied buildings or public roadways or waterways within the MSD areas will be evacuated and/or roadways/waterways blocked to prevent non-essential personnel from entering during the conduct of MEC operations. In the event that roadways/waterways cannot be blocked, guards will be posted, and work halted if non-essential personnel enter the MSD. MEC operations will not resume until non-essential personnel have exited the MSD.

e. The Army will establish underwater QD criteria.

f. Only one team will be working in the AOPI during field investigations.

Table 7-1 Minimum Separation Distances

Areas of Potential Interest (AOPI)	Munition with the Greatest Fragmentation Distance (MGFD)	MSD (feet)			
		Unintentional Detonations		Intentional Detonations	
		Hazardous Fragment Distance (HFD)	Team Separation Distance (K40)	Without Engineering Controls (MFD-H)	Using Engineering Controls
Nashua River	60mm M49 Mortar	184[1]	39[1]	1322[2]	125

Note
1. MSDs are for the 60mm M49A5 HE Mortar filled with Composition B.
2. MSDs are for the 60mm M49A2 HE Mortar filled with TNT.

8. Methods of Disposal:

a. The contractor will not maintain any explosives on site. Explosives will be delivered to the project location on an "as needed" basis and will be guarded by the contractor until used. The Senior UXO Supervisor (SUXOS) and UXO Safety Officer (UXOSO) are authorized to approve the movement of "acceptable to move" items within the AOPI for the purpose of activity efficiency and protection of personnel, property, and/or critical assets. All "acceptable to move" items will be transported and destroyed within the designated disposal area (**Figure 4**). Items deemed unacceptable to move will be blown in place (**Table 7-1**)

b. All recovered MEC and Material Presenting an Explosive Hazard (MPPEH) identified as Material Documented as an Explosive Hazard (MDEH) will be destroyed on the same day found. In the event this cannot occur due to weather or delay in explosive delivery, items will be guarded until disposal.

c. The MSD for intentional detonation when conducting disposal operation is identified in Table 7-1.

d. MPPEH procedures will be IAW DoDI 4140.62, DODM 4140.72 and EM 385-1-97. ALL MPPEH will be assessed, and its explosives safety status determined and documented prior to transfer within DoD or release from DoD control. Prior to release to the public, MPPEH will be documented by authorized and technically qualified personnel as Material Documented as Safe (MDAS) after 100% inspection and an independent 100% re-inspection to determine that it is safe from an explosive safety perspective.

e. Collection Points are those areas used to temporarily accumulate MEC determined "acceptable to move" by the SUXOS and UXOSO personnel pending destruction at the end of the day. The maximum net explosive weight (NEW) at a collection point will be limited such that the K40 overpressure distance for the total NEW does not exceed the HFD for the area.

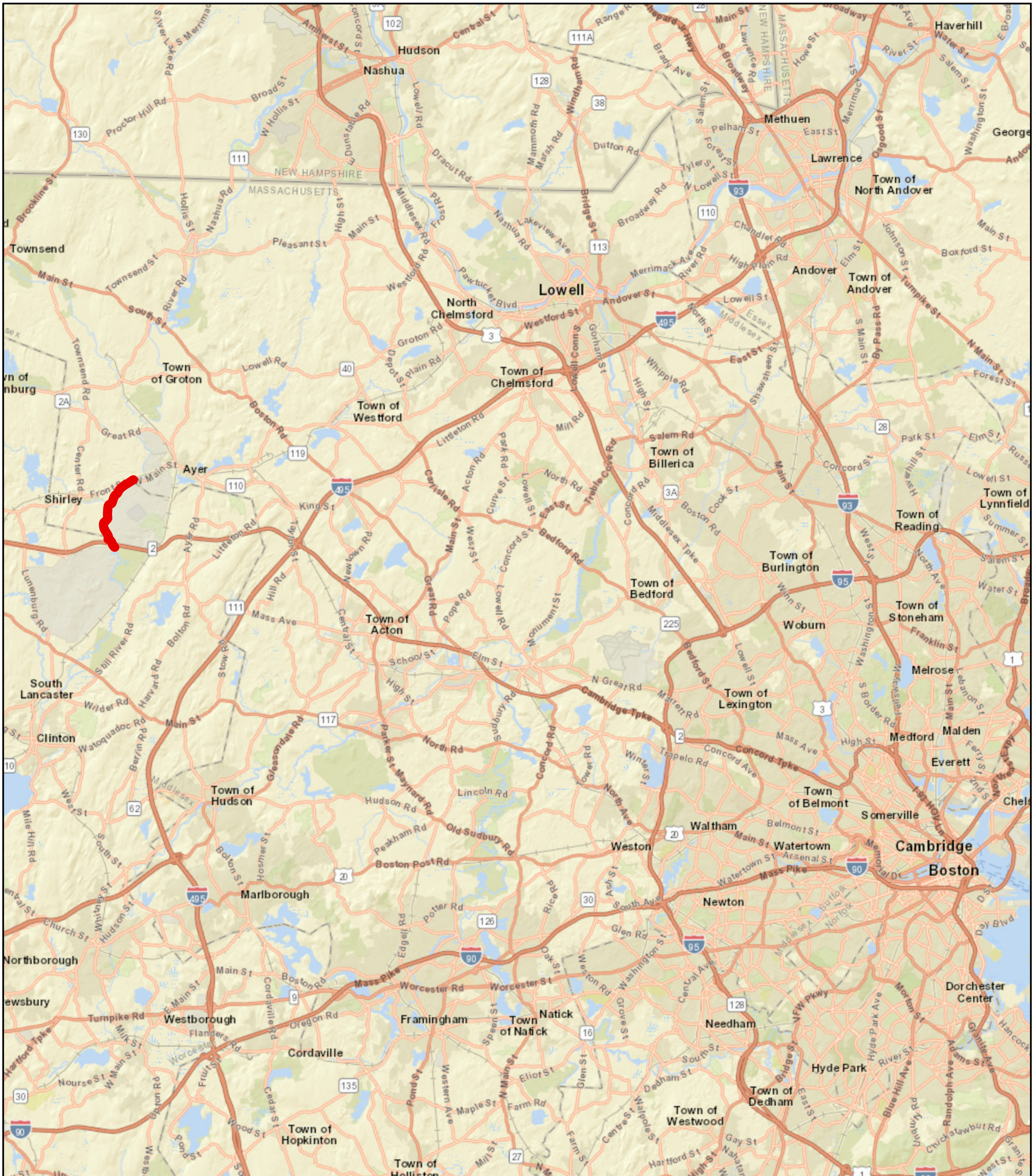
f. Consolidated shots for multiple MEC items determined "acceptable to move", by the SUXOS and UXOSO, may be used for this project IAW US Army Engineering and Support Center, Huntsville (USAESCH) publication "Procedures for Demolition of Multiple Rounds (Consolidated Shots) on Ordnance and Explosives (OE) Sites", dated March 2000 will be used and a copy of this report will be available on site. The maximum Net Explosive Weight (NEW) for a consolidated shot will be limited such that the K328 overpressure distance for the total NEW (including donor charges) does not exceed the MSD for the intentional detonation."

g. Engineering Controls (EC): For intentional detonations, the UXO Team may use earth tamp as an engineering control in accordance with DDESB Buried Explosion Module, latest version, and DDESB TP 16.

Sandbag mitigation may be used as an engineering control to reduce the intentional detonation MSD. The sandbag controls will be used in accordance with HNC-ED-CS-98-7, Use of Sandbags for Mitigation of Fragmentation and Blast Effects Due to Intentional Detonation of Munitions, August 1998, its Amendment 1, February 2011, and its Amendment 2, Nov 2014; CEHNC-EMM Memorandum, Safety Advisory: Use of Jet Perforator During Intentional Detonation While Using Sandbag Mitigation for Engineering Controls, 7 November 2011; and DDESB-PD memorandum of 22 May 2014, Subject: Revision of DDESB Approval for Use of Sandbags for Mitigation of Fragmentation and Blast Effects Resulting From Intentional Detonation of Munitions.

Appendix A

Figures

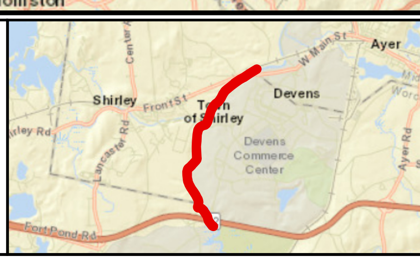


Legend

Nashua River AOPI

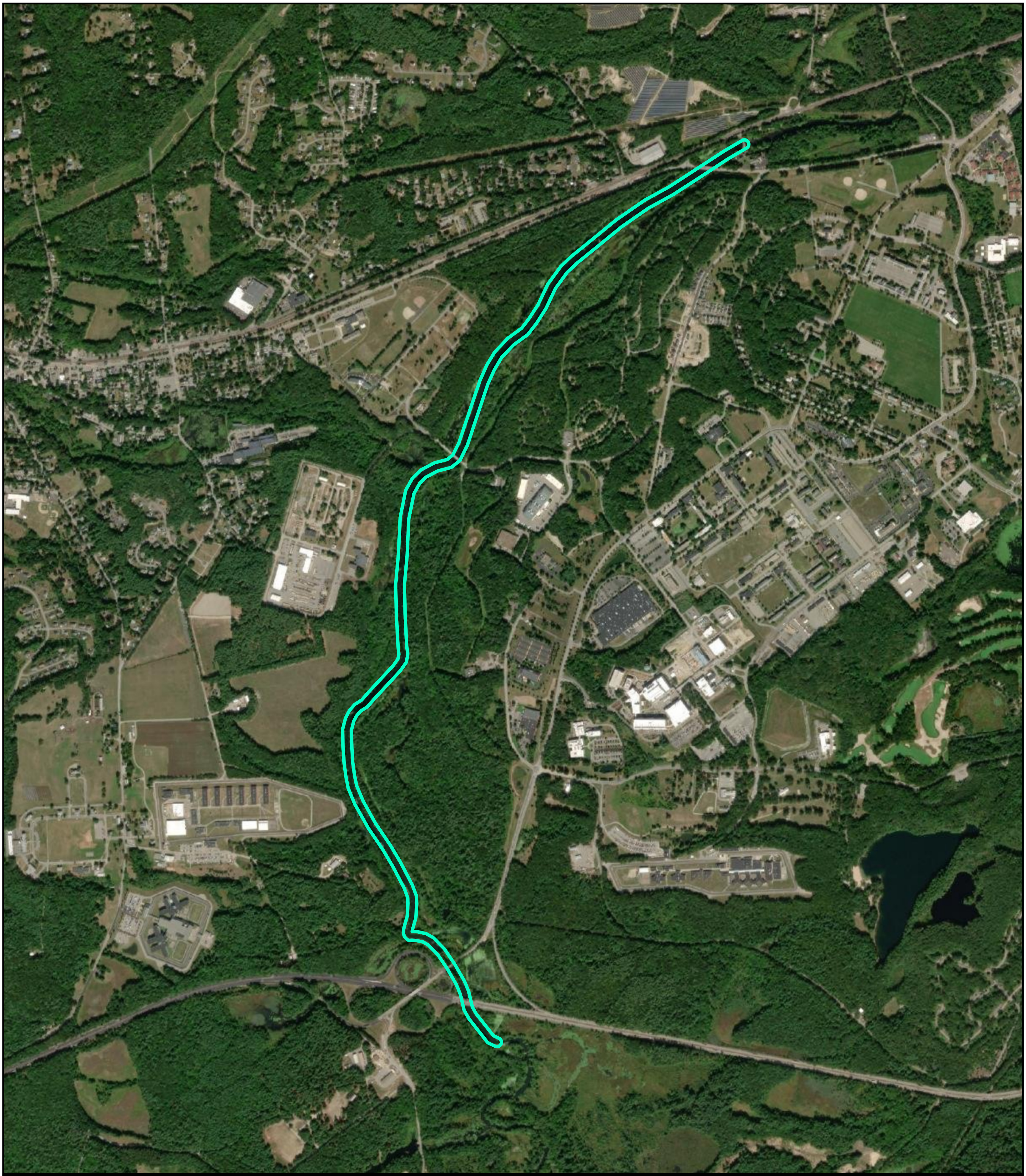
N

0 12,500 25,000 50,000 Feet



US Army Corps of Engineers
Baltimore District

Figure 1
Devens Nashua River,
Regional Map,
Devens, MA



Legend

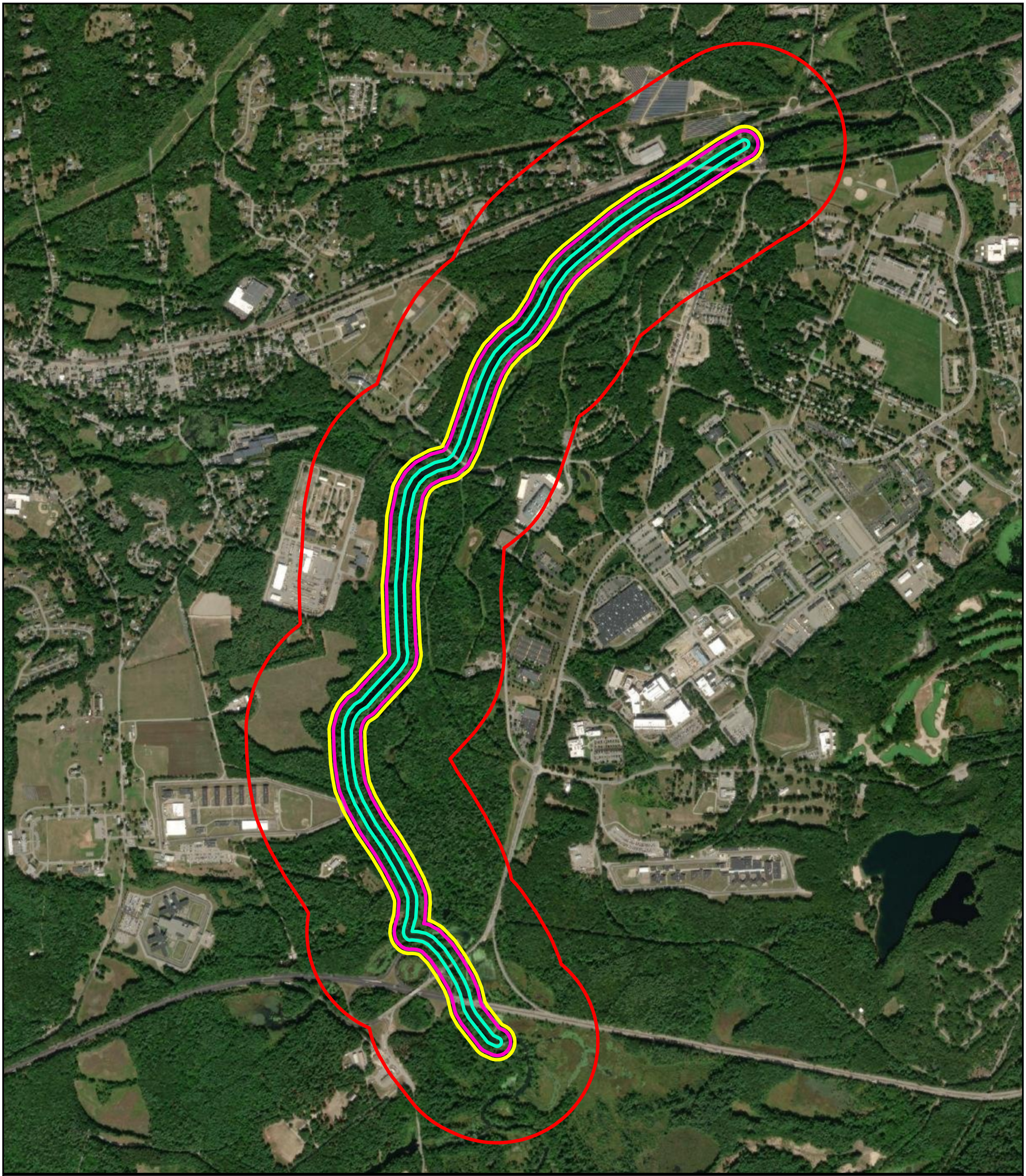
Nashua River AOPI

N

0 1,000 2,000 4,000 Feet

US Army Corps of Engineers
Baltimore District

Figure 2
Devens Nashua River,
Area of Potential Interest,
Devens, MA



Legend

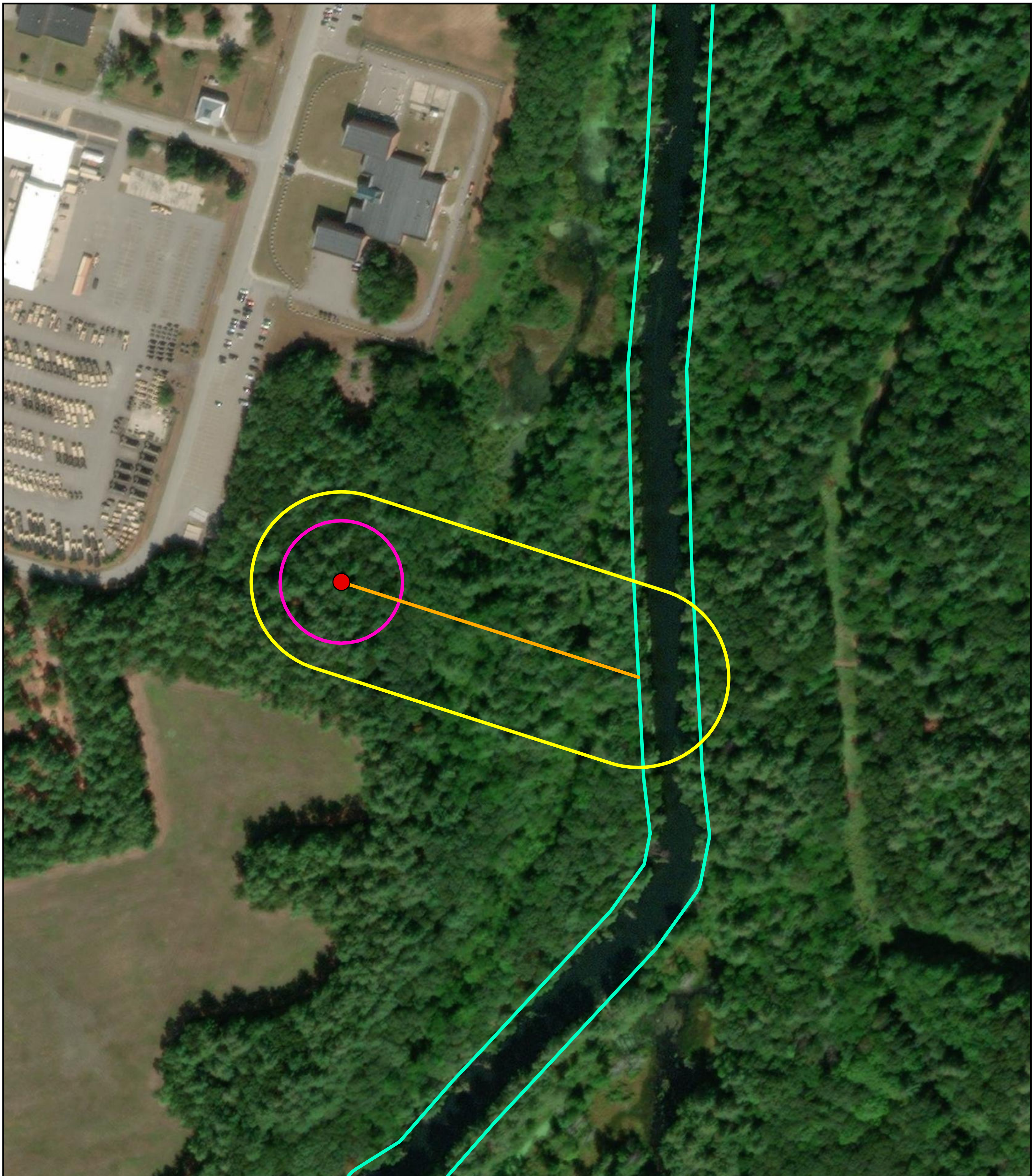
- Nashua River AOPI
- EC 125ft
- HFD 184ft
- MFD 1322ft

N

0 1,000 2,000 4,000 Feet

US Army Corps of Engineers
Baltimore District

Figure 3
Devens Nashua River,
Minimum Safe Distances,
Devens, MA

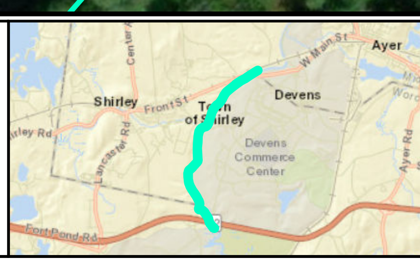


Legend

- Nashua River AOPI
- Disposal Site
- Transport Route
- EC 125ft
- HFD 184ft

N

0 150 300 600 Feet



US Army Corps of Engineers
Baltimore District

Figure 4
Devens Nashua River,
Minimum Safe Distances,
Devens, MA

Appendix B

Fragmentation Data Review Forms

Fragmentation Data Review Form

Database Revision Date 4/7/2021

Category:	Surface-Launched HE Rounds
Munition:	60 mm M49A2
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Mortar
Munition Case Classification:	Robust

DODIC:	B632
Date Record Created:	9/21/2004
Record Created By:	MMC
Last Date Record Updated:	5/3/2018
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	TNT
Explosive Weight (lb):	0.34
Diameter (in):	1.6540
Cylindrical Case Weight (lb):	1.45420
Maximum Fragment Weight (Intentional) (lb):	0.0570
Design Fragment Weight (95%) (Unintentional) (lb):	0.0159
Critical Fragment Velocity (fps):	3985

Sandbag and Water Mitigation Options

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	0.340
Kinetic Energy 10^6 (lb-ft²/s²):	0.4524

Single Sandbag Mitigation

Required Wall & Roof Thickness (in)	20
Expected Max. Throw Distance (ft):	125
Minimum Separation Distance (ft):	125

Double Sandbag Mitigation

Required Wall & Roof Thickness (in)	48
Expected Max. Throw Distance (ft):	10
Minimum Separation Distance (ft):	12.5

Water Mitigation

Minimum Separation Distance (ft):	264/200
Water Containment System:	5 gal carboys/ inflatable pool

Note: Use Sandbag and Water Mitigation in accordance with all applicable documents and guidance. If a donor charge larger than 32 grams is utilized, the above mitigation options are no longer applicable. Subject matter experts may be contacted to develop site specific mitigation options.

Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	152
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1322
MFD-V [Maximum Fragment Distance, Vertical] (ft):	1025

Overpressure Distances

TNT Equivalent (Pressure):	1
TNT Equivalent Weight - Pressure (lbs):	0.340
3.5 psi, K18 Distance (ft):	13
2.3 psi; K24 Distance (ft):	17
1.2 psi, K40 Distance (ft):	28
0.0655 psi, K328 Distance (ft):	229

"NOTE: Values shown within this section only address overpressure hazards and do not account for applicable distance values for fragments and debris as required per DoD 6055.09-M."

Minimum Thickness to Prevent Perforation (in)

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	4.96	2.99
Mild Steel:	0.97	0.58
Hard Steel:	0.79	0.48
Aluminum:	1.97	1.23
LEXAN:	5.75	4.22
Plexi-glass:	4.14	2.74
Bullet Resist Glass:	3.47	2.19

Item Notes

Distribution Statement D. Distribution authorized to the Department of Defense and U.S. DoD contractors only for Administrative-Operational Use (7 January 2020). Other requests shall be referred to the Department of Defense Explosives Safety Board, 4800 Mark Center Drive, Suite 16E12, Alexandria, VA 22350.

Fragmentation Data Review Form

Database Revision Date 4/7/2021

Category:	Surface-Launched HE Rounds
Munition:	60 mm M49A5
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Mortar
Munition Case Classification:	Robust

DODIC:	B632
Date Record Created:	9/21/2004
Record Created By:	MMC
Last Date Record Updated:	5/3/2018
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	Composition B
Explosive Weight (lb):	0.79
Diameter (in):	2.3180
Cylindrical Case Weight (lb):	1.77907
Maximum Fragment Weight (Intentional) (lb):	0.0206
Design Fragment Weight (95%) (Unintentional) (lb):	0.0036
Critical Fragment Velocity (fps):	6044

Sandbag and Water Mitigation Options

TNT Equivalent (Impulse):	1.14
TNT Equivalent Weight - Impulse (lbs):	0.901
Kinetic Energy 10^6 (lb-ft²/s²):	0.3761

Single Sandbag Mitigation

Required Wall & Roof Thickness (in)	20
Expected Max. Throw Distance (ft):	125
Minimum Separation Distance (ft):	125

Double Sandbag Mitigation

Required Wall & Roof Thickness (in)	48
Expected Max. Throw Distance (ft):	10
Minimum Separation Distance (ft):	12.5

Water Mitigation

Minimum Separation Distance (ft):	264/200
Water Containment System:	5 gal carboys/ inflatable pool

Note: Use Sandbag and Water Mitigation in accordance with all applicable documents and guidance. If a donor charge larger than 32 grams is utilized, the above mitigation options are no longer applicable. Subject matter experts may be contacted to develop site specific mitigation options.

Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	184
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1070
MFD-V [Maximum Fragment Distance, Vertical] (ft):	854

Overpressure Distances

TNT Equivalent (Pressure):	1.16
TNT Equivalent Weight - Pressure (lbs):	0.916
3.5 psi, K18 Distance (ft):	17
2.3 psi; K24 Distance (ft):	23
1.2 psi, K40 Distance (ft):	39
0.0655 psi, K328 Distance (ft):	319

"NOTE: Values shown within this section only address overpressure hazards and do not account for applicable distance values for fragments and debris as required per DoD 6055.09-M."

Minimum Thickness to Prevent Perforation (in)

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	5.47	2.68
Mild Steel:	1.02	0.51
Hard Steel:	0.84	0.42
Aluminum:	2.14	1.12
LEXAN:	5.65	3.69
Plexi-glass:	4.03	2.29
Bullet Resist Glass:	3.30	1.76

Item Notes

APPENDIX G

Responses to Comments on Draft and Draft Final Munitions Response - Quality Assurance Project Plan

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US Army Corps of Engineers ®

New England District
696 Virginia Road
Concord, Massachusetts
01742-2751

TECHNICAL LEAD REVIEW COMMENTS

Project Name: Military Munitions Investigation Nashua River Former Fort Devens
Location: Former Fort Devens Army Installation
Document Name: Draft Munitions Response Quality Assurance Project Plan
Prepared By: Tetra Tech

No.	Reviewer	Ref. Page / Para.	COMMENTS	Disposition
1.	USEPA Region 1	General	Specifically, as specified in the Dispute Resolution Committee's (DRC's) January 20, 2022, agreement, Army is to perform a geophysical investigation along a 3-mile stretch of the Nashua River, to the north and south of locations of MEC discoveries in 2020 and 2021. However, the "Underwater Digital Geophysical Mapping" (UDGM) described in the draft MR-QAPP is limited to 26-foot spaced, geophysical transect surveys in five "Areas of Potential Interest" (AOPIs), which would result in far less coverage than envisioned in the DRC agreement. When investigating munitions training ranges, transects are commonly used and calculated using a Visual Sampling Plan (VSP), which designs the transect spacing to pass through a target area (of known historical size) at least twice. However, in this case, because munitions were likely randomly disposed in the river and there is no known information about size of those potential disposal areas, the geophysical investigation could very easily miss areas of concentrated disposal with the currently proposed transect design. The transect spacing in the draft MR-QAPP seems to have been selected only to accomplish the survey design metric of ≥25% coverage in each AOPI and not based on any statistical factors and/or analysis. The design, as presented in the draft MR-QAPP, also imposes problems regarding conclusions that can be drawn from the data collected. There cannot be any conclusive statements made after this investigation about the presence/absence of munitions other than in the actual 25% of the site that was investigated. USEPA is concerned that the investigation, as currently presented in the draft MR-QAPP, will not achieve the objectives contemplated in the DRC agreement because the scope of work proposed is inadequate to evaluate areas of previous military munition discoveries and identify areas/locations of high anomaly density.	The survey design and technical approach presented in the draft MR-QAPP are rooted in the current CSM (presented in detail in Worksheet #10) for an investigation, which is not required to include 100% coverage. In addition, 100% coverage was not identified as a requirement in the DRC agreement either. This CSM includes no evidence or documentation of munitions use or "disposal" at the site, consistent with the 2021 RSE. The use of "disposal" coupled with references to high density areas as the underlying premise for the approach rationale, implies otherwise (i.e., this does not match the current CSM). The 2021 RSE concludes the likely source of munitions is DMM; this includes single, isolated occurrences. Furthermore, each AOPI is 0.95 acres. Thus, the transect approach at the proposed spacing would identify relevant high anomaly density areas in terms of lateral extent, be they associated with non-munitions related scrap/trash or unexpectedly associated with munitions-related items, which would necessitate an update to the CSM. Therefore, the proposed approach was intended as an investigation of the area to better understand the conditions and if necessary, refine the problem statement. In keeping with MMRP guidance (EM 200-1-15, MR-QAPP Module 1), investigation next steps and future actions must consider the weight of evidence gathered at each phase of data collection to make informed decisions on how to proceed. Please refer to response to Item No. 2 for details on survey design changes to the MR-QAPP.

US Army Corps
of Engineers ®

New England District
696 Virginia Road
Concord, Massachusetts
01742-2751

TECHNICAL LEAD REVIEW COMMENTS

Project Name: Military Munitions Investigation Nashua River Former Fort Devens
Location: Former Fort Devens Army Installation
Document Name: Draft Munitions Response Quality Assurance Project Plan
Prepared By: Tetra Tech

No.	Reviewer	Ref. Page / Para.	COMMENTS	Disposition
2.	USEPA Region 1	General	However, USEPA notes that USEPA's Doug Maddox and Army's Bryan Frey spoke about the draft MR-QAPP and the issues USEPA identified above during a telephone call last Friday, August 26, 2022. During this telephone conversation, Bryan Frey explained that his understanding of Army's proposed investigation design would include nearly 100% geophysical coverage in the five (5) identified AOPIs (i.e., full coverage survey with overlapping sensor array swaths) with additional transects in other areas of the Nashua River in between the AOPIs. USEPA agrees that this design is appropriate and reasonable and further that it would be beneficial to position those additional transects closer to shore where disposal is likely to have taken place rather than in deeper water areas in the middle of the river that would not be accessible for disposal.	It is understood the Army and USEPA have agreed to an approach of nearly 100% coverage within each AOPI since the issuance of the draft MR-QAPP. The approach will be updated to include 100% coverage of accessible portions of the AOPIs. This approach will include overlap of the UDGM sensor array along successive survey lines. Additionally, the data collection efforts beyond the five AOPI footprints and within the 3-mile project corridor will include collection of transects closer to the shoreline, as stipulated in the comment, rather than the middle or more deeper sections of the river channel. In each case, collection will be influenced by the ability to safely maneuver the survey vessel in a way that also provides optimal data quality. The bathymetry survey conducted prior to the underwater digital geophysical mapping survey will provide details on obstructions, shallow water, etc. that will guide the final placement of these transects.

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Concord, Massachusetts
01742-2751

TECHNICAL LEAD REVIEW COMMENTS

Project Name: Military Munitions Investigation Nashua River Former Fort Devens
Location: Former Fort Devens Army Installation
Document Name: Draft Munitions Response Quality Assurance Project Plan
Prepared By: Tetra Tech

No.	Reviewer	Ref. Page / Para.	COMMENTS	Disposition
1.	MassDEP	General	Please use consistent terminology through the document when discussing all ordinance items. The document varies between the use of munitions, munitions debris, live munitions, DMM, recovered military munitions, etc.	Terminology has been revised where appropriate. The Military Munitions Response Program has specific definitions for the use of terminology associated with munitions and this has been followed within this document.
2.	MassDEP	Page 15/Line 21	Were the two MK-II hand grenades practice items, live, or expended munitions? Please clarify.	Text added "The two hand grenades were disposed of by the Massachusetts State Police Bomb Squad. While trained and capable in the disposal of the items, they are not qualified to classify the munitions as UXO in accordance with DESR 6055.09. Per DESR 6055.09 and other DoD, only military EOD personnel or qualified UXO Technicians are qualified to make that determination. While the State Police are not qualified to make the determination it is assumed they were live based on their findings post blast."
3.	MassDEP	Page 16/Line 14	Please add the year in which Hospital Bridge Road was constructed.	Unknown. Based on limited articles found online, it appears to have been built in the 1960s, but we cannot confirm a specific year. Text revised to: "During construction of Hospital Road Bridge in the 1960s which involved…"
4.	MassDEP	Page 16/Line 18	Please add the date in which the practice hand grenade was found. It is currently unclear which find this is referring too.	Text has been revised to state: "….the practice hand grenade was found in the summer of 2020…."
5.	MassDEP	Page 16/Line 20	The statement is made that "the Army did not encounter live munitions". Please clarify as to what was found. Otherwise please revise to state that the Army did not encounter any DMM or UXO.	Text revised to: "During these surveys, the Army did not encounter UXO or DMM."

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6.	MassDEP	Page 16/Line 28	The first sentence states "based on other instances where munitions have been recovered" – is this referring to the Summer 2020 and March 2021 finds discussed on Page 15? Please clarify, as the 2020 and 2021 finds are the only finds discussed in the QAPP.	This is a statement about munitions being discovered in areas not reasonably expected to be encountered anywhere, not just Devens or the Nashua River, from Soldiers or Veterans discarding them. Text revised to: "The RSE concluded that based on scenarios where munitions…"
7.	MassDEP	Page 18/Line 1	Please clarify the "recent munitions discoveries". Is this statement referring to the Summer 2020 and March 2021 finds?	Text has been revised to state: "Based on recent munitions discoveries in 2020 and 2021, USACE has delineated five….."
8.	MassDEP	Page 17/Line 33	Please discuss why the "top foot of sediment" was chosen as the exposure pathway. At what depth were the previous ordinance items discovered? It should be assumed that site workers would have the potential to encounter items at a depth below one foot bgs when performing intrusive site activities (i.e., sign installation, bridge abutment work, etc.).	While is not known what depth the magnet pulled the DMM from, it is assumed that it is less than a foot. The DOT workers identified the military munitions on the surface of the river bottom and EOD scanned the river bottom and disturbed some of the river bottom to approximately 6-8" in their search. Additionally, based on the release profile summarized in the CSM is a low probability that items would be present below 1 foot. Current models of munitions mobility in underwater environments have demonstrated that munitions-like items mainly have upward mobility due to the currents scouring of sediments around and under the item. Items have very limited downward mobility in some cases due either liquefaction or sediment deposits covering the item. In those cases, the downward mobility is limited to moving the object just below the sediment surface where the downward forces are no longer driving movement. In order for a DMM to be deposited significantly below the sediment surface in this area, a significant event (i.e. dam construction, mudslide, meandering riverbed) would have taken place.

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9.	MassDEP	Page 19/Bullet Item 2	Please discuss why a vertical boundary of 12 inches below the river bottom was chosen.	The performance criteria of 12 inches below the river bottom is based on the target selection threshold to ensure a detection depth of a hand grenade at 1-foot bgs based on detection capabilities of industry standard equipment when considering the smallest items of concern at their least favorable orientation. There is a low probability that items would be present below that depth and based on the CSM and site conditions. This target selection threshold has the ability to detect hand grenades deeper than 1-foot bgs but will ensure detection of potential DMM at their anticipated depth at this site. The above text has been added to provide details for this bullet.
10.	MassDEP	Page 26 / Measurement 8 Anomaly Resolution	This section states that anomalies detected below 24 inches bgs will not be resolved and that targets detected below 24 inches bgs will be recorded as “too deep”. Please discuss why the excavation activities will be halted at the 24 inch bgs depth rather than investigated until resolved.	The target selection threshold will be designed to detect all potential DMM of concern at their anticipated depth in their least favorable orientation. Using this conservative approach, some targets may be selected for investigation due to metallic sources that are deeper than 1-foot bgs. Recovering and documenting the source of each target is valuable information even if the recovered item is cultural debris or geologic features. However, recovering items greater than 2 feet bgs, which are well past the anticipated depth of potential DMM at this site, can present additional challenges to divers which may not be warranted.
11.	MassDEP	Page 36/Line 25	Please explain why the targets will only be investigated “to a depth of up to two feet” bgs.	See response to Comment #11.

Comments for the Devens Nashua River MR-QAPP
Former Ft. Devens
Devens, MA

Comment Number	Commenter	Page(s)	Line	Comment	Response Code	Response
Response Code: A = Agree with comment D = Disagree with comment C = Comment requires clarification						
Comments						
1	M.Holmes	37	16	Also include DoDM 4140.72 for MPPEH Management in all appropriate sections and SOP, it is not mentioned anywhere in this QAPP		DoDM 4140.72 added where appropriate to the QAPP and SOP.
2	M.Holmes	37	44	Move any reference to government representative for MPPEH/MDAS management & certification.		"…in absence of a government representative…" has been removed from the QAPP.
3	M.Holmes	UXO SOP 2		This SOP needs to be updated to be incompliance with DoDM 4140.72. This SOP must clearly state that the certifying individuals must have performed or witnessed the 100% inspection and re-inspection. QC cannot do random inspections if signing, nor can the 100% inspection be done by a UXO Tech II in the certification process IAW DoDM 4140.72. The certification statement also needs to be updated per DoDM 4140.72 The following statement is required on MDAS documentation and it must identify which methodology is used: "The material listed on this form has been inspected, processed by DDESB-approved means, or undergone the application of expert knowledge, in compliance with DoD policy, and to the best of my knowledge and belief, does not pose an explosive hazard."		The SOP has been revised as requested.
4	M.Holmes	35	14-16	How will data collection verification to ensure good data has been completed without seeding in this 3 miles?		Intrusive investigation of UDGM targets will presumably focus on the AOPIs, since these AOPIs are the primary objective. The additional 3-mile stretch of data collection will provide supplemental anomaly counts to the project team. Thus, the purpose of this additional data collection does not necessitate blind seeding. An assessment of data quality will be through the UIVS and QC test data because collection of the 3 miles (in each direction) would take an estimated one field day. To the extent practical during field operations, this 3-mile stretch of additional collection will be broken into sections to allow for collection of sections on the same days that seeded AOPI transects are collected. No change made to the QAPP text in response to this comment.
5	M.Holmes	Figure A-3		State Route 2 Bridge AOPI seems a little small, the throw distance should be measured from the edges of the bridge, since this is a 4 lane road that distance should be from both sides. This appears to be from the center of the 4 lanes.		The AOPI has been slightly revised to address this comment. The AOPIs as presented matched the figures provided by USACE during the proposal process.
1	D. Dorrell	32	35	Recommend Remove: **"40s"**.		Text revised as requested.
2	D. Dorrell	32	36	Recommend Remove: **"Schedule 40"**.		Text revised as requested.
3a	D. Dorrell	22		Conflicts with Page 36, Sections 25 - 26. **"Underwater Intrusive Investigation -If the UXO diver does not locate the target within a 24-inch radius of the GPS target location, then the UXO diver will expand the search radius by an additional 24 inches."**		Concur on the existence of this inadvertent inconsistency. In response to this comment and others in this matrix regarding the relationship between UDGM target positioning accuracy and UXO dive team search radius, Tetra Tech has updated the QAPP to convene a project team meeting to specifically address the UXO dive team search radius that will be appropriate during intrusive investigation, with this decision informed by QC review and QA inspection of the processed and targeted data. It is unknown at this time what accuracy will be achieved and demonstrated through blind seed performance. Therefore, Tetra Tech would like the opportunity to discuss with the project team a search radius that meets the project objectives and maintains confidence in quality of work performed. This meeting would occur prior to the UXO dive team mobilization. QAPP edits are not included in this response, but updated sections in response to this comment include Worksheet #11 | DQO Step 5 | Underwater Intrusive Investigation; Worksheet #17 | Section 17.6 | DFW 6 | Underwater Intrusive Investigation | 1st Paragraph; Worksheet #22 | Table 22-3 | MQO #21 | Acceptance Criteria.

Comment Number	Commenter	Page(s)	Line	Comment	Response Code	Response
3b	D. Dorrell	36	25 - 26	Conflicts with Page 22 Underwater Intrusive Investigation. **25 - 26 "up to two feet with an initial search radius of 3.3 feet. The diver will set out to a search radius of 5 feet if the anomaly source is inconsistent with the DGM anomaly characteristics."**		See Response to D. Dorrell Comment #3a.
4a	D. Dorrell	Dive SOP 3	5.5.4.3 *Misfire Procedures for the RFD*	Electric cap misfire procedures differ. Which is correct? **"If electric caps were used, do not remove the old blasting caps from the detonating cord, but disconnect the firing wire from the receiver and shunt the firing wire."**		The difference in procedures for these SOPs are due to the fact that MEC disposal operations conducted from a small boat are slightly different than those conducted in on land. Dive SOP 3 addresses misfire procedures that are conducted from a small boat on the water with restricted maneuverability. The UXO SOP addresses misfire procedures in a terrestrial environment. Both procedures are correct as written and no changes will be made to the SOPs. The team will use the appropriate procedure based on whether they are on land or in the boat. It is assumed unless there is a item that is unsafe to move, the detonations for this project will occur on land at the ESP designated disposal location.
4b	D. Dorrell	UXO SOP	3.6.5 Misfires *Misfire Procedures for the Scorpion Electronic Blasting Machine*	Electric cap misfire procedures differ. Which is correct? **"10.1 If electric caps were used, remove the old blasting caps from charge and disconnect from firing wire. Shunt cap leg wires." "10.2 If detonating cord was used cut detonating cord between cap and charge, disconnect cap from fire wire. Shunt cap leg wires."**		See Response to D. Dorrell Comment #4a.
1	J Day	37	worksheet 17	The government rep does not sign the chain of custody document.		See response to M. Holmes Comment #2. Text has been revised.
2	J Day	para 1.1	SOP 3	"The procedures above will be conducted following a project-specific Work Plan (of which this SOP will be a part)" Change the wording from Work Plan to QAPP		This is a programmatic SOP that is used for all of Tetra Tech's projects, including projects that do not have a QAPP and instead have a Work Plan. The QAPP is considered a Work Plan in Tetra Tech's quality system. Therefore, no changes will be made to the SOP.
3	J Day	para 3.2	UXO SOP MPPEH and MDAS Management and Disposal	The government rep does not sign the chain of custody document.		This is a programmatic SOP that is used for all of Tetra Tech's projects. We have removed the statement from the QAPP, but there are other non-USACE projects that this SOP is used for that may have a government representative sign the DD 134-1A. As the QAPP has the correct information, no changes will be made to the SOP.
4	J Day	Dive Plan		Dive plan comments provided separate		These comments are being addressed separately.
1	G. Abrams	24	Worksheet #12	Please add MPC for Survey control under site preparation.		Survey control has been added as new MPC #2 in Table 12-1: "Measurement: Survey Control | Data Quality Indicator: Accuracy/Completeness | Specification: Initial site controls at the beginning of the project are independently established by professional land surveyor (PLS) and conform to third order accuracy (1:10,000) | Activity Used to Assess Performance: Land Surveyor Report"
2	G. Abrams	24	Worksheet #12	Please add MPCs for SSS survey.		New MPC #5 in Table 12-1 has been added for the SSS/Bathymetry survey: "Measurement: Achieved Survey Coverage | Data Quality Indicator: Completeness | Specification: 100% of 3-mile study area along Nashua River (including the AOPIs) is surveyed prior to the UDGM survey. Exception: Areas not accessible to the survey vessel are excluded, including sections of the river with insufficient water depth to navigate the vessel or accurate field measurements. | Activity Used to Assess Performance: Review survey line paths and achieved data coverage, with particular emphasis on planned UDGM transects within the five AOPIs. Review daily field reports for explanation of excepting conditions."

Comment Number	Commenter	Page(s)	Line	Comment	Response Code	Response
3	G. Abrams	41	Worksheet #22	Initial Dynamic Positioning (UIVS) states IVS seed accuracy will be +/-5'. Is +/-5' the expected accuracy of the seed positioning even in the IVS? How does this relate to dive team dig radius, step-out procedures, and probability of successful seed recovery? If the max dig radius is 5' and the diver has an expected accuracy of 12" then items could be missed. Is this system capable of sub-meter accuracy?		See Response to D. Dorrell Comment #3a.
4	G. Abrams	43	Worksheet #22	Topside Pressure Sensor Function Test. Please add survey method in parenthesis.		(UDGM) has been added to the Measurement Quality Objective column text in Table Worksheet #22, Table 22-2.
5	G. Abrams	43	Worksheet #22	Downline Data Density - please add survey method.		(UDGM) has been added to the Measurement Quality Objective column text in Table Worksheet #22, Table 22-2.
6	G. Abrams	43	Worksheet #22	Please add specific data density/linespacing/accuracy metrics for the SSS survey?		Two new MQOs added to Worksheet #22, Table 22-2: "Sonar Positioning Test (SSS/Bathymetry)" and "Sonar Line Spacing (SSS/Bathymetry)". Specific table updates not summarized here for brevity, but remaining MQO columns populated in RLSO version of QAPP.
7	G. Abrams	43	Worksheet #22	Dynamic Survey Performance (blind Seeds) - +/-5' accuracy is at the edge of our current maximum dig radius. This may have negative effects on target recovery.		See Response to D. Dorrell Comment #3a.
8	G. Abrams	46	Worksheet #29	Please add DUA(s) to the list of Document/Record		DUA has been added to the list of documents/records as requested.
1	P. Phillips	15 / WS#10	20	Revise to "…munitions include:"		Text has been revised as requested.
2	P. Phillips	29 / WS#14	CLIN 0004	The Finish date for "Site Cleanup and Shipping out of Equipment" should be 4/17/2024 not 4/17/2022		Text has been revised as requested.
3	P. Phillips	App A	Figure A-2 & A-3	Please revise legend to replace "MEC" with "Military Munitions" for the 24 July and 12 August 2020 events.		Legend has been revised as requested.
4	P. Phillips	App A	Figure A-3	Please verify if one or two river transects should be illustrated for project area, outside the footprint of the AOPIs.		As these are conceptual transects and we are going to map going both up and down the River, we have chosen to show two transects. We know the actual transects locations will be based on the bathymetry and side scan sonar data. No changes are being made to Figure A-3.
1	P. Reddy	10	29	Add definition of DMM		DMM was defined in the Introduction section. Once defined it is typically not redefined. No changes to text.
2	P. Reddy	24	28	add to end of paragraph after DMM. *Please note magnetic fishing has been prohibited along this portion of the Nashua River and advisory signs are in place.*		Text added as requested.
3	P. Reddy	24	37	Add after water areas….*Based on the historical records search, no other munitions encounters have been documented for the Nashua River beside the recent incidents discussed above.*		Text added as requested.
4	P. Reddy	26	32 or in table	Define site worker receptor in work plan or table (once) similar to recreational receptors.		Text added: "Site workers (MDoT divers)
5	P. Reddy	References		Add 1991 Devens Federal Facility Agreement to reference list. U.S. Army and U.S. USEPA 1991. Final U.S. Environmental Protection Agency Region 1 and U.S. Army Federal Faculties Agreement Under CERCLA Section 120 Former Fort Devens Army Installation. November.		Reference added as requested.
				End of Comments		

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1.	USEPA Region 1	Introduction (pgs. 1-2), QAPP Worksheet #10 – Conceptual Site Model (pgs. 16-19) and QAPP Worksheet #11 – Project/Data Quality Objectives (pgs. 20-25)	USEPA is concerned that Army has not described how it intends to investigate areas within the 3-mile stretch of the Nashua River that do not fall within the five AOPIs. Specifically, the first paragraph on page 1 states that, "[t]he military munitions investigation will be performed within an approximate 3-mile stretch of the Nashua River, which includes five areas of potential interest (AOPIs) near Former Fort Devens." Then, the first paragraph on page 16 states that "[t]he area of investigation for this project as defined by USACE, includes 5 AOPIs within the Nashua River next to the Former Fort Devens." Although Army's September 30, 2022, response to USEPA comment #2 indicates that data collection efforts will include transects beyond the five AOPI footprints, language mentioned above and from Worksheet #11 (i.e., "The goal of the military munitions investigation is to assess whether an explosive safety hazard remains within the five AOPIs delineated by USACE in the Nashua River study area.") suggests that *only* the five AOPIs will be investigated. As a result, USEPA is concerned that the scope of the munitions investigation and boundaries of the study/ project area, as currently described in the draft final MR-QAPP, will not achieve the objectives contemplated in the Dispute Resolution Committee's (DRC) January 20, 2022, Agreement, which identified the area of investigation as "the approximately 3-mile stretch of the Nashua River next to the Former Fort Devens, from an area just south of the Jackson Road/State Route 2 interchange to an area just north of West Main Street in Ayer, close to where it intersects with Walker Road in Shirley." Therefore, consistent with Army's September 30, 2022, response to USEPA comment #2, the Final MR-QAPP must describe, in sufficient detail, the activities to be performed (i.e., collection of initial SSS/bathymetry data, UDGM surveying, and intrusive investigation of anomaly sources) in the three-mile stretch of the Nashua River in between and outside the five AOPIs, spanning the length of the project area from south to north.	Text has been revised within Worksheets #10 and #11 to clarify that the study area is the approximate 3-mile stretch of the Nashua River, which includes five areas of potential interest (AOPIs) near Former Fort Devens. Specifically, text has been clarified in Worksheet #10, Location, size and ownership, and Worksheet #11, Steps 1, 2, 3, 4, and 5.

2.	USEPA Region 1	Conceptual Site Model (pgs. 16-19)	The discussion on pages 16–19 misrepresents the events surrounding Army's preparation and issuance of the draft Removal Site Evaluation (RSE), draft final RSE and RSE Addendum, USEPA's twice invocation of informal dispute resolution on August 24, 2020, and September 16, 2021, and final invocation of formal dispute resolution on December 16, 2021. USEPA requests that the discussion in the Final MR-QAPP be amended to include a complete and accurate summary of events leading to USEPA's invocation of the dispute resolution provisions of the Devens FFA and the Dispute Resolution Committee's January 20, 2022, Agreement, upon which development of this MR-QAPP is based. Specifically, USEPA requests that the discussion be amended to include the following paragraphs: "On August 19, 2020, USEPA requested that Army perform a Removal Site Evaluation (RSE), pursuant to Paragraph 12.3(c) of the Devens Federal Facility Agreement (FFA) and § 300.410 of the NCP, after the discovery of MEC in 2020 and 2021 at three different locations during magnet fishing and bridge restoration activities. These discoveries were located within the Nashua River, adjacent to the former Fort Devens. USEPA requested that Army evaluate the likely presence of additional MEC at other locations along the Nashua River and determine whether a removal or other remedial action was necessary to address the imminent threat and substantial endangerment to human health and the environment posed by these MEC. After USEPA initiated informal dispute to ensure the development of an RSE, the two parties participated in several calls and exchanges of correspondence. Ultimately, upon receiving Army's commitment to perform the RSE and an amended, final schedule to complete the RSE, informal dispute was concluded on September 16, 2020. After Army's submission of a draft RSE on November 18, 2020, USEPA provided comments identifying the actions and revisions necessary to satisfy paragraph 12.3(c) of the FFA and NCP § 300.410. After receiving responses to those comments, USEPA provided follow-up comments on March 4, 2021, again identifying the actions necessary to adequately complete the RSE. Army's submission of a Draft Final RSE in May 2021 and a Draft RSE Addendum in August 2021 did not include the actions and revisions identified by USEPA as necessary to adequately evaluate areas of prior MEC discoveries and confirm potential MEC exposure pathways along the Nashua River. As a result, USEPA again initiated an informal dispute on September 16, 2021, and	Per Army review, the USEPA suggested text was added to Worksheet #11, with minor edits. "On August 19, 2020, the USEPA requested that the Army perform an RSE, pursuant to Paragraph 12.3(c) of the Devens FFA and § 300.410 of the National Contingency Plan (NCP), after the discovery of military munitions (presumed MEC) in 2020 at two different locations during magnet fishing activities. These discoveries were located within the Nashua River, adjacent to the former Fort Devens. The USEPA requested that the Army evaluate the likely presence of additional military munitions (potential MEC) at other locations along the Nashua River and determine whether a removal or other remedial action was necessary to address the imminent threat and substantial endangerment to human health and the environment posed by these military munitions (potential MEC). After the USEPA initiated informal dispute to ensure the development of an RSE, the two parties participated in several calls and exchanges of correspondence. Ultimately, upon receiving the Army's commitment to perform the RSE and an amended, final schedule to complete the RSE, informal dispute was concluded on September 16, 2020. After the Army's submission of a Draft RSE on November 18, 2020, the USEPA provided comments identifying the actions and revisions necessary to satisfy paragraph 12.3(c) of the FFA and NCP §

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			later invoked formal dispute resolution on December 16, 2021. In accordance with the Dispute Resolution Committee's (DRC) January 20, 2022, Agreement, which resolved and ended the formal dispute, Army agreed to perform the activities proposed in this MR-QAPP."	300.410. After receiving responses to those comments, the USEPA provided follow-up comments on March 4, 2021, again identifying the actions necessary to adequately complete the RSE. The Army's submission of a Draft Final RSE in May 2021 and a Draft RSE Addendum in August 2021 did not include the actions and revisions identified by the USEPA as necessary to adequately evaluate areas of prior military munitions (potential MEC) discoveries and to confirm potential presumed MEC exposure pathways along the Nashua River. As a result, the USEPA again initiated an informal dispute on September 16, 2021, and later invoked formal dispute resolution on December 16, 2021. In accordance with the Dispute Resolution Committee's (DRC) January 20, 2022 Agreement, which resolved and ended the formal dispute, the Army agreed to perform the activities proposed in this MR-QAPP."