LONG-TERM MONITORING AND MAINTENANCE PLAN
FOR
FORMER FORT DEVENS ARMY INSTALLATION
AND
SUDBURY ANNEX

FORMER FORT DEVENS ARMY INSTALLATION, DEVENS, MA
SUDBURY ANNEX, SUDBURY, MA

FINAL

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LONG-TERM MONITORING AND MAINTENANCE PLAN FOR FORMER FORT DEVENS ARMY INSTALLATION AND SUDBURY ANNEX

FINAL

February 2015

CERTIFICATION:

I hereby certify that the enclosed Report, shown and marked in this submittal, is that proposed to be incorporated with Contract Number W912WJ-10-D-0003 TO No. 004. This document was prepared in accordance with the U.S. Army Corps of Engineers (USACE) Scope of Work and is hereby submitted for Government Approval.

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2/24/2015

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AAFES	Army Air Force Exchange Service
ADR	Automated Data Review
AOC	area of contamination
Army	U.S. Army
ASTM	American Society for Testing and Materials
bgs	below ground surface
BRAC	Base Realignment and Closure
BTEX	benzene, toluene, ethylbenzene, xylenes
^{o}C	degree Celsius
CCS	Contract Compliance Screening
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CMR	Code of Massachusetts Regulations
COC	contaminant of concern
COD	chemical oxygen demand
DCL	Devens Consolidation Landfill
Devens	former Fort Devens Army Installation
DO	dissolved oxygen
DoD	Department of Defense
DQCR	Daily Quality Control Report
DRFTA	Devens Reserve Forces Training Area
DRMO	Defense Reutilization and Marketing Office
EDD	electronic data deliverable
EM	Engineer Manual
EOD	explosive ordnance disposal
EPH	extractable petroleum hydrocarbons
ESD	Explanation of Significant Differences
ESMA	excavated soils management area
FS	Feasibility Study
FTP	file transfer protocol
GPS	Global Positioning System
HGL	HydroGeoLogic, Inc.
HLA	Harding Lawson Associates
ID	identification
IDW	investigation-derived waste
INRMP	Integrated Natural Resources Management Plan
ITRC	Interstate Technology and Regulator Council

L/min	liters per minute
LEL	lower explosive limit
LCRS	leachate collection and recovery system
LCS	laboratory control sample
LNAPL	light non-aqueous phase liquid
LTM	long-term monitoring
LTMM	long-term monitoring and maintenance
LTMMP	Long-Term Monitoring and Maintenance Plan
LTMP	Long-Term Monitoring Plan
LUC	Land-Use Control
LUCIP	Land-Use Control Implementation Plan
μg/L	milligrams per liter
MAROS	Monitoring and Remediation Optimization System
MassDEP	Massachusetts Department of Environmental Protection
MCL	maximum contaminant level
MCP	Massachusetts Contingency Plan
mg/kg	milligrams per kilogram
MMCL	Massachusetts Maximum Contaminant Level
MS	matrix spike
MSD	matrix spike duplicate
MWPAR	Massachusetts Wetlands Protection Act Regulations
NFA	No Further Action
NFG	National Functional Guidelines
NPL	National Priorities List
NTU	nephelometric turbidity units
O&M	operations and maintenance
ORP	oxidation-reduction potential
OU	Operable Unit
%	Percent
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
PCB	polychlorinated biphenyls
PCE	tetrachloroethene
PID	photoionization detector
PM	Project Manager
POL	petroleum, oils, and lubricant
PPE	personal protective equipment
PRG	preliminary remediation goal
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
QSM	Quality Systems Manual

RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RG	remediation goal
RI	Remedial Investigation
ROD	record of decision
SA	Study Area
SEDD	Staged Electronic Data Deliverable
SI	Site Investigation
Sovereign	Sovereign Consulting Inc.
SOW	Statement of Work
SPIA	South Post Impact Area
SPM	South Post Monitoring
SVE	soil vapor extraction
SVOC	semi-volatile organic compound
TAL	target analyte list
TCE	trichloroethene
TCL	target compound list
TPH	total petroleum hydrocarbons
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USARC	U.S. Army Reserve Command
USEPA	U.S. Environmental Protection Agency
UXO	unexploded ordnance
VOA	volatile organic analyte
VOC	volatile organic compound
VPH	volatile petroleum hydrocarbons

FINAL
LONG-TERM MONITORING AND MAINTENANCE PLAN
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS
SUDBURY ANNEX
SUDBURY, MASSACHUSETTS

1.0 INTRODUCTION

1.1 PURPOSE

The U.S. Army Corps of Engineers (USACE)-New England District contracted Sovereign Consulting Inc. (Sovereign) to conduct environmental remediation services required to meet the objectives of the Statement of Work (SOW) for Contract Number W912WJ-10-D-0003. Sovereign and their subcontractor, HydroGeoLogic, Inc. (HGL), hereinafter referred to as the Sovereign team, have prepared this Long-Term Monitoring and Maintenance Plan (LTMMP) to update the current long-term monitoring (LTM) approach for the seven Former Fort Devens Army Installation (Devens) sites and one Sudbury site identified in this LTMMP. The changes to the LTM approach are necessary to account for changes in a particular site's contaminant distribution and progress towards achieving the goals stated in the site's Record of Decision (ROD). This LTMMP combines the 2008 Devens Long-Term Monitoring Plan (LTMP) (HGL, 2008), and the 2009 Sudbury Annex LTMMP (HGL, 2009) with additional revisions and optimization recommendations. This combined LTMMP includes new contractor-specific information and site information such as building construction or changes in site use. In addition, well 26-10-09X was added to the LTM Program for the South Post Impact Area (SPIA) Area of Contamination (AOC) 26 as a downgradient sentry well and the SPIA AOC 26 section of the LTMMP was updated accordingly. This LTMMP also incorporates the requirement to perform Land Use Control (LUC) inspections at the former Grant Housing and 37-mm Impact Area located within the former Devens Main Post area. Future planned investigation work at SPIA site AOC 26 may require additional revisions to this LTMMP following the completion of field activities and evaluation of the investigation findings.

The LTM optimization recommendations provided in this revised LTMMP are derived from the recent optimization evaluation requested by the U. S. Army (Army) and performed for the Devens and Sudbury sites and presented as **Appendix A** to this LTMMP. The optimization was performed using quantitative and qualitative analyses of LTM data collected from 2009 through 2012 and appended to LTM data presented in the 2008 LTMP for the Main Post and SPIA AOCs and the 2009 LTMMP for the Sudbury Annex AOC. The 2008 and 2009 documents presented detailed qualitative analyses of data trends and provided recommendations for LTM optimization. Most of the optimization recommendations presented in the 2008 LTMP have been implemented. The 2009 through 2012 data were added to the previous LTM data set and evaluated to determine if additional optimization was warranted or if new trends were evident that potentially supported performing further optimization, including eliminating sites from the LTM program. The scope of the optimization did not involve detailed statistical analyses, additional risk assessments, or modeling of data to determine future trends; however, analyses of select data using the Monitoring and Remediation Optimization System (MAROS) were performed to substantiate qualitative interpretations.

The optimization evaluation contains the details of the procedures and rationale used to determine what LTM optimization is appropriate for the Devens and Sudbury sites. This LTMMP revision presents the optimization recommendations determined during performance of the optimization evaluation and does not reproduce the in-depth discussions contained within the optimization report (**Appendix A**).

1.2 BACKGROUND

Devens is located in the towns of Ayer and Shirley in Middlesex County and Harvard and Lancaster in Worcester County, Massachusetts, approximately 35 miles northwest of Boston, Massachusetts. The installation occupied approximately 9,260 acres. **Figures 1.1a and 1.1b** provide site locations for the AOCs and other areas discussed in this section and the remainder of this LTMMP. **Figures 1.2a through 1.11** provide individual site layout information for the AOCs and other areas discussed in this section and the remainder of this LTMMP. Prior to the official base closure, Devens was divided into the North Post, Main Post, and South Post. The South Post is generally referenced as the SPIA and consists of the portion of the South Post that encompasses the training ranges. The North Post is managed as a separate area and is not included within the scope of this LTMMP. Route 2 divides the South Post from the Main Post. The Nashua River runs through the North, Main, and South Posts. The area surrounding Devens is largely rural residential property.

Devens was identified for cessation of operations and closure under Public Law 101-510, the Defense Base Realignment and Closure (BRAC) Act of 1990, and officially closed in March 1996. As part of the Devens BRAC program, portions of the property formerly occupied by Fort Devens were retained by the U.S. Army (Army) for reserve forces training and renamed the Devens Reserve Forces Training Area (DRFTA). Areas not retained as part of DRFTA were, or are in the process of being, transferred to new owners for reuse and redevelopment.

The Sudbury Annex occupies approximately 4.3 square miles in the Massachusetts towns of Hudson, Marlborough, Maynard, Stow and Sudbury. Hudson Road divides the installation into a larger northern section, and a smaller southern section. The Sudbury Annex became part of Fort Devens, now the DRFTA, in 1982. The Sudbury Annex was removed from the National Priorities List (NPL) in January 2002. At that time, 2,205 acres were transferred to the U.S. Fish and Wildlife Service, 4.1 acres were transferred to the U.S. Air Force, and 71.4 acres were transferred to the Federal Emergency Response Agency. In June 2002, all known monitoring wells at the former annex were decommissioned except for those at the one AOC remaining in the long-term monitoring and maintenance (LTMM) program (AOC A7).

A more comprehensive discussion of the Devens and Sudbury background information is provided in **Appendix A**.

1.2.1 Former Fort Devens Army Installation Main Post Site Summary

Detailed site information is provided in the Optimization Evaluation attached as **Appendix A** to this LTMMP. The following sections provide a summary of the sites:

- AOC 57: Located between Barnum Road and Cold Spring Brook on the northeast side of what was formerly the Main Post of Devens (**Figure 1.1a**) and what was used primarily as a storage and maintenance area for military vehicles. The main portion of the site is a former solar panel manufacturing facility. The active portions of AOC 57 consist of Area 2 and Area 3, as depicted on **Figures 1.2a and 1.2b**, respectively.
- AOC 69W: Located at the northeast corner of the intersection of Jackson Road and Antietam Street on the northern portion of what was formerly the Main Post at Devens (**Figure 1.1a**). AOC 69W consists of the former Devens Elementary School (Building 215) and its associated parking lot and adjacent lawn, extending approximately 300 ft northwest to Willow Brook. The layout of AOC 69W is depicted on **Figure 1.3**.
- AOC 43G: Located in the central portion of the former main post of Devens and consists of the former Army Air Force Exchange Service (AAFES) gas station and historical post gas station. This AOC remains entirely within the Army Garrison property. The layout of AOC 43G is depicted on **Figure 1.4**.
- Devens Consolidation Landfill (DCL): Located in the former Main Post of Devens and constructed at the location of the former golf course driving range between 2000 and 2002 to provide an on-site landfill for debris from six individual remedial areas. DCL is depicted on **Figure 1.5**.
- AOCs 32 and 43A: AOCs 32 and 43A were known as the Defense Reutilization and Marketing Office (DRMO) Yard, and the petroleum, oils and lubricant (POL) storage areas, respectively. AOC 32 consisted of three fenced areas (DRMO west yard, DRMO east yard, and tire recycling area) along Cook Street. AOC 43A was located across Market Street from AOC 32. AOC 43A consisted of a fenced lot located within an industrial area and served as the distribution point for all gasoline and other fuels at Devens from the 1940s to 1996. AOCs 32 and 43A are depicted on **Figure 1.6**.
- Former Grant Housing and 37-mm Impact Area: Between 1917 and the 1930's, the Grant Housing Area and 37-mm Impact Area (**Figure 1.7**) were used by the Army as a firing range. From the 1960's until closure of Fort Devens in March 1996, the Grant Housing Area was used for military housing. The housing area has since been demolished and the area is currently vacant. Former infrastructure, including roadways and partial utilities remain in place.

1.2.2 Former Fort Devens Army Installation South Post Impact Area Site Summary

- SPIA: Located in the area known as the South Post of former Fort Devens (**Figure 1.8**). The SPIA is a 964-acre area that was historically used for small firearms and grenade training and also for open burning and detonation of explosives. SPIA is currently an active weapons and ordnance discharge area that is used by the Army, U.S. Army Reserve Command (USARC), the National Guard, and local, state, and federal law enforcement agencies. SPIA AOCs addressed in this LTMMP include AOCs 25, 26, 27, and 41. AOC 25 is known as the Explosive Ordnance Disposal (EOD) Range. AOC 26 is known as Zulu Range and includes the Zulu 1 and Zulu 2 ranges. AOC 27 is known as the Hotel Range. AOC 41 is a former general waste disposal area. AOCs 25 and 41 are not actively monitored under the LTM program. AOCs 25 and 41 are shown on **Figure 1.8** and AOCs 26 and 27 are depicted on **Figures 1.9 and 1.10**, respectively.

1.2.3 Former Sudbury Annex Site Summary

Sudbury Annex: AOC A7 is located at the former Sudbury Training Annex in Sudbury, Massachusetts (**Figure 1.1b**). Site AOC A7 is the only site remaining at the Sudbury Annex that requires environmental monitoring and is depicted on **Figure 1.11**. AOC A7 is a former waste disposal site in the northern portion of the former training annex. A Resource Conservation and Recovery Act (RCRA) Subtitle C landfill cap was installed in 1996.

1.3 ROD OBJECTIVES AND SELECTED REMEDY

The LTMMP strategies implemented at the Devens and Sudbury sites are driven by each site's ROD requirements. In general, the objectives of the long-term groundwater monitoring and maintenance program at the Devens and Sudbury sites are to monitor groundwater conditions, monitor for potential off-site contaminant migration, and to document that concentrations of the contaminants of concern (COC) decrease over time to a level that eventually achieves the objectives stated in the particular site's ROD. The following sections provide a summary of the individual site ROD remedial action objectives (RAO) and their remedy. The RAOs are site-specific, quantitative goals defining the extent of cleanup required to achieve response objectives. The RAOs are formulated to achieve the overall U.S. Environmental Protection Agency (USEPA) goal of protecting human health and the environment. A description of current site LTMM activities is provided in **Section 2**.

1.3.1 AOC 57

The ROD for AOC 57 was approved in 2001. Per the ROD, the site-specific RAOs defining the extent of clean up at AOC 57 are as follows:

Area 2 – Wetland (aka Flood Plain)

- *Protect potential construction workers that might work with future recreational (wetlands) areas at Area 2 from ingesting soils containing Aroclor-1260 and lead in excess of preliminary remediation goal (PRG) concentrations considered protective of human health (3.5 and 600 milligrams per kilogram [mg/kg], respectively).*
- *Prevent potential residential receptors from coming in dermal contact with and ingesting Area 2 wetland soils containing Aroclor-1260, arsenic, chromium, lead, and the extractable petroleum hydrocarbons (EPH)* C_{11}-C_{22} *aromatic carbon range in excess of PRG concentrations considered protective of human health (0.5, 21, 550, 400, and 930 mg/kg, respectively).*
- *Prevent unrestricted potable use of Area 2 wetland groundwater containing arsenic, tetrachloroethene (PCE) in concentrations that exceed Federal maximum contaminant level (MCL)/Massachusetts Maximum Contaminant Level (MMCL) drinking water standards (50 and 5 μg/L, respectively).*

Area 3 – Upland

- *Protect potential future commercial/industrial receptors from ingesting upland Area 3 groundwater that contains arsenic, cadmium, and 1,4-dichlorobenzene at concentrations that exceed MCLs and MMCLs for drinking water.*
- *Prevent unrestricted residential potable use of Area 3 groundwater containing arsenic, cadmium, and 1,4-dichlorobenzene at concentrations that exceed MCLs and MMCLs for drinking water.*

Area 3 – Wetland (aka Flood Plain)

- *Prevent unrestricted use residential receptors from coming in dermal contact and ingestion of surface soils containing the EPH C11-C12 aromatic carbon range at concentrations in excess of PRGs considered protective of human health.*
- *Prevent unrestricted residential potable use of Area 3 floodplain groundwater containing arsenic and PCE at concentrations that exceed MCLs and MMCLs for drinking water (USACE, 2001)*

The ROD remedy selected for Areas 2 and 3 consisted of soil excavation and treatment/disposal at an off-site treatment, storage, or disposal facility, Wetlands Protection, Land Use Controls, Environmental Monitoring, LUC Inspections and Five-year Site Reviews (USACE, 2001). The LUCs consist of continued zoning that prohibits residential use of the Area 2 property and deed restrictions that prohibit potable use of Area 2 and 3 groundwater and residential use of the property. The intent of the ROD was primarily to address petroleum contaminated soils and groundwater. The ROD indicates that groundwater and surface water monitoring is a relevant and appropriate response to confirm that COCs are decreasing, the potential for off-site migration via the groundwater to surface water discharge pathway is evaluated, and that Federal MCL and Massachusetts groundwater quality standards are met.

In March 2004, the USACE published an Explanation of Significant Differences (ESD) for AOC 57. The ESD resulted from data collected during soil excavation activities at Area 2. The changes to the selected remedy for Area 2 were:

- Increased volume and cost of contaminated soil requiring removal to attain cleanup levels at Area 2;
- Inclusion of EPH as a COC for soil at Area 2; and
- Inclusion of EPH and polychlorinated biphenyls (PCB) as COCs for Area 2 groundwater.

The original ROD established risk-based cleanup levels for Area 2 at AOC 57 for the PCBs, Aroclor-1260, and lead. Concerns about the persistent separate phase petroleum waste observed during removal and investigation work in 2002-2003 resulted in the addition of C_{11}-C_{22} aromatic hydrocarbons quantified by EPH (MassDEP EPH Method) as a COC. As a result of the addition of C_{11}-C_{12} as a COC, the ROD adopted the more stringent S3/GW-1 cleanup level of 200 mg/kg EPH C_{11}-C_{22} aromatic fraction for Area 2 soils. Subsequently, PCBs were added as a COC because of their association with the petroleum waste oil.

1.3.2 AOC 69W

The ROD for AOC 69W was signed on June 30, 1999. Per the ROD, the site-specific RAOs defining the extent of cleanup at AOC 69W are as follows:

- *Restore the aquifer to drinking water standards within a reasonable period;*
- *Monitor potential future migration of groundwater contamination;*
- *Eliminate risk from potential consumption of groundwater; and*
- *Reduce or eliminate the direct contact threat of contaminated soils.*

> *The basis of the RAOs is the potential health risks to individuals based on current and future use scenarios at the site (maintenance worker, school children, etc.) (Harding Lawson Associates [HLA], 1999).*

"Limited Action" was the selected remedy for AOC 69W groundwater and subsurface soils based on the risk assessment results estimating cancer and non-cancer risks associated with the current and future exposure, which were all within acceptable levels. The intent of the ROD was primarily to address soils and groundwater contaminated with fuel oil. To meet Federal MCLs and Massachusetts Drinking Water Regulations 310 Code of Massachusetts Regulations (CMR) 22, the ROD specifies that two actions are to be undertaken. First, long-term groundwater monitoring is to be applied to ensure that contaminants do not migrate off-site, and second, LUCs are to be implemented to prohibit the installation of drinking water wells and prevent exposure. These actions are also qualified by the statement "In addition, arsenic concentrations are expected to decrease following the soil removal which eliminated the source." According to the ROD, the LTM program was implemented to ensure that contaminants do not migrate off-site, rather than demonstrate that cleanup goals are met. Additional key components of the Limited Action Remedy, as detailed in the ROD, included development of a Long-Term Groundwater Monitoring Plan and conducting 5-year reviews.

1.3.3 AOC 43G

The ROD for AOC 43G was signed in 1996. Per the ROD, the site-specific RAOs defining the extent of clean up at AOC 43G are as follows:

- *Protect potential commercial/industrial receptors located on Devens property from exposure to groundwater having chemicals in excess of the following remedial goals (RG): iron (9,100 µg/L), manganese (291 µg/L), nickel (100 µg/L), benzene (5 µg/L), ethylbenzene (700 µg/L), and xylenes (10,000 µg/L).*
- *Protect potential commercial/industrial receptors located off Devens property from exposure to groundwater having chemicals in excess of the above RGs.*
- *Prevent contaminated groundwater having chemicals in excess of RGs from migrating off Army property.*

> *The RGs for benzene, ethylbenzene, xylenes, and nickel are the MCLs and MMCLs in effect at the time. The RGs for iron and manganese are Devens background concentrations, because*

> *background concentrations exceeded the risk-based concentrations derived from available RfD values at the time of the Remedial Investigation (RI)/Feasibility Study (FS).*
>
> *The risk assessments did not identify potential risks from exposure to surface soil or subsurface soil, and ambient air monitoring during the RI did not identify airborne contaminants (USACE, 1996).*

The ROD documented the selection of intrinsic remediation with LTM as the selected remedy (USACE, 1996). The major components of the selected remedy included intrinsic bioremediation, intrinsic bioremediation assessment data collection and groundwater modeling, installing additional monitoring wells, long-term groundwater monitoring, annual data reports to USEPA and MassDEP, and 5-year site reviews. Intrinsic bioremediation is the principal component proposed to prevent COCs that exceed groundwater cleanup levels from potentially migrating off Army property. The ROD stated that the minimum cleanup criteria will meet drinking water standards. The ROD specifies that if the intrinsic bioremediation assessment results indicate that (1) the groundwater contaminant plume increases in size on Army property, and/or (2) the groundwater contaminant plume remains the same size, but cannot be remediated within 30 years, then a soil vapor extraction (SVE) system will be installed at the existing AOC 43G source area. Furthermore, if at any time during this remedy there is an indication that contaminants are migrating off Army property above drinking water standards (MCLs/MMCL or risk-based concentration [i.e., groundwater cleanup levels]); and/or if the five-year review indicates that the intrinsic remediation alternative is not protective of human health, the Army will implement an additional cleanup action to protect human health and the environment as required under Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

1.3.4 Devens Consolidation Landfill

The USEPA approved the ROD for DCL sites in July 1999. Per the ROD, the following RAOs were developed to mitigate existing and future potential threats to human health and the environment:

- *Prevent human exposure to groundwater contaminants released from Devens landfills that exceed acceptable risk thresholds.*
- *Protect human and ecological receptors from exposure to landfills soils having concentrations of contaminants exceeding acceptable risk thresholds.*
- *Prevent landfill contaminant releases to surface water that result in exceedance of ambient water quality criteria or acceptable ecological risk-based thresholds.*
- *Prevent exposure by ecological receptors to landfill-contaminated sediments exceeding acceptable risk-based thresholds.*
- *Reduce adverse impacts from contaminated landfill media to the environment that would reduce the amount of land area available for natural resource use.*
- *Support the civilian redevelopment effort at Devens (USACE, 1999).*

The approved remedial alternative documented in the ROD called for No Further Action (NFA) at Study Area (SA) 6, limited removal at SA 12 and AOC 41, and full excavation of AOCs 9, 11, and 40, and SA 13, with on-site consolidation or off-site disposal. The on-site landfill construction alternative was selected as the best value for the DCL contributor sites. The ROD included recommendations for cover system monitoring and maintenance consisting of annual site inspections, mowing of vegetation on the landfill cap, and additional cap inspections and/or maintenance resulting from severe weather events. The ROD also required the collection of samples from groundwater monitoring wells in accordance with 310 CMR 19.132 and the performance of five-year reviews to assess the effectiveness of the remedy.

Post-closure monitoring of the DCL is required for a minimum period of 30 years according to Massachusetts Solid Waste Management Regulations (310 CMR 19.142). However, per 310 CMR 19.142, the post-closure period waiver states that upon request a reduction in the post-closure monitoring period can be obtained if sufficient evidence is reviewed by the Massachusetts Department of Environmental Protection (MassDEP). The review will consist of, but is not limited to, a consideration of the quantity and quality of leachate generated by the landfill, ground water monitoring results, characteristics of the waste disposed, stability of the waste, design of the facility, and location of the site. If the information presented in the demonstration report or tech memo concludes that the site continues to protect public health, safety, and the environment, then a shorter period of monitoring can be implemented. Furthermore, Code of Federal Regulations (CFR) 258.61 states that post-closure monitoring can be decreased by the Director of an approved State if the owner or operator demonstrates that the reduced period is sufficient to protect human health and the environment

1.3.5 AOC 32 and 43A

The ROD for AOC 32 and 43A was signed in 1998. Per the ROD, the site-specific RAOs defining the extent of cleanup of both surface and subsurface soils, as well as, groundwater at AOC 32 and 43A are as follows:

The RAOs for surface and subsurface soils were:

- *Prevent direct and indirect contact, ingestion, and inhalation of the soil contaminated with COCs at levels that could pose risks to human and ecological receptors.*
- *Prevent erosion and migration of soil contaminated with COCs to storm sewers and surface water bodies.*
- *Prevent COC migration to the groundwater at levels that could adversely affect human health and the environment.*

The RAOs for groundwater included the following:

- *Prevent off-site migration of COCs at levels that could adversely affect flora and fauna.*
- *Prevent lateral and vertical migration of COCs at levels that could adversely affect potential and existing drinking water supply aquifers.*
- *Prevent seepage of groundwater from AOC 32 and 43A that could result in surface water concentrations in excess of ambient water quality standards (Horne, 1998).*

The ROD detailed remedies for both soil and groundwater. The selected ROD soil remedial alternative is excavation and off-site disposal. The major components of this selected remedy include "excavating contaminated soil, immediately transporting soils to an off-site, nonhazardous landfill for disposal, backfilling the excavated area with clean material and revegatating the area, monitoring groundwater on an annual basis and reviewing the site every 5 years for 30 years until contamination is reduced to acceptable concentrations". The selected ROD groundwater remedial alternative is "monitored natural attenuation". The major components of the selected groundwater remedy include establishing land use controls, "installing additional monitoring wells, providing for monitored natural attenuation, collecting data on monitored natural attenuation, assessing the data, and performing groundwater modeling, performing long-term monitoring on an annual basis, reviewing the site every 5 years for 30 years or until contamination is reduced to acceptable concentrations and providing reports to USEPA and MassDEP".

The ROD for AOCs 32 and 43A specifies that MCLs are the groundwater cleanup goals at the site. The MCLs are consistent with Federal MCLs and State of Massachusetts GW-1 standards that are included in the Massachusetts Contingency Plan (MCP).

1.3.6 Grant Housing and 37-mm Impact Area

The ROD for the Grant Housing Area and 37-mm Impact Area was signed in September 2009. Per the ROD, the site-specific RAO is to prevent direct contact with unexploded ordnance (UXO) that may remain in the soil at the sites.

The selected remedy for both the Housing Area and 37-mm impact area is the implementation of LUCs. The LUCs provide a blueprint for how the property should be used in order to maintain the level of protectiveness intended by the remedial alternative. The LUCs for Grant Housing Area include: (1) public education to property owners, residents, as well as any construction and/or utility contractors conducting ground intrusive activities on the property. The intent is to provide education on the potential presence of UXO, how to identify UXO, and what actions to take if suspect UXO is encountered; and (2) a deed notice will be inserted by MassDevelopment into any Grant Housing Area deeds stating that the property with the LUCs is suitable for proposed future us, that there is no evidence of additional UXO present at the site, but that the possibility does remain that UXO could be discovered in the future. On an annual basis, the Army will also conduct annual reviews to confirm the overall effectiveness and compliance with the established LUCs (Weston, 2009). The LUCs are addressed in a Land Use Control Implementation Plan (LUCIP) that was developed following approval of the ROD. Both sites have a residual UXO risk due to their previous use as a firing range. There is no environmental sampling or monitoring activities associated with these sites. The LUCIP requirement to provide access restriction by placing a fence around the former 37-mm Impact Area and associated signage was accomplished in 2012. Additional LUC requirements are presented in Section 4 of this LTMMP.

1.3.7 South Post Impact Area

The ROD for the SPIA sites was signed in July 1996 documenting "No Action" as the final selected remedy for the SPIA monitored-area and AOC 41 groundwater. "No Action" is also the selected remedy for surface water, soil, and sediment at the EOD, Zulu, and Hotel Ranges. Under the "No Action" remedy, no formal remedial action is taken and the site is considered to be left "as is," with no additional institutional controls, containment, removal, treatment or other mitigating measures. Because "No Action" was selected and approved as the remedy, a FS was not performed and RAOs were not developed.

As part of the remedy, Fort Devens ensures the following in the ROD:

- *Groundwater monitoring for potential contaminant migration out of the SPIA monitored-area will continue: (1) Monitoring wells will be used to monitor the groundwater from the EOD Range, Zulu Ranges, Hotel Range, and AOC 41; (2) Monitoring wells will be used to monitor the north, northeast, southeast, and east sides of the SPIA monitored-area.*
- *Monitoring wells will be sampled for explosives, target compound list (TCL) organics, and target analyte list (TAL) metals.*
- *A groundwater monitoring plan for the South Post will be developed that will include detailed groundwater monitoring at discharge points. The plan may include installation of additional monitoring wells to monitor for off-site groundwater flow.*
- *Well D-1 will be sampled and samples will be analyzed for explosives and Massachusetts and federal drinking water requirements (MMCLs/MCLs).*
- *The Army will not develop new drinking water sources within the SPIA monitored area.*
- *An Integrated Natural Resource Management Plan (INRMP) will be developed and implemented to monitor adverse effects on the ecosystem in the SPIA monitored area.*
- *Monitoring reports will include a description of site activities and a summary of analytical results. The Army will submit these reports annually. If there is an indication of contamination emanating from the SPIA monitored-area, the Army will evaluate the need for additional assessment.*
- *As required by CERCLA, the site will be subject to five-year reviews to assess if the No Action remedy remains protective of human health and the environment (Horne, 1996).*

The groundwater analytical results at SPIA are compared to the MCP GW-1 and GW-3 standards for comparison purposes only, as the criteria are not considered "clean-up" standards under a "No Action" ROD.

1.3.8 Sudbury Annex

The ROD for the Source Control of the Operable Unit (OU) at AOC A7 was signed in September 1995 and the ROD for Management of Migration was signed in September 1997. Per the ROD, the following RAOs were developed to mitigate existing and future potential threats to public health and the environment:

- *Eliminate potential risk to human health and the environment associated with exposure to contaminated wastes;*
- *Minimize off-site migration of contaminants; and,*
- *Limit infiltration of precipitation to the underlying waste within the landfill area, thereby minimizing leachate generation and groundwater degradation (OHM, 1995).*

The remedy selection for the source control OU for AOC A7 was the installation of an impermeable landfill cover system that met RCRA Subtitle C requirements. The landfill remedy also included the following:

- removal and off-site disposal of chemical waste debris in the laboratory dump area;
- operations and maintenance (O&M);
- LUCs and land use restrictions to limit future use of land at AOC A7;
- long-term groundwater monitoring; and
- five-year reviews to assess whether the remedy remains protective of human health and the environment.

A remedy was also selected by the Army to create a wetland at AOC A7 in the fall of 1996 to replace "Wetland B", a seasonal wetland that is now incorporated as part of the landfill. Wetland B was classified as a natural resource area under the Massachusetts Wetlands Protection Act Regulations (MWPAR), as an "Isolated Land Subject to Flooding". Based on size (40 by 60 feet [ft], or 2,400 ft^2), Wetland B was not subject to regulation under the MWPAR. Nonetheless, the decision to replace Wetland B was made in accordance with the USACE policy of "No Net Loss of Wetlands" and the requirements of Army Regulation 200-3 (Natural Resources - Land, Forest and Wildlife Management).

2.0 LONG-TERM MONITORING AND MAINTENANCE PROGRAM

This section provides a summary of the current LTMM program implemented at the Devens and Sudbury sites, and summarizes the recommended optimization strategy for the individual sites where optimization is appropriate based on changes in site conditions or progress made towards achieving the goals stated in the particular site's ROD. The attached **Appendix A** Optimization Evaluation provides a more detailed discussion of the rationale for the selected optimization approach and is not reproduced within this section; however, the Army's rationale for implementing LTM optimization can be summarized by the following:

- The LTM sites do not pose a risk to human health and the environment based on the lack of an exposure pathway. This is based on the fact that LUCs are in place; in addition, historical groundwater monitoring data indicate that the concentrations of COC are either stable, or in most cases, steadily declining since monitoring inception.
- The LTM site conditions (as established by prior removal actions), remaining source/groundwater COCs concentrations, and current and historical monitoring data do not indicate (and are not conducive to) any significant contaminant migration beyond the boundary of the monitoring networks.

The recommended changes to the monitoring well network and/or sampling frequency of wells within a particular site's monitoring program, where indicated, are based on the need to properly define plume extent and/or monitor changes in the plume composition over time. Wells were selected for elimination if the sampling point/data collected from the sampling point was determined to not add value to the monitoring program. The frequency of monitoring was reduced at other wells where frequent monitoring did not enhance the site's data set and the groundwater from a particular well had established a defined concentration trend and did not show evidence of rapid contaminant or geochemical variations between sampling events. Other wells were selected for reduced sampling frequency where data have shown little change over time but data from the particular well would help to confirm plume delineation. A statistical analysis of data trends was performed through the MAROS program. The analysis supported the proposed changes where reduction in frequency was recommended.

2.1 CURRENT AND PROPOSED CHANGES TO THE LONG-TERM MONITORING AND MAINTENACE PROGRAM

The following sections provide a summary of the current LTM program at each respective AOC followed by a summary of the recommended changes to the current program. The recommended changes are based on the optimization evaluation performed for the Devens and Sudbury LTM programs (**Appendix A**).

2.1.1 AOC 57

2.1.1.1 Current Program

Groundwater and surface water at AOC 57 (**Figures 1.2a and 1.2b**) are sampled annually. Wells sampled as part of the LTM program include Area 2 wells (57M-03-02X, 57M-03-03X, 57M-03-04X, and 57M-03-05X) and Area 3 wells (57M-95-03X and 57M-96-11X). Depth to water is also measured in the following vicinity wells, piezometers and well points that were not sampled:

57M-03-01X, 57M-03-06X, 57M-95-05X, 57M-95-06X, 57M-95-07X, 57M-96-10X, 57M-96-12X, 57M-96-13X, 57P-98-03X, 57P-95-04X, 57WP-06-02 and 57WP-06-03. In addition to the well sampling and depth to water monitoring activities, the four groundwater sumps located at Area 2 are visually inspected for petroleum sheen or the presence of a light non-aqueous phase liquid (LNAPL). No petroleum sheen, LNAPL, or petroleum odor was observed within the sumps during recent LTM activities.

Two surface water locations are sampled at Area 2 on the fringe of the marsh close to the edge of the former removal action excavation limit. One surface water location is sampled at Area 3 on the downstream edge of the former excavation area.

2.1.1.2 Recommended Changes to Current Program

- Use HydraSleeve™ technology to perform groundwater sampling at Area 3.
- Reduce surface water sampling to every 5 years at Area 3 to coincide with the five-year review and eliminate VOCs from the COC list.
- Reduce groundwater sampling to every 5 years at Area 3 to coincide with the five-year review and eliminate VOCs from the groundwater and COC list. Discontinue sampling of surface water and groundwater from all wells at Area 2.
- Decommission sumps at Area 2.
- Prepare technical memorandum for AOC 57 presenting site specific information that supports justification for site closure, and path forward.

2.1.2 AOC 69W

2.1.2.1 Current Program

Sampling is conducted on an annual basis at AOC 69W (**Figure 1.3**). The annual fall sampling event consists of collecting eight groundwater monitoring well samples, one groundwater field duplicate sample, and one groundwater well point sample. Wells ZWM-95-17X and ZWM-01-26X were previously removed from the list of sampled wells as part of the LTM program optimization, although both wells are purged to collect geochemical parameters during LTM events. The collected groundwater samples are analyzed for volatile petroleum hydrocarbons (VPH), EPH, and dissolved metals (arsenic, iron, and manganese) with the exception of the sample from well point 69WP-08-01, which is analyzed for dissolved manganese only. Well point 69WP-08-01 was added to the LTM program in 2008 due to an exceedance of groundwater manganese criteria in downgradient monitoring wells. Elevated dissolved metals, including manganese, is anticipated and is due to reducing conditions resulting from hydrocarbon degradation. The metals dissolution is self-limiting once the hydrocarbon source is mitigated and is not expected to migrate a significant distance beyond the original hydrocarbon release point. Future LTM will determine if this detection is indicative of manganese migration from the source area. Additionally, the Army installed a well point in 2013 to further characterize the area downgradient for manganese. This well point, 69WP-13-01, was first sampled during the fall 2013 LTM event.

2.1.2.2 Recommended Changes to Current Program

- Eliminate VPH (carbon ranges and target analytes) from the LTM program.
- Prepare technical memorandum for AOC 69W presenting site specific information that supports conditions defined within the MCP revision for petroleum release sites, justification for site closure, and path forward.

2.1.3 AOC 43G

2.1.3.1 Current Program

Eight monitoring wells (four source wells and four sentry wells) at AOC 43G (**Figure 1.4**) are sampled for benzene, toluene, ethylbenzene, xylenes (BTEX), VPH, iron, and manganese on an annual basis in the fall. Source wells include AAFES-2, AAFES-6R, XGM-93-02X, and XGM-97-12X. Sentry wells include AAFES-5, XGM-94-04X, XGM-94-07X, and XGM-94-08X. Monitoring well AAFES-6R was installed in January 2006 as a replacement for monitoring well AAFES-6, which had become damaged and was abandoned in January 2006. AAFES-7 was added to the LTM program in 2010 as a downgradient sentry well to determine if dissolved metals, specifically manganese, were migrating off site. The recent (2012) LTM event revealed a manganese detection in groundwater at well AAFES-7. This detection is likely the result of a well-established reducing groundwater environment that is low in dissolved oxygen (DO) and high in turbidity, generating a more soluble and mobile metal molecule. The basewide Conceptual Site Model indicates metals dissolution and limited migration is an expected byproduct of hydrocarbon degradation within this and similar petroleum release sites. If another exceedance is noted in the fall of 2013, further evaluation will be necessary to assess the potential for off-site manganese migration. The groundwater velocity in this area is approximately 29 ft per year, which indicates that off-site migration will not occur prior to the collection, analysis, and evaluation of manganese data from the fall 2013 sampling of well AAFES-7.

2.1.3.2 Recommended Changes to Current Program

- Based on results of the MAROs Mann-Kendall analyses of manganese concentration trends discontinue sampling AAFES-5 (only exceedance was in 1999), AAFES-6R (decreasing), XGM-94-07X (stable) and XGM-94-08X (decreasing).
- Reduce TAL for metals (remove manganese) and VPH (removed C9-C10 Aromatics) analyses for "alternate" year annual sampling events (CY2015, CY2017, etc.)
- Non-alternate year (CY2014, CY2016, etc.) annual sampling events will continue with current full TAL for both metals and VPH. Use HydraSleeve™ technology to perform groundwater sampling at AOC 43G.
- Prepare technical memorandum for AOC 43G presenting site specific information for reclassification of groundwater from GW-1 to GW-3, justification for site closure, and path forward.

2.1.4 Devens Consolidation Landfill

2.1.4.1 Current Program

Current LTM and landfill O&M activities at DCL (**Figure 1.5**) include annual landfill gas vent monitoring, semi-annual groundwater sampling, monthly O&M of the leachate pump station, semi-annual well gauging, and annual landfill cap inspections. Eleven landfill gas vents are monitored annually, four groundwater monitoring wells are sampled semi-annually, seven monitoring wells are gauged semi-annually, and leachate discharge is sampled annually, as part of the current LTM program for the DCL.

Additionally, MassDevelopment correspondence dated July 29, 2009, discussed the most recent changes to the LTM program that included eliminating the requirement to sample cyanide, aluminum, heptachlor, phenol, and total petroleum hydrocarbons from the new landfill discharge permit. The annual DCL leachate sampling is still to be completed between October 1, and December 31, each year, with the self-monitoring reports due to MassDevelopment by January 5, the following year.

The following analytes are monitored yearly:

1.) Metals including: arsenic, chromium (total), cadmium, copper, lead, nickel, silver, zinc, and mercury;

2.) Total suspended solids (TSS);

3.) Total toxic organics (the sum of VOCs, semi-volatile organic compounds [SVOC], pesticides and PCB); and

4.) pH.

2.1.4.2 Recommended Changes to Current Program

- Evaluate the feasibility of modifying the leachate collection and recovery system (LCRS) to allow discharge on-site to groundwater instead of to the MassDevelopment sewer system via a technical memo. If deemed feasible, obtain state regulatory approval for the modification per the appropriate state regulatory procedures (310 CMR 19.000 and 314 CMR 5.000). Discharge of leachate to groundwater on site would, per 40 CFR 261.4 (b) (15) (iv), be subject to federal regulation under sections 307 (b) or 402 of the Clean Water Act. Once approved, perform an engineering redesign of the LCRS to allow for on-site discharge. An ESD would be prepared following the approval of the modification to the LCRS.
- Revise the LTM frequency from semi-annually to annually (fall event) after demonstrating that discharge of leachate to ground surface is not impacting groundwater.

2.1.5 AOC 32 and 43A

2.1.5.1 Current Program

The current sequence of semi-annual long-term groundwater sampling at AOCs 32 and 43A (**Figure 1.6**) was initiated in the spring of 2002. Groundwater at AOC 32 is sampled during the spring LTM and fall performance monitoring events. Wells sampled during the spring LTM event include: 32M-01-13XBR, 32M-01-14XOB, 32M-01-14XBR, 32M-01-15XBR, 32M-01-16XBR, 32M-01-17XBR, 32M-01-18XBR and 32Z-99-02X. The fall sampling event (non-LTM) includes wells 32M-01-13XBR, 32M-01-15XBR, 32M-01-16XBR, 32M-01-17XBR, and 32M-01-18XBR. No AOC 43A wells are sampled due to a lack of contaminant exceedances in the 43A series wells since 2002; however, depth to water measurements are collected from six AOC 43A wells during the LTM sampling and an additional 19 AOC 32 wells to determine groundwater flow patterns across the site. Site reviews are conducted every 5 years to ensure that the remedy continues to provide adequate protection of human health and the environment.

2.1.5.2 Recommended Changes to Current Program

- Discontinue the fall performance monitoring event.
- Reduce the number of monitoring wells sampled during the primary spring event to the following four wells: 32M-01-13XBR, 32M-01-17XBR, 32M-01-18XBR and 32M-01-14XOB. Three of the four wells were sampled during the fall performance monitoring event.
- Reduce frequency of site-wide depth to water collection to a final site-wide event prior to the 2015 five year review.
- Decommission all non-LTM program monitoring wells west of the groundwater divide after the final site-wide gauging event.
- Remove the EPH carbon ranges from the COC list.
- Use HydraSleeve™ technology to collect groundwater samples.
- Prepare technical memorandum for AOCs 32 and 43A presenting site specific information for reclassification of groundwater from GW-1 to GW-3, justification for site closure, and path forward.

2.1.6 Grant Housing Area and 37-mm Impact Area

2.1.6.1 Current Program

The LUCIP for Grant Housing Area and 37-mm Impact Area (**Figure 1.7**) was finalized in May 2011. The requirement for restricting access to the former 37-mm Impact Area by erecting a fence was completed in 2012. The annual LUC inspection will be performed in the fall of 2013 and annually thereafter.

2.1.6.2 Recommended Changes to Current Program

None.

2.1.7 Devens South Post Impact Area (SPIA)

AOC 26 at the SPIA (**Figures 1.8 through 1.10**) is currently under additional investigation to determine the extent of a potential perchlorate release. Additional changes to the current program, beyond those stated below, may be required following the completion of the investigation. Also, periodic, off-cycle and non-LTM well perchlorate sampling has been performed at AOC 26 to monitor the perchlorate exceedance at AOC 26. The non-LTM sampling is performed on an as-needed basis and is not incorporated within the LTM program.

2.1.7.1 Current Program

LTM activities are performed annually (AOC 26, South Post Monitoring [SPM], and D-1) and biennially (AOC 27) in the fall. A total of 16 groundwater monitoring wells, 4 well points, and 1 drinking water well/hydrant are sampled in association with the SPIA LTM event. SPIA sampling includes:

- Five wells and four well points at AOC 26;
- Four wells at AOC 27;
- Seven SPM wells (including AOC 41 well 41M-93-04X); and
- Drinking water well/hydrant D-1.

Groundwater from four wells and two well points at AOC 26 and four wells at AOC 27 are analyzed for explosives and total metals. In addition, two wells (26M-92-04X and 26M-10-09X) and four well points (26WP-06-01, 26WP-08-02, 26WP-09-01 and 26WP-09-02) at AOC 26 are sampled for perchlorate. In addition to the samples collected from the AOCs, groundwater samples are collected from seven SPM wells and one drinking water well that are not associated with an AOC. Groundwater from the SPM wells are analyzed for explosives and total metals. SPM well 41M-93-04X samples were analyzed for VOCs and explosives. Drinking water well D-1 is sampled annually for explosives; however it is also sampled annually by USACE on an independent basis for metals, wet chemistry, and perchlorate. Nashoba Analytical, LLC of Ayer, MA, is the contracted laboratory that processes the samples. Water levels are gauged prior to five year reviews at AOC 25. No other LTM related activities are performed at AOC 25.

2.1.7.2 Recommended Changes to Current Program

- Discontinue metals analyses for well points 26WP-06-01 and 26WP-08-02.
- Add perchlorate analysis for existing LTM sampling program monitoring wells 26M-92-02X, 26M-92-03X, 26M-97-08X and SPM-93-06X.
- Add explosives and metals analyses for existing LTM sampling program monitoring well 26M-10-09X.
- Remove well 41M-93-04X from the SPM sampling network but retain this well for five year gauging events.
- Decommission all monitoring wells at AOC 41 except for well 41M-93-04X.

2.1.8 Sudbury Annex

During the recent 2012 LTM event at Sudbury Annex (**Figure 1.11**) well JO-A07-M62 was found to be damaged and could not be used for groundwater sampling. This well was likely displaced by a snowplow and is not repairable. Groundwater from well OHM-A7-10 was subsequently sampled as a one-time substitute for JO-A07-M62 based on its similar screened zone elevation and proximity relative to other potential locations. A new well point, SUDWP-A07-01, was installed for the 2013 fall LTM event and is located approximately 15 to 20 ft downgradient (northwest) of damaged well JO-A07-M62. OHM-A7-10 will revert back to its status as a "LTM water level only" location for all future LTM events.

2.1.8.1 Current Program

The current program is conducted in accordance with the 2009 Sudbury LTMMP and includes annual sampling of six groundwater monitoring wells for VOCs, organochlorine pesticides, TAL metals and mercury, total cyanide, and chemical oxygen demand (COD) according to the reduced testing program approved by the USEPA and MassDEP. In addition, depth to water is measured at all of the monitoring wells and at two staff gauge surface water locations. The AOC A7 RCRA cap and the surrounding area are monitored on an annual basis through visual inspections and field monitoring performed with landfill gas detection equipment. A passive gas venting system consisting of four 6-inch diameter gas vents is monitored during the cap inspections for methane, carbon dioxide, oxygen, lower explosive limit (LEL) and total VOC levels. Landfill maintenance is also perform annually and includes: lawn mowing, clearing of debris from fence line, and ensuring the toe drain, as well as the riprap areas, are clear of moss and particulates. If necessary, herbicide is applied to areas encroached with invasive vegetation. The 2011 FYR for the Sudbury landfill recommended establishing performance metrics per Interstate Technology and Regulator Council (ITRC) guidance. Because there is no active or passive remediation in progress at the landfill, the performance metric will consist of evaluating the annual LTM data against established COC trends. The landfill also will be evaluated for transition from Post-Closure Care to Custodial Care per the ITRC guidance. Additionally, the Army and USEPA agreed upon criteria to reduce sampling frequency and analyses and number of compliance monitoring locations, as detailed in Section 2.9.2.2 of Appendix A.

2.1.8.2 Recommended Changes to Current Program

- Remove metals analyses from the fall 2016 LTM program via a recommendation in the next five-year review report, scheduled to be completed in 2016.
- Remove well OHM-A7-51 from the LTM sampling program based on the last groundwater analytical exceedance documented in October 2003 (PCE) and a compliance point, per 310 CMR 19.132 (2), is located hydraulically downgradient (SUD-AO7-065).
- Remove well OHM-A7-09 from the LTM sampling program based on no historical groundwater analytical exceedances and a compliance point, per 310 CMR 19.132 (2), is located hydraulically downgradient (SUDWP-AO7-01).

- Continue sampling upgradient monitoring well SUD-A07-14 on an annual basis and revise sampling frequency to biennial, based on no groundwater analytical exceedances. The sampling frequency will be revisited after the next five-year report (CY2016).
- Continue sampling OHM-A7-08 and SUD-A07-065 on an annual basis until the next five-year review and revise sampling frequency to biennial if a downward trend is maintained.
- Continue sampling new well point SUDWP-A07-01 on an annual basis. The sampling frequency will be revisited as an evaluation point during the next five year review.
- Change the collection frequency of landfill gas monitoring from annually to every 5 years, prior to the five-year report.
- Utilize global positioning system (GPS) coordinates and a GPS unit to locate surface water gauges during the annual sampling event.

3.0 SAMPLING AND ANALYSIS PLAN FOR GROUNDWATER AND SURFACE WATER

This section constitutes a project-specific sampling and analysis plan and was prepared in accordance with the guidelines set forth in the USACE Engineer Manual (EM) *EM200-1-2, Technical Project Planning Guidance for HTRW Data Quality Design* (USACE, 1995); *EM 200-1-3, Requirements for the Preparation of Sampling and Analysis Plans* (USACE, 2001); and USEPA, Region 1, *Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells* (USEPA, Region 1, 2010). The sampling activities described in this section are based on the 2008 LTMP (HGL, 2008) and recommendations included in the attached Optimization Evaluation for LTMM document (**Appendix A**).

3.1 OBJECTIVES

The following subsections were developed to ensure that data quality objectives specific to this project are met; field sampling protocols are implemented, documented and reviewed in a consistent manner; and data collected are scientifically valid and defensible.

3.2 MONITORING WELL SAMPLING

Based on recommendations within the Optimization Evaluation (**Appendix A**) and CY2013 discussions specific to SPIA site AOC 26, groundwater samples from the following number of monitoring wells will be collected at the given frequency per site.

- Sample two monitoring wells every 5 years during the spring LTM event at AOC 57 (Area 3).
- Sample eight monitoring wells and two existing well points annually during the fall LTM event at AOC 69W.
- Sample five monitoring wells annually during the fall LTM event at AOC 43G.
- Sample 12 monitoring wells and four well points annually during the fall LTM event at AOC 26/SPM Well Network (SPIA).
- Sample four monitoring wells biennially during the fall LTM event at AOC 27 (SPIA).
- Sample four monitoring wells semi-annually during the fall LTM event at DCL (revise frequency to annual after it is demonstrated that leachate discharge to the ground surface is not impacting groundwater).
- Sample four monitoring wells annually during the spring LTM event at AOCs 32 and 43A.
- Sample four monitoring wells annually during the fall LTM event at Sudbury (A7).

Procedures for collecting samples from groundwater monitoring wells are discussed in Section 3.10. Groundwater monitoring wells selected for LTM and the rationale for their selection are presented in **Table 3.1**. Groundwater monitoring wells were typically selected to confirm the absence or presence of COCs at downgradient locations or to document the anticipated decrease in COCs over time within source areas at each AOC. Historical groundwater sampling results also were used to select groundwater monitoring wells for LTM. Recovered groundwater samples will be transferred to the appropriate sample bottles for each analytical method, labeled according to Section 3.10.1, and placed in a cooler with ice prior to delivery or shipment to the fixed-laboratory (see **Section 3.11.3**). The following subsections provide additional information regarding groundwater monitoring well sampling.

3.2.1 Area of Contamination 57

Area 2 groundwater monitoring wells (57M-03-02X, 57M-03-03X, 57M-03-04X, and 57M-03-05X) and Area 3 groundwater monitoring wells (57M-95-03X and 57M-96-11X) are included in the current LTM sample program for AOC 57. For the revised LTM sample program Area 2 monitoring and sampling activities will no longer be conducted, based on the LTM program recommendations provided in the attached Optimization Evaluation (**Appendix A**). Additionally, the Optimization Evaluation (**Appendix A**) recommends that the frequency of Area 3 LTM sampling and monitoring be revised from annual to every 5 years, sampling methods be revised (low-flow to HydraSleeve™ technology) and VOCs analysis be removed from the surface water COC list. **Figure 1.2b** identifies the locations of groundwater monitoring wells that are included in spring LTM sample event within Area 3. **Table 3.2** lists the locations that will be sampled and the sample methods to be used during the LTM sample event.

3.2.2 Area of Contamination 69W

Groundwater monitoring wells 69W-94-13, 69W-94-14, ZWM-95-15X, ZWM-95-18X, ZWM-99-22X, ZWM-99-23X, ZWM-99-24X and ZWM-01-25X are included in the current LTM sample program for AOC 69W. In addition to the existing wells, as recommended in the Optimization Evaluation (**Appendix A**), a well point was installed downgradient of 69WP-08-01 to characterize manganese. The new well point, 69WP-13-01, was sampled for dissolved metals during the fall 2013 LTM event and will be sampled during subsequent LTM sample events. In addition, monitoring wells 69W-94-12 and ZWM-95-16X, piezometers ZWP-95-01X, and ZWP-95-02X, and the Willow Brook piezometer will be gauged for the depth to water during LTM sample events. **Figure 1.3** identifies the location of groundwater monitoring wells that are included in fall LTM events in AOC 69W. Groundwater quality parameters are recorded while monitoring wells ZWM-95-17X and ZWM-01-26X are purged for the stabilization of groundwater quality parameters, but samples for laboratory analyses are not collected. Specific groundwater quality parameters to be recorded are discussed in Section 3.9.2. **Table 3.3** lists the locations that will be sampled and the sample methods to be used during LTM events (VPH carbon ranges analysis has been removed per an Optimization Evaluation recommendation).

3.2.3 Area of Contamination 43G

Groundwater monitoring wells AAFES-2, AAFES-5, AAFES-6R, XGM-93-02X, XGM-94-04X, XGM-94-07X, XGM-94-08X, XGM-97-12X and AAFES-7 are included in the current LTM sample program for AOC 43G. The Optimization Evaluation (**Appendix A**) recommendation for future LTM events consists of discontinuing sampling at four wells (AAFES-6R, AAFES-5, XGM-94-07X and XGM-94-08X) and revising field sampling methods (switch from low-flow methods to HydraSleeve™ technology). **Figure 1.4** specifies the location of groundwater monitoring wells that are included in fall LTM sample events at AOC 43G. **Table 3.4** lists the locations that will be sampled and the sample methods to be used during LTM sample events.

3.2.4 Devens Consolidation Landfill

Groundwater monitoring wells LFM-99-02B, LFM-99-05A, LFM-99-06A, and LFM-03-07 are included in the current sampling program for the DCL. In addition, monitoring wells LFM-99-01B, LFM-99-03B, and LFM-99-05B are gauged for the depth to water. The Optimization Evaluation (**Appendix A**) recommends the frequency of DCL groundwater monitoring be reduced from semi-annual to annual after demonstrating that leachate discharge to the ground surface has not impacted groundwater. **Figure 1.5** specifies the location of DCL groundwater monitoring wells. **Table 3.5** lists the locations that will be sampled and the sample methods to be used during the fall LTM sampling event.

3.2.5 Areas of Contamination 32 and 43A

Groundwater monitoring wells 32M-01-14XOB, 32M-01-14XBR, 32M-01-13XBR, 32M-01-15XBR, 32M-01-16XBR, 32M-01-17XBR, 32M-01-18XBR, and 32Z-99-02X are included in the current annual LTM sample program for AOCs 32 and 43A (April/May). Monitoring wells 32M-01-18XBR, 32M-01-13XBR, 32M-01-15XBR, 32M-01-16XBR and 32M-01-17XBR are included in the current annual persulfate injection performance monitoring event (October/November). The Optimization Evaluation (**Appendix A**) recommendations for future AOCs 32 and 43A LTM events consist of discontinuing the fall performance monitoring event, reducing the spring LTM event list of wells sampled to four wells (32M-01-13XBR, 32M-01-18XBR, 32M-01-17XBR and 32M-01-14XOB), reducing site-wide gauging from annual to every 5 years, removing the VOC chlorobenzene and EPH carbon ranges from the COC list and revising field sampling methods (switch from low-flow methods to HydraSleeve™ technology). **Figure 1.6** identifies the location of monitoring wells that are included in annual spring LTM event at AOCs 32 and 43A. **Table 3.6** lists the locations that will be sampled and the sample methods to be used during spring LTM sample event.

3.2.6 Grant Housing Area and 37-mm Impact Area

No environmental sampling is required at this site.

3.2.7 South Post Impact Area

Groundwater monitoring wells 26M-92-02X, 26M-92-03X, 26M-92-04X, 26M-92-08X and 26M-10-09X, and well points 26WP-06-01, 26WP-08-02, 26WP-09-01 and 26WP-09-02, are included in the current annual sampling program for AOC 26. Well points 26WP-08-02, 26WP-09-01, 26WP-09-02 and 26WP-09-03 were installed in 2008 to 2009 in the downgradient area of AOC 26. Monitoring well, 26M-10-09X, installed in 2010, is also located in a downgradient location of AOC 26. The Optimization Evaluation (**Appendix A**) recommendation for future AOC 26 LTM events consists of discontinuing metals analyses for wells points 26WP-06-01 and 26WP-08-02. Additional analyses were added for four existing LTM sampling monitoring wells and two existing LTM sample well points based on CY2013 AOC 26 discussions. The revised LTM sampling program is detailed in **Table 3.7** and depicted in **Figure 1.9**. Well point 26WP-09-03 is not included in **Table 3.7** because it was installed for the sole purpose of groundwater elevation monitoring.

Groundwater monitoring wells 27M-92-01X, 27M-93-05X, 27M-93-06X, and 27M-93-08X are included in the biennial sampling program for AOC 27. No changes to the monitoring program were recommended in the Optimization Evaluation (**Appendix A**).

In 2007, AOC 41 groundwater monitoring wells 41M-94-09A, 41M-94 -09B, 41M-94-11X, 41M-94-12X, 41M-94-13X, and 41M-94-14X were removed from the annual sampling program in accordance with recommendations included in the Final LTMP (HGL, 2008) and the approval of the USEPA Region 1 and the MassDEP. Due to the exceedance of the 5 µg/L GW-1 standard for trichloroethene (TCE) in 2006, AOC 41 monitoring well 41M-93-04X was incorporated into the annual SPM sampling program in 2007. The Optimization Evaluation (**Appendix A**) recommends the removal of SPM well 41M-93-04X from the LTM program. The SPM network monitoring wells remaining in the LTM sampling program include SPM-93-06X, SPM-93-08X, SPM-93-10X, SPM-93-12X, SPM-93-16X, SPM-97-23X, SPM-97-24X, and Hydrant D-1. The SPM wells are sampled to monitor for contaminants outside of individual AOCs. In addition, a number of other SPIA monitoring wells are gauged for the depth to water once every 5 years to re-evaluate general groundwater flow patterns; however, the AOC 41 wells are recommended for decommissioning with the exception of well 41M-93-04X.

The wells that are included in the 5-year review SPIA gauging network include:

- AOC 25 monitoring wells (EOD-1, EOD-2, EOD-3, EOD-4, 25M-92-05X, 25M-92-06X, 25M-92-07X, 25M-92-08X, 25M-93-09X and 25M-93-10X).
- AOC 26 monitoring wells (26M-92-01X, 26M-92-05X, 26M-92-06X, 26M-92-07X.
- AOC 27 monitoring wells (27M-92-02X, 27M-92-03X, 27M-92-04X, 27M-93-07X, 27M-93-09X, and 27M-93-10X).
- AOC 41 monitoring wells (41M-92-01X, 41M-93-02A, 41M-93-02B, 41M-94-02C, 41M-93-03X, 41M-93-05X, 41M-94-03B, 41M-94-06X, 41M-94-07X, 41M-94-08A, 41M-94-08B, 41M-94-10X, 41M-94-09A, 41M-94-09B, 41M-94-11X, 41M-94-12X, 41M-94-13X, and 41M-94-14X).
- South Post Monitoring wells (SPM-93-02X, SPM-93-03X, SPM-93-05X, SPM-93-07X, SPM-93-09X, SPM-93-11X, SPM-93-13X, and SPM-93-15X).

Figure 1.8 specifies the location of groundwater monitoring wells that are included in fall LTM sample events within the SPIA. **Figures 1.9 and 1.10** have close-up views that identify the location of groundwater monitoring wells at AOCs 26 and 27, respectively. The locations that will be sampled and the sample methods to be used during SPIA sampling events, with and without the sampling of AOC 27 wells, are presented in **Table 3.7**.

3.2.8 Sudbury Annex (AOC A7)

Groundwater monitoring wells OHM-A7-08, OHM-A7-09, OHM-A7-51, JO-A07-M62, SUD-A07-014 and SUD-A07-065 are included in the current LTM sample program for Sudbury Annex (A7). These wells were sampled during LTM sampling events conducted from 2009 through 2011. During the fall 2012 LTM sample event, a slight modification to the current LTM program was made when it was discovered that JO-A07-M62 was damaged and could not be sampled. OHM-A7-10 was sampled in fall 2012 based on its similar screen elevation and proximity, relative to other potential locations, to damaged well JO-A07-M62. This was an one-time sampling event for OHM-A7-10, a new well point was installed in CY2013 to replace JO-A07-M62. The new well point, SUDWP-A07-01, was sampled as part of the 2013 fall groundwater sampling event. OHM-A7-10 will revert back to its designation as "LTM water level only" well. The Optimization Evaluation (**Appendix A**) recommends removing metals analyses from LTM program via a recommendation in the next five-year review report; removing wells OHM-A7-51 and OHM-A7-09 from the LTM sampling program after the next five year review; continued sampling of wells OHM-A7-08 and SUD-A07-065 on an annual basis until the next five-year review and revise sampling frequency to biennial if a downward trend is maintained; continued sampling of well SUD-A07-14 on an annual basis with a revision of the sampling frequency to biennial following the next five-year review; continued sampling of new well point SUDWP-A07-01 on an annual basis until a trend is established; reduce performing landfill gas monitoring from annually to every 5 years;; and collecting coordinates for surface water gauges with a GPS unit. Procedures for collecting samples from groundwater monitoring wells are discussed in Section 3.9. Groundwater monitoring wells selected for LTMM and the rationale for their selection are presented in **Table 3.1**. Recovered groundwater samples will be transferred to the appropriate sample bottles for each analytical method, labeled according to **Section 3.10.1**, and placed in a cooler with ice prior to delivery or shipment to the fixed-laboratory (see **Section 3.11.3**). The following paragraph provides additional information regarding groundwater monitoring well sampling.

AOC A7 groundwater monitoring wells (OHM-A7-08, OHM-A7-09, OHM-A7-11, OHM-A7-46, OHM-A7-51, JO-A07-M62, SUD-A07-014 and SUD-A07-065) were included in the LTMM sample program for AOC A7 prior to CY2008. Groundwater monitoring wells OHM-A7-11 and OHM-A7-46 were removed from the sampling program in 2009 but were retained for groundwater level measurements. New well point, SUDWP-A07-01, was installed in CY2013 to replace damaged well JO-A07-M62. Monitoring wells OHM-A7-10, OHM-A7-12, OHM-A7-45, OHM-A7-52 and JO-A07-M61 are also gauged for the depth to water during LTMM sample events. The location of groundwater monitoring wells that are included in fall LTMM sample events within AOC A7 are identified in **Figure 1.11**. The locations that will be sampled and the sample methods to be used during LTMM sample events are listed in **Table 3.8**.

3.3 SURFACE WATER SAMPLING

The current LTM sampling program has surface water samples collected from three surface water locations within Areas 2 and 3 of AOC 57 during LTM sample events. The Optimization Evaluation (**Appendix A**) recommendations for future LTM events at AOC 57 includes the discontinuation of LTM events at Area 2, discontinuation of VOCs analysis and reduction of sampling frequency from annual to every 5 years at Area 3. Based on this recommendation, no surface water samples will be collected at Area 2 and only the single surface water sample at Area 3 will be collected and analyzed for dissolved metals. Discreet grab samples will be collected as close to the bottom as possible without allowing bottom sediment to enter the sampling chamber. Discreet grab sampling methodology is preferred over composite samples because compositing can mask the presence of contaminants by diluting isolated concentrations of analytes that may be present in the sample. Surface water sampling will be performed in accordance with the procedures specified in Part C.3.4.2 of USACE EM200-1-3, *Requirements for the Preparation of Sampling and Analysis Plans*, 2001; (excerpts provided in **Appendix B**).

Dissolved metals samples will be collected with a peristaltic pump to facilitate field filtering of the samples. The Area 3 surface water sample location is depicted on **Figure 1.2b**. **Table 3.1** lists the surface water locations that will be sampled and the sample method to be used during LTM sample events.

The recovered surface water samples will be transferred to the appropriate sample bottles for each analytical method, labeled according to Section 3.10.1 and placed in a cooler with ice prior to delivery or shipment to the fixed-laboratory according to Section 3.11.3.

3.4 LEACHATE SAMPLING

The DCL discharges industrial wastewater to the Devens Sewerage System in accordance with an Industrial Discharge Permit granted by MassDevelopment. The permit legally binds the DCL effluent to meet the specified permit conditions. Leachate sampling takes place annually in October/November and the results are submitted to the MassDevelopment utilities manager by January 5th of the following year. Leachate discharge quantities are generally declining over time and have significantly decreased since the construction of the landfill cap. The leachate samples will be labeled according to Section 3.10.1 and placed in a cooler with ice prior to delivery or shipment to the fixed-laboratory according to Section 3.11.3. Leachate sample methods are presented in **Table 3.9** and permit discharge limits are presented in **Table 3.10**.

3.5 LANDFILL GAS VENT MONITORING

A passive gas venting system was installed at the DCL and Sudbury to facilitate the ventilation of any methane generated from the degradation of waste material beneath the landfill cover system.

The passive system for DCL consists of eleven 6-inch diameter gas vents integrated into the geocomposite gas collection layer immediately beneath the 40-mil very flexible polyethylene geomembrane. Screens were installed at the end of each vent pipe to prevent access by birds or other animals. Field monitoring is performed at the landfill gas vents for hydrogen sulfide, carbon dioxide, VOCs, carbon monoxide, oxygen, methane and LEL levels. A LandTec GEM 500 GA-90 or equivalent gas monitor is typically used to monitor the gas vents for methane, carbon dioxide, oxygen, and LEL. A Thermo 580B photoionization detector (PID) or equivalent is typically used to monitor VOC levels. Lastly, an Industrial Scientific TMX 412 CGI or equivalent is typically used to monitor hydrogen sulfide, carbon monoxide, oxygen, and LEL readings.

The passive system for Sudbury consists of four 6-inch diameter gas vents. Gas vent locations are depicted on **Figure 1.11**. Screens were installed at the end of each vent pipe to prevent access by birds or other animals. Field monitoring is performed at the landfill gas vents for carbon dioxide, oxygen and methane. Barometric pressure is also measured. A LandTec GEM-500 or equivalent gas monitor is typically used to monitor the gas vents. Landfill gas parameters are collected by inserting the monitoring equipment intake tube into the landfill gas vent and recording the parameter values after 1 to 2 minutes. The monitoring equipment intake tube is inserted past the landfill gas vent elbow to ensure that the parameters are reflective of landfill gas and not ambient air.

3.6 SAMPLING FREQUENCY SUMMARY

Based on the Optimization Evaluation (**Appendix A**) recommendations LTM sample events will be performed annually at AOC 57 (April/May), AOC 43G (October/November), AOC 26/SPM wells (SPIA) (October/November),AOCs 32 and 43A (April/May), AOC 69W (October/November) and Sudbury (A7)(October/November). AOC 27 (October/November) groundwater sampling will continue on a biennial schedule per the previously approved LTMP (HGL, 2008). DCL LTM sampling will be revised from annual to semi-annual after demonstrating leachate discharge to the ground surface is not impacting groundwater. DCL leachate sample events will be performed annually (October/November). Field monitoring of the DCL and Sudbury Annex (A7) landfill gas vents will be performed annually for DCL and every 5 years for A7. Specific analytical methods and analytes for each AOC are discussed in **Section 3.7**.

3.7 ANALYTICAL METHODS AND ANALYTES

Analytical methods and analytes utilized for LTM sample events will be in accordance with this document and the Generic Quality Assurance Project Plan (QAPP) (Sovereign and HGL, 2012b). **Table 3.11** lists the analytical parameters, sample container quantities, preservation, holding times and quality control (QC) samples required for groundwater, surface water, and leachate monitoring. The sample methods for groundwater monitoring at AOCs 57, 69W, 43G, DCL, AOCs 32 and 43A, SPIA, and Sudbury Annex are presented in **Tables 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, and 3.8**, respectively. The sample methods for leachate monitoring at DCL are presented in **Table 3.9**. Action levels to be used in the assessment of potential COC off-site migration are presented in **Table 3.12**. Background levels to be used in the assessment of potential migration of chemicals of potential concern within SPIA are presented in **Table 3.14**. Specific analytical parameters and methods to be used during LTM sample events are summarized below.

3.7.1 Groundwater Analytical Methods and Analytes

The following groundwater laboratory and field parameters will be performed or collected during LTM sample events based on the Optimization Evaluation (**Appendix A**) recommendations:

AOC 57 (Area 3):

- Total Metals (arsenic, iron, manganese) (SW-846 method 6010B and 7421 [SW6010B and SW7421]), and
- Dissolved Metals (arsenic, iron, manganese) (SW-846 method 6010B and 7421 [SW6010B and SW7421]), to be evaluated each year.

AOC 69W:

- EPH (MassDEP), and
- Dissolved Metals (arsenic by USEPA 206.2, iron and manganese by USEPA 200.7), all field-filtered.

AOC 43G:

- VPH (MassDEP), Reduce VPH (remove C9-C10 Aromatics) analyses for "alternate" year annual sampling events (CY2015, CY2017, etc.),
- Total Metals (iron, manganese), (3010A/6010B), Reduce TAL for metals (remove manganese) analyses for "alternate" year annual sampling events (CY2015, CY2017, etc.), and
- Alkalinity (2320B), to be evaluated each year.

DCL:

- VPH (MassDEP),
- EPH (MassDEP),
- Pesticides (8081A),
- ICP Metals, Total, 12-Compound TAL (6010B),
- Total Dissolved Solids (160.1),
- Anions (300),
- Nitrate/Nitrite (353.2),
- Alkalinity, Total (as $CaCO_3$),
- Cyanide (335.2),
- COD (410.4), and
- PCBs (8082), (every 5 years), immediately prior to five-year reviews.

AOCs 32 and 43A:

- VOC (SW-846 method 8260B [SW8260B]),
- VPH (MassDEP),
- Total Metals (arsenic and manganese), (3010A/6010B), and
- Dissolved Metals (3010A/6010B), to be evaluated each year.

Former Grant Housing and 37-mm Impact Area:

- None

SPIA:

- Total Metals, 23-Compound TAL (6010B),
- Explosives, 14-Compound TAL (8330), and
- Perchlorate (6860).

Sudbury Annex (A7):

- VOC (SW-846 method 8260B [SW8260B]),
- Pesticides (SW-846 method 8081A [SW8081A]),
- Total metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium and zinc) (SW-846 methods 6010B, 7421, 7841 and 7470A)(to be considered for removal during next five-year review evaluation),
- COD (410.4), and
- Cyanide (SM4500CN-CE).

Field measurements will be collected during groundwater monitoring low-flow well purging activities to compliment laboratory analytical methods. Specific parameters will include pH, temperature, specific conductance, DO, ORP and turbidity. The collection of field measurements is discussed in Section 3.10.2.

3.7.2 Surface Water Analytical Methods and Analytes

The following groundwater laboratory and field parameters will be performed or collected during LTM sample events based on the Optimization Evaluation (**Appendix A**) recommendations:

<u>Chemicals of Concern for AOC 57</u>

- Dissolved Metals (arsenic, iron, manganese) (SW-846 method 6010B and 7421 [SW6010B and SW7421]).

Field measurements will be recorded prior to the collection of surface water samples. Specific parameters to be measured will include pH, temperature, specific conductance, DO, ORP and turbidity. Parameters will be allowed to stabilize briefly before they are recorded.

3.7.3 Leachate Analytical Methods

The following groundwater laboratory and field parameters will be performed or collected during LTM sample events:

- VOC (624),
- SVOC (625),
- Pesticides with Heptachlor (8081A),
- Total Metals, 10-Elements TAL (SW-846 method 6010B),
- Total Cyanide (335.2),
- TSS (160.2),
- Total Petroleum Hydrocarbons (TPH) (8015B),

- pH,
- Total Phenol (E420.1), and
- PCBs (8082).

3.8 PRE-SAMPLING ACTIVITIES

The Groundwater Sampling Checklist presented in **Appendix C** summarizes action items that need to be performed before and during each LTM sample event to ensure that LTM tasks are completed. The following sections provide a more detailed discussion of the pre-sampling activities that will be conducted prior to the collection of water samples at each of the AOCs at the Devens and Sudbury sites.

3.8.1 Equipment and Supplies

The following equipment and supplies will be utilized in the collection of low-flow groundwater samples:

- Dedicated and non-dedicated variable speed submersible bladder pumps and Teflon®-lined tubing,
- Water level indicator,
- DO, pH specific conductance, ORP and temperature probes (within a single unit) and appropriate calibration solutions, turbidity meter (separate meter from the above unit), flow-through cell,
- Pre-cleaned sample containers, equipped with Teflon®-lined lids or septa and certified "clean" per Office of Solid Waste and Emergency Response Directive 9240.9-05,
- Sample preservation solutions,
- Decontamination supplies including isopropyl alcohol and detergent,
- VOC-free deionized water,
- 500-milliliter graduated cylinder,
- Graduated 5-gallon buckets for purge water and decontamination,
- Plastic sealable bags,
- 0.45 micron in-line filters,
- Well keys,
- Field logbook and field sampling forms,
- Chain of custody forms and seals,
- Cooler with packing material and ice to cool all samples to 4 degrees Celsius (°C), +/- 2 °C,
- Temperature blank for each cooler to be submitted to the laboratory,
- Trip blanks,

- Polyethylene sheeting, and
- Paper towels.

The following equipment and supplies will be utilized in the collection of HydraSleeve™ technology samples:

- 2-inch HydraSleeves™,
- Suspension line or tether,
- Reusable stainless steel weights with clip (dedicated to well),
- Pre-cleaned sample containers, equipped with Teflon®-lined lids or septa and certified "clean" per Office of Solid Waste and Emergency Response Directive 9240.9-05,
- Sample preservation solutions,
- Plastic sealable bags,
- Well keys,
- Field logbook and field sampling forms,
- Chain of custody forms and seals, and
- Cooler with packing material and ice to cool all samples to 4°C, +/- 2 °C.

3.8.2 Site Location, Security and Access

With the exception of AOC 43G, the SPIA, and Sudbury, where access is restricted to the general public, groundwater monitoring wells are generally located in unsecured areas. However, security of the groundwater monitoring wells is not a concern at the present time. Security measures will be enacted if evidence of tampering or suspicious damage is noted. Damage observed at sampling locations will be reported to the Army for appropriate action. Information to be reported will include a written description and photograph of each damaged sample location. Arrangements will be made to coordinate LTM activities at any groundwater monitoring wells that are located in areas whose ownership has been transferred from the Army to another entity in an effort to ensure that LTM activities are conducted in a timeframe that is acceptable to all stakeholders and the property owner. Sampling activities at the SPIA will be coordinated through the Range Control; AOC 43G sampling activities will be coordinated through the BRAC Environmental Coordinator; and Sudbury sampling activities of the wells within security fencing, will be coordinated through the property owner.

3.8.3 Initial Well Opening and Inspection

Olfactory and visual observations will be made upon opening the well casing protective cap. A PID will be used immediately to monitor the headspace of the well casing for VOCs. All observations, including any observed odors, will be documented in the logbook and on the Static Groundwater Elevation Form presented in **Appendix D**. The general condition of the protective cover, its associated concrete apron, well casing protective cap, and the well casing will be inspected and noted in the logbook. Any damage, evidence of tampering, or immediately necessary repairs will be communicated to the USACE-NAE Project Manager (PM) within 24 hours.

3.8.4 Water Level Measurements

Water level measurements will be collected at each groundwater monitoring well before purging and sampling activities are performed. Field personnel will wait approximately 1 hour after the opening of each monitoring well before water level measurements are collected to ensure that the well's water level has adequate time to equilibrate with atmospheric conditions. Water level measurements will be collected on the marked side of the riser pipe and will be accurate to the nearest 0.01 ft. Water level measurements will be collected on the north side of any riser pipe that has not been previously marked. Every effort will be made to minimize the physical disturbance of water in the monitoring wells. Water level data will be recorded on a Static Groundwater Elevation Form (**Appendix D**). The water level probe end and tape will be decontaminated before use in the first well, between each well, between sample locations, and at the conclusion of sample activities in accordance with the procedures specified in Section 3.11.4. Total well depth measurements will be collected as part of the post-sampling activities described in Section 3.11.1. In some instances, however, total well depth measurements will be collected prior to the collection of water samples if information is not available for a particular well and is necessary to facilitate the correct placement of a groundwater sample pump.

3.8.5 Well Point Installation Methodology

The following paragraphs discuss the general procedures to be used if additional well point installation is required.

Utility clearance will be obtained from Dig Safe System, Inc. (1-888-DIG-SAFE or 1-888-344-7233) at least 3 days prior to the date of the well point installation activities. The area where a well point will be installed will be pre-marked to facilitate utility clearance. Detailed information regarding the location and date of the installation activities will be provided to Dig Safe System, Inc. personnel. A reference number provided by Dig Safe System, Inc., will be recorded in the project file and made available during field activities. Dig Safe System, Inc., will be contacted again to confirm that utilities were marked and if well point installation work does not begin within 30 days of the initial call. A list of notified utilities will be made available to field personnel.

The well points will be hand-driven with a sledge hammer or slide-hammer such that the well screen is between approximately 2 and 10 ft below ground surface (bgs) or refusal, whichever comes first. A post-hole digger or hand auger will be used to dig the first 4 ft of the well point to prevent or minimize damage to utilities. The well point sections will be assembled as the well point is installed. The well point screens will be constructed with 1.25-inch diameter, factory slotted (0.010-inch) stainless steel material. Riser material will consist of new, 1.25-inch inside diameter (standard well), threaded, flush-joint, black steel material. The well point screen intervals will be between 2 and 5 ft in length and will be located in the lower section of the well point. An angular tip will be located on the bottom of the well point. The well points will be completed as a stickup with a water-tight locking cap.

Well points will be developed after their installation to open the well screen and the formation around the well. Development activities will include the use of a stainless steel bailer to surge the well and a pump to purge the well of sand and silt that is drawn through the well point screen. Water quality parameters will be measured as the well point is purged. The well point will be developed until turbidity has been significantly reduced or has reached asymptotic levels.

3.8.6 Methodology for Manganese Evaluation at AOC 43G

Evaluation activities were performed in accordance with the 2008 LTMP (HGL, 2008) at AOC 43G to address concerns expressed by the USEPA Region 1 and the MassDEP regarding the potential for the migration of manganese beyond the boundary of Army-retained property. The concerns were based on exceedances of the current site-specific manganese cleanup goal of 291 μg/L in AOC 43G sentry wells. Existing wells XGM-94-06X and AAFES-7 were sampled for total manganese in 2008 and 2009. Sampling results indicated an exceedance of the manganese standard at XGM-94-06X but not AAFES-7. Based on manganese not migrating beyond AAFES-7 it was added to the annual LTM sampling program for total manganese analyses by SW-846 Method 6010B; however, manganese was observed for the first time above the manganese standard at AAFES-7 during the October 2012 LTM event.

Additional sampling for manganese at AAFES-7 will be conducted to confirm the exceedance. If the confirmation sampling results indicate that manganese has migrated past the AAFES-7, an additional monitoring point will be installed downgradient to monitor for manganese in groundwater. This point would be added to the LTM program for AOC 43G..

3.8.7 Methodology for Manganese Evaluation at AOC 69W

Based on the exceedance of manganese observed at 69WP-08-01, the Optimization Evaluation (**Appendix A**) recommended the installation of a well point/well downgradient of this location to characterize manganese in groundwater. A new well point, 69WP-13-01, was installed in 2013 and was first sampled during the fall 2013 LTM event.

3.9 SAMPLING PROCEDURES

3.9.1 Equipment Calibration

Some equipment that will be used during the LTM event will require periodic calibration to ensure optimum performance, including a PID, a LandTec GEM-500, a YSI 600XL water quality meter, and a Lamotte 2020 turbidimeter. This equipment will be calibrated in accordance with manufacturer's instructions before its initial use at the site and at the beginning of each work day thereafter. The equipment calibration also will be checked at the conclusion of each work day. Calibrations and the end of the day drifts will be documented on log sheets included in **Appendix D**. The calibration procedure for the LandTec GEM-500 is included in **Appendix H**.

3.9.2 Low-Flow Well Purging

Each groundwater monitoring well will be purged in accordance with the USEPA Region 1 Guidance Document titled *Low Stress (low-flow) Purging and Sampling Procedure for the Collection* *of Ground Water Samples from Monitoring Wells* (USEPA, Region 1, 2010), included as **Appendix E**, prior to sampling unless sampled via HydraSleeve™ technology. The goal of low-flow purging and sampling is to remove stagnant water from the well and collect representative samples at near ambient conditions. A dedicated or properly decontaminated, submersible, low-flow pump will be used to purge the wells. Dedicated teflon-lined tubing will be used during purging and sampling activities.

The depth to water will be measured with a water level indicator in accordance with Section 3.8.4 prior to installing the submersible pump in the well. Caution will be exercised to minimize disturbance of the well water. The submersible bladder pump will be placed into the well gently such that the intake will be located in the middle or slightly below the middle of the screened interval to ensure that most of the water will be pumped directly from the formation.

A properly calibrated water quality parameter probe will be fitted into the flow-through cell provided with the instrument with the included mounting hardware. The line from the in-well submersible pump will be attached to the barbed hose fitting on the bottom of the flow-through cell. A spigot will be attached to the line from the in-well submersible pump prior to the flow-through cell for the purpose of collecting turbidity samples. A drain line will be attached to the top fitting of the flow-through cell to direct the effluent to a bucket.

The depth to water will be remeasured to account for any water level variations caused by the placement of the submersible bladder pump. The pre- and post-pump placement measurements will be recorded on the field sampling form and in the field logbook. Flow rates of 0.1 to 0.5 liters per minute (L/min) will be used for purging. The pump will be operated at a flow rate where minimal drawdown occurs during purging. The goal of low-flow purging is for the drawdown to be less than or equal to 0.3 ft.

Water quality measurements will be used as the basis for establishing the stabilization of the well water. Well stabilization parameters will include pH, specific conductance, temperature, ORP and turbidity. Turbidity samples must be collected from a spigot placed on the sample tubing prior to the flow-through cell and measured with a stand-alone meter. The parameters will be measured every 3 to 5 minutes until stabilization of all parameters is achieved. Stabilization has been reached when pH measurements remain constant within 0.1 standard unit, specific conductance is constant within 3percent (%), the temperature is constant within 3%, ORP is constant within 10 millivolts and the turbidity is either constant within 10% for values above 5 Nephelometric Turbidity Units (NTU) or below 5 NTUs for three consecutive readings. All measurements will be tabulated for comparison on the Groundwater Field Sampling Data Sheet (**Appendix D**). Observations such as odors, water color or the appearance of soil particles or iron floc will also be recorded on the Groundwater Field Sampling Data Sheet. Final measurements will be recorded in the sampling logbook.

If the water level drops more than the goal of 0.3 ft during purging, additional measures such as reducing the purge flow rate, will be enacted to reduce drawdown. These activities will be documented. Purging will continue until well stabilization parameters stabilize, the water level drops to the screened interval for wells with shorter screened intervals, or until the water level drops to the top of the pump for wells with longer screened intervals that encompass the pre-purging groundwater level. If the water level drops to the top of the pump or the screened interval, purging will be stopped and up to 24 hours will be allowed to pass for the well to recharge. The well will be sampled using low-flow sample collection procedures although it will not be purged and it will not be necessary for field parameters to stabilize.

It should be noted that two of the current LTMM program wells at the Sudbury Annex, OHM-A7-08 and OHM-A7-51, have screen intervals that are 15-ft long, which is greater than the 10-foot guideline referenced in the USEPA Region 1 guidance document. These wells will be purged until a minimum of three screen volumes are pumped from the well, or until purging has been conducted for a minimum of 2 hours. A notation will be made on the Groundwater Field Sampling data sheet if samples are collected when water quality parameter stabilization or purge volume criteria have not been met.

3.9.3 HydraSleeve™ Installation

HydraSleeve™ samplers will be installed a minimum of 2 weeks prior to collecting groundwater samples to allow for equilibration with the aquifer. The complete HydraSleeve™ assembly will be constructed off site prior to installation based on a previously determined design specific to each monitoring well. Information used in the design includes depth of well, depth of water, screen interval and lengths of various HydraSleeve™ components (HydraSleeve™, weights, custom length suspension tether). After opening each monitoring well, the HydraSleeve™ sampler assembly will be lowered slowly to depth and then tied off at the top of the well. The well would then be secured during the interim prior to collecting groundwater samples. Additional details on HydraSleeve™ installation are included in the SOP within the Optimization Evaluation (**Appendix A**).

3.9.4 Sample Containers and Preservatives

Laboratory provided sample containers will be used during LTM events. Sample containers will not be reused. The laboratory will pre-preserve sample containers as appropriate for the analysis to be performed. Field personnel will conduct a visual check to ensure that pre-preserved sample containers contain preservative. Field personnel will either use a replacement container or add the appropriate preservative if it observed that containers needing preservative are not pre-preserved. A summary of the sample containers, preservation, and holding times for water samples are presented in **Table 3.11**.

3.10 SAMPLE COLLECTION

Dedicated and non-dedicated variable speed submersible bladder pumps will be used to collect samples from groundwater monitoring wells not sampled via HydraSleeve™ technology. The objectives and methods for this procedure are described in USEPA's Region 1 Guidance Document entitled *Low Stress (low-flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells* (USEPA, Region 1, 2010) that is presented in **Appendix E**. The goal of sampling monitoring wells is to provide groundwater quality data that is representative of actual aquifer conditions with minimal alteration caused by inappropriate or variable sampling techniques. Typically, flow rates of 0.1 to 0.5 L/min are used; however, this is dependent on site-specific hydrogeology (USEPA, 2010).

Once groundwater quality parameters have stabilized, groundwater samples will be collected directly from the tubing connected to the pump. The sampling flow rate will be the same flow rate that was used during the purging process to maintain equilibrium between the well and the formation. The flow-through cell will be bypassed or disconnected during the collection of samples. Sample containers will be filled by allowing water from the pump to gently enter the containers with minimal disturbance. Sampling will begin with the VOC portion of the sample and continue with other portions of the sample. Once full, containers will be stored in a cooler and placed on ice immediately. All samples will be labeled as described in Section 3.10.1 and immediately placed in a cooler with ice to maintain a sample temperature of approximately 2 to 6 °C.

Monitoring wells with HydraSleeve™ samplers installed will be sampled after a minimum of 2 weeks has elapsed since their installation. The wells will be opened and a water level will be recorded prior to removing the HydraSleeve™ sampler. Removal of the HydraSleeve™ will consist of pulling the suspension tether in one constant motion at a rate of 1-foot/second (or greater). Once the HydraSleeve™ sampler is full, the upper check valve will close and prevent water above the sampled zone from entering the sampler. Upon retrieval of the HydraSleeve™ sampler any trapped water above the check valve will be discarded and a new disposable discharge tube will be used to puncture the HydraSleeve™ sampler to collect groundwater samples within various analytical sample bottles. The minimal volume collected via HydraSleeve™ samplers will be less than the sample container volumes detailed within **Table 3.11** but is sufficient to allow laboratory analyses to be completed. Additionally, groundwater quality parameters will not be collected from HydraSleeve™ samplers due to the limited volume of groundwater collected. The loss of water quality measurements is not significant based on the sites being mature with a large historical dataset of groundwater quality parameters. Additional details on HydraSleeve™ retrieval and sampling protocols are included in the SOP within the Optimization Evaluation (**Appendix A**).

3.10.1 Sample Identification

All samples will be assigned a unique sample identifier. Field personnel will generate a label for each sample container that will contain the sample identifier, date and time of sample collection, the sampler's initials, analytical parameters, and type of preservation used. The sampler will initial any change in the label information prior to the sample collection.

A sample numbering system will be used to identify each sample collected and submitted for analysis. The purpose of the numbering system is to assist in the tracking of samples and to facilitate retrieval of analytical results. The sampling number will be used on sample labels, sample tracking forms, chain of custody forms (**Appendix D**), field logbooks, and for other applicable documentation. The field sample numbering system will follow the format used for previous LTM events. The sample identification (ID) for groundwater monitoring wells will be the name of the particular groundwater monitoring well. Similarly, the sample ID for surface water samples will be the name of the surface water location name. Duplicate sample IDs will specify the AOC from which the sample was collected without revealing the parent sample ID to the laboratory. Matrix spike (MS)/matrix spike duplicate (MSD) sample IDs will be indicative of the parent sample ID. Examples are listed below:

Sample Location:	**Sample ID:**
AOC 69W Monitoring Well ZWM-99-22X	ZWM-99-22X
AOC 57 Surface Water Location SW1	57-AREA 3-SW1
SPIA AOC 26 Blind Duplicate from Monitoring Well 26M-92-04X	26M-Dup1
DCL Matrix Spike from Monitoring Well LFM-99-02B	LFM-99-02B-MS
AOC A7 Monitoring Well OHM-A7-08	OHM-A7-08
Blind Duplicate from Monitoring Well OHM-A7-51	A7-Dup1
Matrix Spike from Monitoring Well OHM-A7-51	SUD-A07-065-MS

3.10.2 Quality Assurance/Quality Control Samples

Quality assurance (QA)/QC samples will be collected during each LTM event. The following sub sections specify the type and quantity of samples to be collected for QA/QC purposes.

3.10.2.1 Duplicate Sample

Field duplicate samples will be collected and submitted for analysis in conjunction with all analyses associated with primary field samples. Field duplicates are additional samples subjected to the same collection methods, preparation and analysis as the original sample but are identified with a unique identification number so that they are blind to the laboratory. These samples will be used to evaluate the precision of sample collection, field sample preparation and laboratory analysis. Blind field duplicates will be collected and analyzed at a frequency one per AOC for all analyses. Locations will be determined in the field and duplicate samples will be collected concurrently with field samples. The planned numbers of duplicates are listed in **Tables 3.2, 3.3, 3.4, 3.5, 3.6, 3.7,** and **3.8**.

3.10.2.2 Rinsate Blank

Sampling methods called for in this plan include the use of both dedicated and non-dedicated sampling equipment. Therefore, some gauging or sampling equipment will be used in more than one well and will require decontamination between uses. In these cases, rinsate blanks will be prepared and submitted for analysis to determine the potential for cross-contamination from the sampling equipment. Rinsate blanks will be prepared at a frequency of one per AOC per LTM event. Rinsate blanks are prepared by decontaminating the field equipment according to the procedure specified in **Section 3.11.4**, followed by pumping distilled water through the submersible pump and capturing the rinsate water in a sample bottle.

3.10.2.3 Trip Blank

Trip blanks will be submitted to the laboratory in conjunction with VOC samples. Trip blanks are used to identify the potential for contamination associated with sample shipment, containers, and storage to affect the samples in a shipment. Alpha Analytical will prepare trip blanks in the laboratory by filling preserved volatile organic analyte (VOA) vials with American Society for Testing and Materials (ASTM) Type II water and ship them to the field. A set of trip blanks is included in each cooler containing samples for VOC or VPH analysis and returned to the laboratory with the environmental samples. Once prepared by the laboratory, trip blanks are not opened. The expected number of project trip blanks per AOC is listed in **Tables 3.3, 3.6,** and **3.8**.

3.10.2.4 Matrix Spike/Matrix Spike Duplicates

MS/MSD samples will be submitted for all analyses in conjunction with primary field samples. Results from MS/MSD samples will be used to evaluate the potential for sample matrix interferences versus laboratory analytical errors as well as to assess the accuracy of the analysis. MS/MSD samples will be collected at a frequency of one per AOC for all analyses. Samples from MS/MSD locations will have a total of three times the standard volume collected. MS/MSD sample locations are listed in **Tables 3.2, 3.3, 3.4, 3.5, 3.6, 3.7,** and **3.8**.

3.11 POST-SAMPLING ACTIVITIES

3.11.1 Total Well Depth Measurement

The total depth in each well will be measured and recorded following the collection of groundwater samples. Bladder pumps are narrow enough to allow total depth measurement in wells with dedicated bladder pumps without removing the pumps. Every effort will be made to minimize the physical disturbance of water in the monitoring wells. Water level data will be recorded on a Groundwater Field Sampling Data Sheet (**Appendix D**). The total depth measurements will be used to evaluate potential well screen failure or the need for well development. The water level probe end and tape will be decontaminated before use in the first well, between each well, between sample locations, and at the conclusion of sample activities in accordance with the procedures specified in Section 3.11.4.

3.11.2 Chain of Custody

Sample custody will be maintained at all times. A sample is considered to be in custody under the following situations:

- The sample is directly in your possession;
- The sample is clearly in your view;
- The sample is placed in a locked location; and
- The sample is in a designated secure area.

If an overnight courier is used, adhesive custody seals will be used to demonstrate that the samples and coolers have not been tampered with during shipment. The custody seals will be placed across the cooler lids in such a manner that they will be visibly disturbed upon opening of the cooler. The seals will be initialed and dated by field personnel when affixed to the container and cooler.

Documentation of the chain of custody of the samples is necessary to demonstrate that the integrity of the samples has not been compromised between collection and delivery to the laboratory. A chain of custody record to document the transfer of custody from the field to the laboratory will accompany each sample cooler. All information requested in the chain of custody record will be completed. If samples are shipped by an overnight courier, the air bill number assigned by the overnight courier will be listed on the chain of custody record or the general logbook. One copy of the custody form will be retained by the samplers and placed in the project records file. The remaining pages will be sealed in a plastic bag and placed inside the cooler. Upon receipt at the laboratory, the chain of custody forms will be completed and a cooler receipt form will be completed (**Appendix D**). It is the responsibility of the laboratory to document the condition of custody seals and sample integrity upon receipt.

3.11.3 Sample Delivery/Shipment to Laboratory

Sample containers will be placed inside sealed plastic bags as a precaution against cross-contamination caused by leakage or breakage. Bagged sample containers will be placed in insulated coolers with bubble wrap or other wrapping to eliminate the chance of breakage during delivery or shipment. Ice in plastic bags will be placed in the coolers to keep the samples between 2 and 6 °C throughout storage and shipment.

Sample delivery or shipment will be performed in strict accordance with all applicable U.S. Department of Transportation regulations. The samples will be transported from the site to the laboratory by laboratory personnel or shipped to the laboratory by an overnight courier service. Arrangements will be made between the Sovereign team and the contract laboratory point-of-contact for samples that are to be delivered to a laboratory on a weekend so that holding times and cooler temperatures are not compromised.

3.11.4 Equipment Decontamination

Equipment or supplies that cannot be effectively decontaminated (e.g., sample tubing or rope) will be disposed of after sampling, if not dedicated. Gauging/sampling equipment will be decontaminated at the site before use, between sampling locations, and after its last use at the site. Decontamination of field equipment will be noted in the project logbook. If it is necessary to make decontamination procedural changes in the field, the changes will be noted in the logbook. Otherwise, a notation will be made each day that decontamination was conducted as specified in the project documents. Procedures for decontaminating sampling equipment that may be used at the Devens site will be conducted in accordance with guidance specified in USEPA Region 1, 2010, *Low Stress (low-flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from the Collection of Ground Water Samples from Monitoring Wells*; and is summarized below:

Groundwater gauging equipment and non-dedicated sampling equipment and materials will be decontaminated using the following procedure:

- Potable water flush immediately after use.
- Detergent scrub with brushes (Liquinox or equivalent detergent). The solution will be changed periodically.
- Potable or deionized water flush to remove all detergent solution. The solution will be changed periodically.
- Light spray down with pesticide-grade isopropyl alcohol. For LTM events conducted subsequent to the spring 2006 event, if equipment blank data from the previous sample event show that the level of contaminant is insignificant, this step may be skipped.
- Distilled/deionized water flush. The water will not be recycled.
- Air dry.

- Cover with aluminum foil (if not to be used immediately).

The water level probe and tape will be decontaminated by the above referenced procedure; substituting air drying with drying the probe tape with a clean paper towel. Equipment that cannot be adequately cleaned will be discarded.

3.11.5 Investigation-Derived Waste

This section identifies the methodology for the handling, sampling, and disposal of investigation-derived waste (IDW). All IDW will be handled in a manner consistent with USACE and USEPA guidance for managing IDW for Site Investigations (SI) (USEPA, 1992) and applicable Federal and state regulations. IDW to be generated will include:

- Decontamination water,
- Well purge water, and
- Personal protective equipment (PPE).

The primary source of IDW will be well purge water and decontamination water. Visual and olfactory observations will serve as the initial screening of well purge water for possible contamination. Additionally, purge water will be screened with a PID using standard headspace screening procedures listed below:

- Purge water will be placed in glass containers and the container will be covered with aluminum foil and capped.
- Purge water will stabilize at a temperature of approximately 20˚C for approximately 45 minutes.
- The container lid will be removed and the PID probe will be inserted through the aluminum foil cover to measure the VOC concentration in the container's headspace.

If PID screening and visual/olfactory observations do not indicate possible contamination in the purge water, it will be poured onto the ground in the area of monitoring well. Contaminated purge water is identified as ≥ 10 parts per million from PID, petroleum sheen, or strong odor and will be containerized in Department of Transportation approved 55-gallon drums or other approved containers. All drums and containers shall be labeled "UNCLASSIFIED-WASTE ANALYSIS PENDING." In addition, the following information shall be included on the waste label:

- Well number,
- Sovereign's point of contact and telephone number (Philip McBain, 508-339-3200),
- HGL's point-of-contact and telephone number (Peter Dacyk, 518-877-0390),
- Devens/Sudbury site point-of-contact and telephone number (Robert Simeone, 978-796-2205),
- SPIA point-of-contact and telephone number (James C. Chambers, 978-796-2565), and
- Description of the container's contents.

IDW drums will be transported to a secure storage area to be determined by the BRAC Environmental Coordinator and/or USACE Contracting Officer Representative. IDW will be characterized for disposal and subsequently disposed of off site when three to four drums have been filled or at a minimum of once per year.

IDW will be characterized for disposal as non-hazardous or hazardous waste if contamination has been observed by the methods above. **Table 3.15** summarizes the various components of IDW sampling procedures and rationale. Disposable drum thieves or bailers will be used to collect samples from IDW drums. Sampling documentation will follow the protocols detailed in Section 3.11 of this document. When three to four drums have been filled or at a minimum of once each year, one composite waste characterization sample will be obtained from the IDW drums and analyzed to determine whether the IDW meets the definition of a hazardous waste according to 40 CFR 261. IDW water sampling will include one sample for RCRA VOCs, SVOC, pesticides, herbicides and metals. The sample also will be analyzed for ignitability, corrosivity, cyanide, sulfide, and mercury.

In general, the following procedures will be used to dispose of IDW:

- RCRA non-hazardous wastes (except disposable equipment and PPE) will be disposed of on-site when possible. Liquid wastes, such as monitoring well purge water from uncontaminated areas, will be poured onto the ground in the area of the monitoring well.
- RCRA non-hazardous and decontaminated disposable equipment and PPE will be double bagged and placed inside a dumpster for disposal.
- IDW that is characterized as RCRA hazardous waste will be disposed of at an appropriate licensed hazardous waste disposal facility in accordance with applicable Federal, state and local regulations.

All emptied drums will be removed from the site by Sovereign or its subcontractors. All required manifests for waste disposal will be completed by Sovereign and signed by a site environmental representative. Site representatives will be given a 72-hour notice prior to any waste hauling activity. Sovereign or its subcontractor will be on site during all waste removal activities. The site's point-of-contact will be provided with an original and three copies of all manifests, destruction/disposal documents, and any analytical results within 30-day of disposal. Waste manifests will be signed by the site point-of-contact.

3.11.6 Data Validation

Data validation is a process in which analytical data generated by the laboratory are evaluated against a specific set of requirements and criteria, and appropriate qualifications are applied, if necessary, according to the usability and limitations of the data. Validation examines the analytical data from four perspectives, as follows:

- Technical requirements;
- Contractual requirements;
- Determination of compliance; and

- Determination and action of how to define the usability or qualify the data.

USEPA National Functional Guidelines (NFG) Level II validation procedures will be performed by applying, where appropriate, the acceptance criteria presented in the most current Department of Defense (DoD) *Quality Systems Manual (QSM) for Environmental Laboratories* (DoD, 2010), the Region 1, USEPA *Data Validation Functional Guidelines for Evaluating Environmental Analyses* (USEPA Region 1, 1996), and the Generic QAPP (Sovereign and HGL, 2012b). The data will be evaluated for compliance to method guidelines and the following criteria, as appropriate:

- Adherence to specified holding times and sample preservation conditions;
- Detected constituents in the field and laboratory method blanks;
- Surrogate recoveries;
- Laboratory control sample (LCS)/LCS duplicate precision and accuracy;
- MS/MSD precision and accuracy; and
- Field Duplicate precision.

According to the Generic QAPP (Sovereign and HGL, 2012b), if it is determined that USEPA NFG Level III validation is necessary due to spurious or suspicious analytical results, the data will be evaluated for compliance with the following additional items, as appropriate for the method:

- Initial and continuing calibration criteria;
- Detected constituents in the calibration blanks;
- Instrument tuning;
- Internal standard peak areas and retention times; and
- All other method-specific criteria.

The Project Chemist will review all final validation of the project data for compliance with the method-specific QA/QC guidelines for precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS) listed in the Generic QAPP and good analytical practices (Sovereign and HGL, 2012b). A more detailed discussion of the laboratory and field quality control guidelines, as well as the data validation protocols adopted by HGL and Sovereign, are presented in the Generic QAPP (Sovereign and HGL, 2012b).

3.12 FIELD DOCUMENTATION

3.12.1 Field Logbooks

During all site activities, field logbooks will be maintained to record information related to site activities, health and safety, level of protection worn and any upgrades, visitors to the site, sampling activities/locations and observations. Field logbooks will be bound volumes with sequentially numbered pages. No pages will be removed from the logbooks for any reason. If corrections are necessary, they will be made by drawing a single line through the original entry (so that original entry can still be read) and writing the corrected entry alongside it. The correction will be initialed and dated. Information to be recorded, if appropriate, will include, but is not limited to, the following:

- Project name and number,
- Arrival and departure times,
- Personnel on site and their affiliation,
- Date and time,
- Tasks for the day,
- Weather conditions,
- Site activities,
- Health and safety meetings and issues,
- Names and affiliations of visitors,
- Sample location (including field sketches, if appropriate),
- Sample number,
- Sample depth,
- Sample time,
- Number of aliquots,
- Media type,
- Air monitoring readings and equipment used,
- Sampling personnel present,
- Sampling equipment used,
- PPE level, clothing, and equipment used,
- Analyses requested,
- Sample preservation,
- Associated QC samples,
- Decontamination procedures,
- Field observations,
- Photographic records,
- Other project specific information, and
- Changes or deviations to the project scope or the procedures specified in this LTMMP.

All entries will be in ink with any corrections crossed out with a single line, initialed and dated. Each page of the logbook will be signed and dated at the bottom by each individual making an entry. The logbooks will be marked with the project number and the sequential number of the logbook (i.e., Logbook #1, #2, etc.) using indelible, waterproof ink. At the completion of field activities, the logbooks will be maintained in the permanent project files.

3.12.2 Field Sample Collection Sheets

Indelible water proof ink will be used to record data and observations on Field Sample Collection Sheets. Field Sample Collection Sheets will be maintained by sampling personnel to supplement the field logbook. An example of the field sheets to be used is provided in **Appendix E**. Copies of the sample collection field sheets will be hand delivered to the PM for review and distribution at the completion of each sampling event and will be maintained in the permanent project files.

3.12.3 Daily Quality Control Reports

Field data and pertinent QA/QC information will be recorded in Daily Quality Control Reports (DQCR) during all field activities. A sample DQCR form is presented in **Appendix D**. DQCRs will be prepared, signed, and dated by the field team leader. Copies of the DQCR sheets will be attached to annual LTM reports. If problems are encountered, HGL's PM will be notified by telephone and a copy of the relevant DQCR faxed as soon as possible for transmission to USACE's PM.

3.12.4 Photographic Documentation

A photographic record of all sampling locations will be prepared by the field team. New photographs will be obtained during subsequent LTM events only if site conditions change or new sample locations added. If film cameras are used, photographs and rolls of film will be numbered and recorded as appropriate in the field logbooks and on DQCR documentation, including identification of the subject and area photographed. Digital images will be downloaded from the digital media to the digital project files.

3.12.5 Project File

Project files will be maintained by HGL's PM and, after completion of field and analytical work will include a minimum of the following project records:

- Project plans and specifications, if any,
- Field logbooks and data records,
- Photographs, maps, and drawings,
- Sample identification documents,
- Chain of custody records (copies),
- Analytical data package from the laboratory, including QC documentation,
- Data review notes,
- References and literature,
- Report notes and calculations,

- Progress and technical reports,
- Correspondence and other pertinent information, and
- Authorizations (e.g., property access, well installation forms, etc.).

4.0 LAND-USE CONTROL IMPLEMENTATION & MONITORING PLAN

4.1 GENERAL

Key components of the remedies selected by the site-specific RODs for AOCs 57, 69W, 43G, 32 and 43A, the DCL (including contributor sites AOC 9, SA 13 and AOC 40), Grant Housing Area and 37-mm Impact Area, and Sudbury Annex (AOCs A7, P31, and P58) are LUCs . **Table 4.1** summarizes the key components of the remedies. These LUCs include preventing the use of these sites for residential purposes and preventing the use of site groundwater. The SPIA sites remain under active military use and no LUCs were established in the ROD. LUCs have been formally incorporated in the deed for transferred properties such as AOCs 32 and 43A. LUCs were incorporated into the deed for the property encompassing AOC 69W in the latter portion of 2007 to facilitate its transfer to the Francis W. Parker Charter Essential School. LUCs have not been formally incorporated into the deed for non-transferred sites such as AOC 57. In August 2007, the Army formalized LUCs and property transfer procedures for Army-retained properties such as AOC 43G and the SPIA in an addendum to the Real Property Master Plan, Long Range Component for Devens Reserve Forces Training Area, presented in **Appendix G**. The following subsections describe the methodology used to perform LUC monitoring activities.

4.2 LAND-USE CONTROL INSPECTION

Existing land use and site conditions will be assessed remotely during annual LUCs interviews with site representatives and on site during LTM events to ensure that the LUC requirements are being met. If future proposed land uses are inconsistent with the LUCs, then site exposure scenarios to human health and the environment will be re-evaluated to ensure that the selected response actions are appropriate.

4.3 INTERVIEW

Telephone interviews will be conducted with the property owner, manager or other designee familiar with the day-to-day activities at AOCs 57, 69W, 32 and 43A, DCL (including contributor sites AOC 9, SA 13 and AOC 40), 43G, the SPIA, Grant Housing Area and 37-mm Impact Area, and Sudbury Annex (AOC A7, P31, and P58). During the interviews, the representative from each site will be asked about compliance with the existing LUCs. Specifically, the following items will be discussed during the interviews:

- The representative's familiarity with the LUCs imposed upon the property and documentation of these controls;
- Changes to site use;
- Approved conditional exemptions, amendments and/or releases;
- Unauthorized use and activities;
- Review of corrective action to resolve unauthorized uses and activities;
- Overall effectiveness of the LUCs;

- Excavations (planned or emergency) that may involve soils and groundwater in AOCs 32 and 43A or Areas 2 or 3 of AOC 57. Excavations (planned or emergency) at AOC 69W that may have extended to soils below 2 ft in depth north of the school within the excavated soils management area (ESMA) delineated on **Figure 1.3**;
- The source of public drinking water for the property; and
- Proposed plans for property sale, future redevelopment and construction or demolition activities at the site.

Site-specific annual LUC checklists, including interview components, were developed in 2007 for use during LUC verification activities. Checklists for each site are presented in **Appendix G**.

4.3.1 Physical On-Site Inspection

Field personnel will perform a physical inspection of the AOCs during LTM events to determine compliance with the LUCs. The physical inspection will include the area surrounding groundwater monitoring well locations and the path or route to them. The physical inspection of each AOC will include the following items:

- An examination for evidence that groundwater extraction wells have been installed on the premises;
- An examination for evidence that no harmful exposures to the public are evident regarding soil or groundwater;
- An examination for penetrations through the pavement within the ESMA in AOC 69W;
- An examination for repaved cut marks in the pavement within the ESMA in AOC 69W that have not otherwise been identified and properly documented by the property owner;
- Any evidence of site use changes, and
- Any evidence of residential use of DCL contributor sites AOC 9, SA 13, and AOC 40.

Site-specific annual LUC checklists, including physical on-site inspection components, were developed in 2007 for use during LUC verification activities. Checklists for each site are presented in **Appendix G**.

4.4 GRANT HOUSING AREA AND 37-mm IMPACT AREA LAND USE CONTROL INSPECTION

The RAO for the Grant Housing Area is to prevent direct contact with UXO, which may remain in the soils at the site. In order to achieve this objective, LUCs were implemented to ensure that proper public education was given to property owners, residents, as well as any construction and/or utility contractors conducting ground intrusive activities on the property. An additional LUC provision stated that upon future transfer of the property from MassDevelopment, a deed notice will be provided to the new owners detailing the property's history. This notice will convey additional information about UXO investigations and removal actions conducted at Grant Housing Area as well as include the summation of the ROD that states the property is suitable for the proposed future use as long as the LUCs remain in place. The notice also will state that there is no evidence of additional UXO present at the site, but it is possible that UXO could be discovered in the future.

LUC inspections will be performed annually at the former Grant Housing Area and 37-mm Impact Area per protocols detailed within the approved LUCIP (MassDevelopment, 2011). A UXO sweep will be completed by a subcontractor over an approximate 13 acre area (10%) based on a total estimated former Grant Housing and 37-mm Impact Area of 130 acres. The inspection will be performed in the fall. The “Annual Review Checklist”, Exhibit G of the LUCIP, will be utilized to ensure full compliance with all requirements for the annual LUC inspection.

5.0 REPORTING REQUIREMENTS

Requirements for LTM reporting are discussed below and additional details are provided in the Generic QAPP (Sovereign and HGL, 2012b). Proposed changes to the LTM activities or reporting will be presented in revisions to this LTMMP.

5.1 ANNUAL DATA REPORTS

Annual reports will be prepared to summarize LTM activities and results. Reports will include a description of LTM activities, a summary of groundwater sampling results and an assessment of groundwater and surface water elevation data as applicable. Reports also will include an assessment of the potential for off-site migration and LUC inspection results as appropriate. Completed field documentation forms will be included as an appendix to each LTM report. Finally, the reports will include a discussion of any corrective actions that were necessary due to changing site conditions and/or land use. Reports will be submitted to the BRAC distribution list that includes USACE, USEPA, MassDEP, MassDevelopment, BRAC Environmental Coordinator and Restoration Advisory Board members. **Table 5.1** summarizes the sampling and reporting requirements for each AOC.

5.2 ANALYTICAL REPORTS

Groundwater analytical results will be submitted to USACE, USEPA and MassDEP within 60 days of the completion of LTM activities. The results will be summarized in a data table presenting only the detected analytes with both raw (unvalidated) and validated data, as appropriate.

5.2.1 Analytical Data Format

The report will use the Staged Electronic Data Deliverable (SEDD) format with Stage 2a or 2b deliverables to provide a uniform electronic format for submission of analytical data from the laboratory.

The SEDD electronic data files will be electronically reviewed by qualified personnel to check project data quality requirements using the USACE Automated Data Review (ADR) software. The ADR software is designed to electronically review analytical data received in the SEDD format. A comprehensive ADR LTM/Project Library file will be utilized for all of the methods that are analyzed for the LTM sites. The Library file will accurately reflect all of the analytical quality requirements as documented in the final project QAPP. The Library file will be provided to the laboratory for use in screening the electronic data deliverable (EDD) submittals.

The laboratory is required to check the integrity of the SEDD using the SEDD checker tool and check the SEDD file against the ADR Library using the Contract Compliance Screening (CCS) tool contained in ADR (Laboratory Version). EDD non-conformances generated by ADR that the laboratory is responsible for will be corrected at the laboratory, a new SEDD file resubmitted and reviewed again. The laboratory will address via a brief explanation in the Non-Conformance Log any non-conformance that is not within their control. The final SEDD XML file, final laboratory non-conformance report, and results of the automated data review in the form of ADR text files will be provided to the USACE and a Sovereign chemist for review.

5.2.2 Analytical Data Review

A data review of the SEDD XML file will be performed by importing the SEDD file into an ADR file. ADR files will be reviewed by utilizing the ADR software to check for compliance using the same ADR Library used by the laboratory. The USACE will be provided with both (1) the reviewed data from ADR in Standard ADR format (A1 through A5) as .txt files and (2) the USACE Environmental Data Management System generated database file(s) in *.mdb format incorporating current chemistry data and corresponding field data via the USACE file transfer protocol (FTP) web site, or some other mutually agreed upon means. The database file will be resubmitted to the USACE after any subsequent updates. All postings to the USACE FTP web site will be accompanied by notification to the designated USACE point-of-contact of said posting.

5.2.3 Analytical Data Submission

All electronic data submitted by the laboratory is required to be error-free, and in complete agreement with the hardcopy data. Data files are to be delivered both by e-mail and on high density CD accompanying the hardcopy data reports. The disk must be submitted with a transmittal letter from the laboratory that certifies that the file is in agreement with hardcopy data reports and has been found to be free of errors using the latest version of the ADR evaluation software provided to the laboratory. The laboratory, at their cost, will correct any errors identified by the USACE-NAE.

5.3 OTHER REPORTS

DQCR forms will be completed during LTM events by the field team leader. The DQCRs will be attached to each LTM report in an appendix with other field documentation forms, and will be forwarded to the USACE PM as soon as possible if problems are encountered in the field. Weekly sample summary reports will be prepared by the field team leader during LTM events for submittal to the USACE PM via the Sovereign PM.

6.0 HEALTH AND SAFETY

Health and safety policies, procedures, and requirements are fully documented in the Accident Prevention Plan and Site Safety and Health Plan (HGL, 2011). A designated Site Safety and Health Officer will be present for each LTM event and will be responsible for ensuring that all LTM activities are conducted in accordance with health and safety requirements.

7.0 REFERENCES

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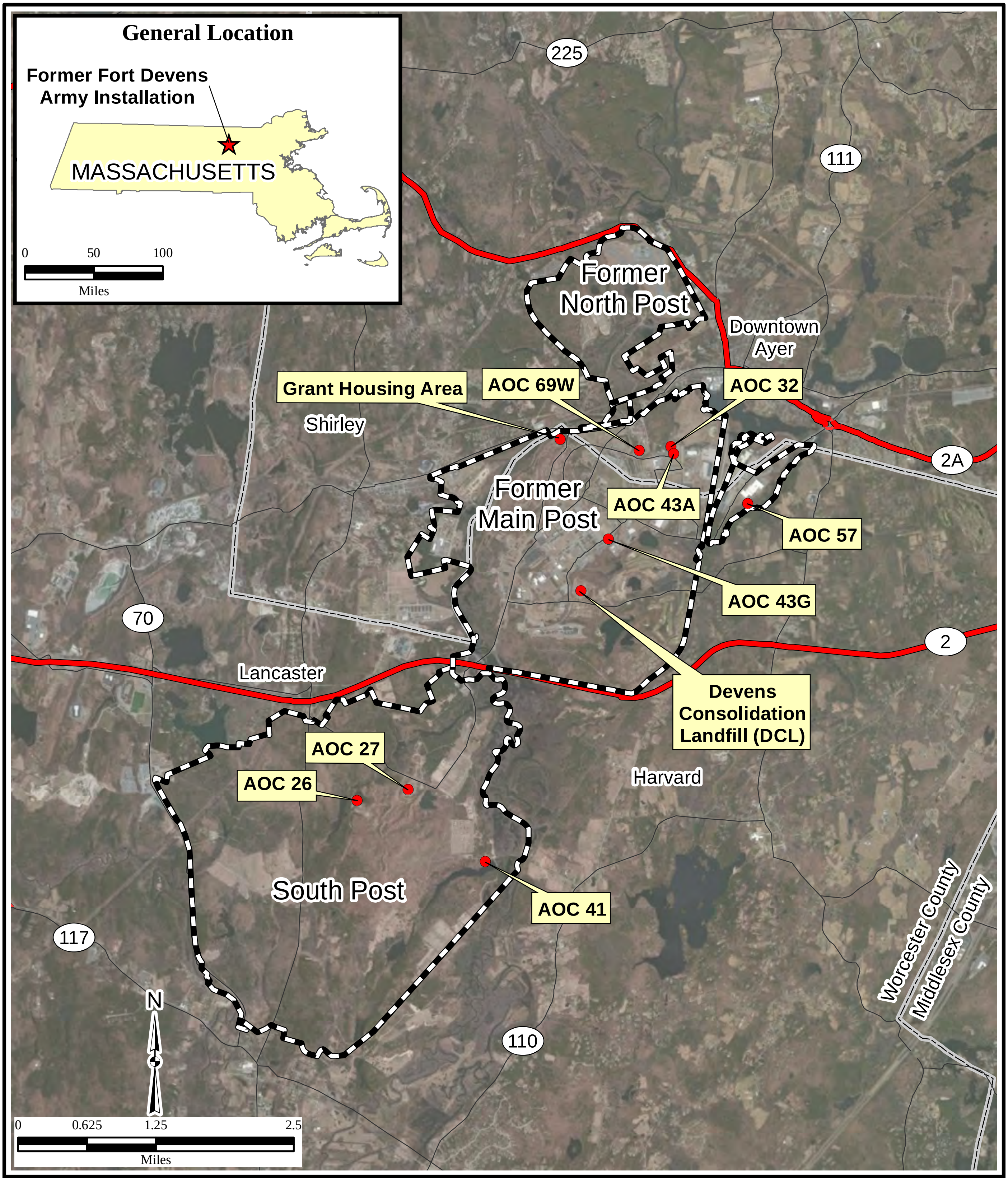
FIGURES



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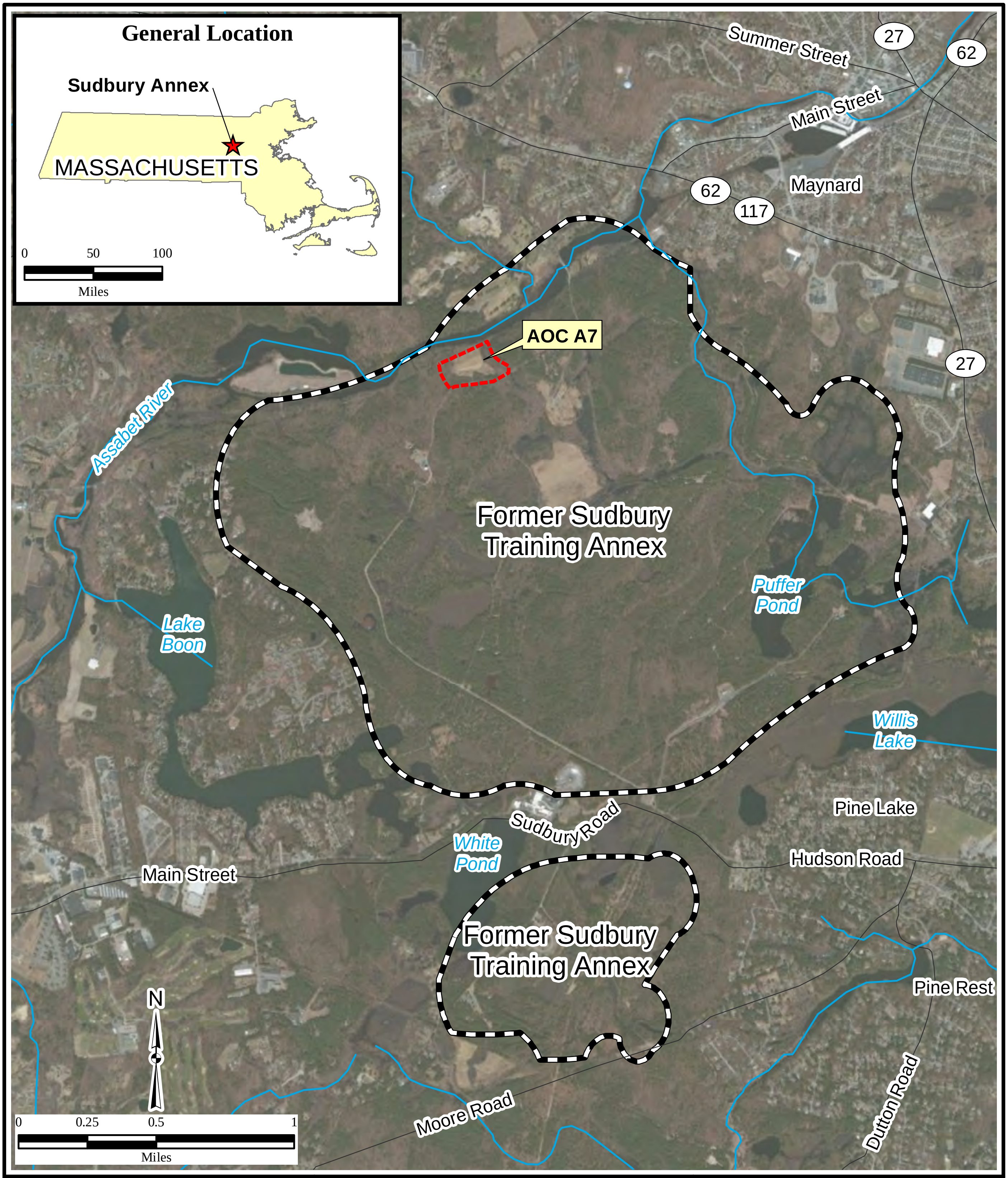
Source: HGL ESRI, USACE, www.mass.gov, ArcGIS Online Bing Maps Aerial

Legend

●	Area of Contamination (AOC)
─	Major Road
▬	Highway
‐ ‐ ‐	County Line
▭	Former Fort Devens

Figure 1.1a
Site Location
Former Fort Devens
Army Installation



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Source: HGL, USACE, ESRI,
ArcGIS Online Bing Maps Aerial

Legend

— Major Road

— Surface Water Course

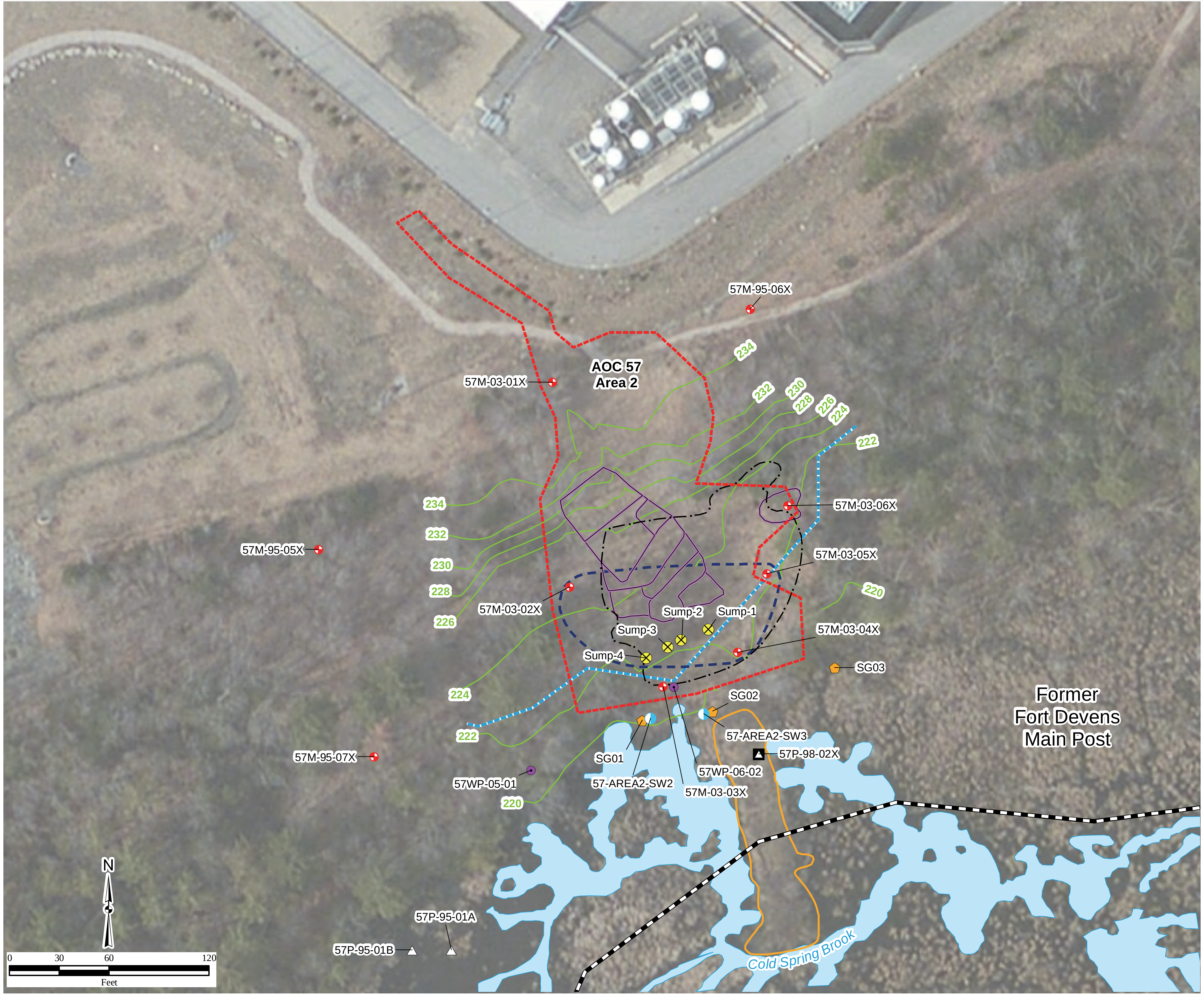
▭ Area of Contamination (AOC)

▭ Former Sudbury Training Annex

Figure 1.1b
Site Location
Sudbury Annex

Sovereign and HGL—LTMMP
Former Fort Devens Army Installation and Sudbury Annex

Figure 1.2a
Site Layout
Area of Contamination 57–Area 2



Legend

⊕	Monitoring Well
●	Well Point
△	Piezometer–Abandoned
▲	Piezometer–Presumed Destroyed
⬟	Staff Gauge
◑	Former Surface Water Sample Location
⊗	Decommissioned Sump
57M-03-06X	Well/Piezometer/Sump/Sample Location Identification
—	Final Excavation Limit (2003)
–·–	Conti Excavation Limit (2002)
—222—	Topographic Contour (ft amsl) (contour interval=2 ft)
▬ ▬	Former Fort Devens Boundary
-----	Flagged Wetland Limits
⬚	Approximate Historical Extent of Groundwater Contamination in Exceedance of Cleanup Goals (based on Fall 2003 to Spring 2011 analytical data)
☐	Containment Dam
⬚	Area of Contamination (AOC)
■	Surface Water

Notes:
Topographic contours from www.mass.gov, dated 2003.

ft amsl=feet above mean sea level
LTM=long-term monitoring

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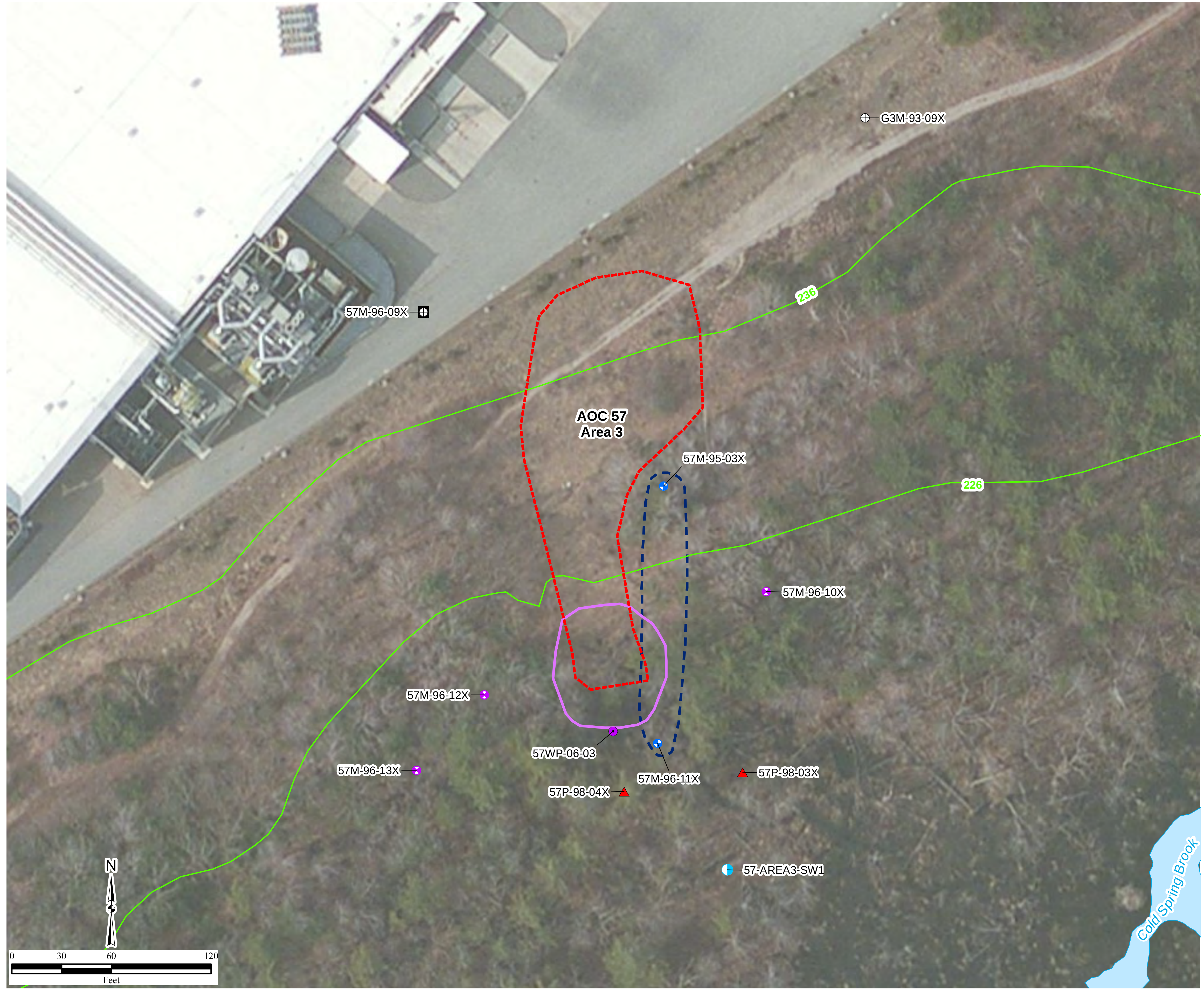
Source: HGL, USACE, www.mass.gov,
ArcGIS Online Bing Maps Aerial

Figure 1.2b
Site Layout
Area of Contamination 57–Area 3



Legend

● LTM Sample Well

● LTM Well–Gauge Only

● LTM Well Point–Gauge Only

▲ LTM Piezometer

◑ Surface Water Sample Location

⊕ Monitoring Well–Abandoned (2012)

⊞ Monitoring Well–Destroyed

57M-96-12X Well/Piezometer/Sample Location Identification

—226— Topographic Contour (ft amsl) (contour interval=10 ft)

▭ Approximate Historical Extent of Groundwater Contamination in Exceedance of Cleanup Goals (based on Fall 2003 to Spring 2011 analytical data)

▭ Area of Contamination (AOC)/ 1999 Excavation Area

▭ Alternate III-2a Estimated Soil Excavation Area (approximate location)

▭ Surface Water

Notes:
Well 57M-96-09X buried by construction.
Topographic contours from www.mass.gov, dated 2003.

ft amsl=feet above mean sea level
LTM=long-term monitoring

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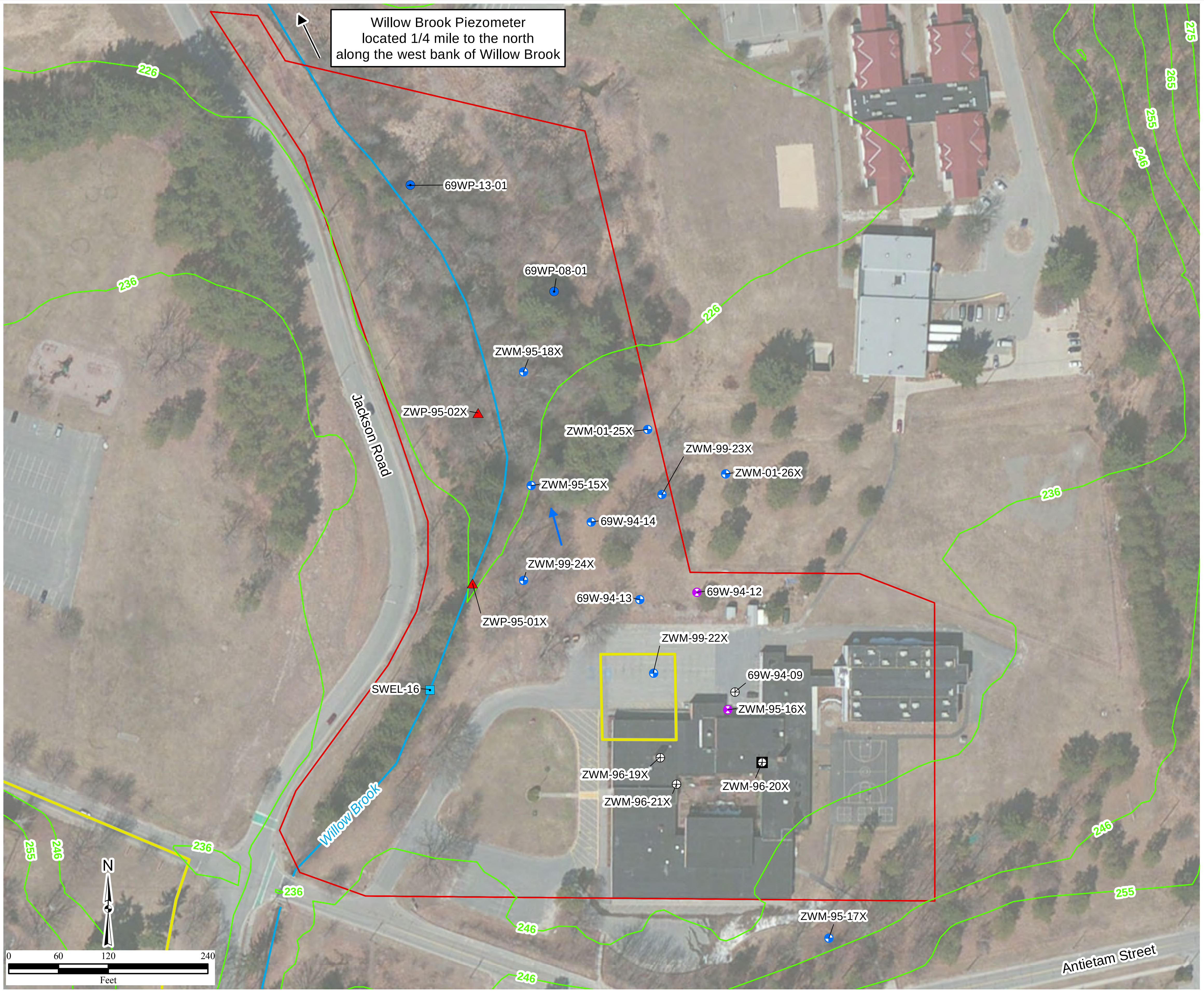
HGL HydroGeoLogic, Inc.



Sovereign and HGL—LTMMP
Former Fort Devens Army Installation and Sudbury Annex

Figure 1.3
Site Layout
Area of Contamination 69W

Legend

●	LTM Sample Well
●	LTM Sample Well Point
●	LTM Well–Gauge Only
▲	LTM Piezometer
⊕	Monitoring Well–Abandoned (2012)
⊞	Monitoring Well–Presumed Destroyed
■	Surface Water Elevation Location
ZWM-95-16X	Well/Piezometer/Surface Water Elevation Location Identification
→	Groundwater Flow Direction (October 2012)
—	Parcel Boundary
—226—	Topographic Contour (ft amsl)
—	Surface Water Course
▭	Excavated Soils Management Area

Notes:
Topographic contours from www.mass.gov, dated 2003.

ft amsl=feet above mean sea level
LTM=long-term monitoring

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Source: HGL, USACE, www.mass.gov,
ArcGIS Online Bing Maps Aerial

Sovereign Consulting Inc.
HGL
HydroGeoLogic, Inc

Figure 1.4
Site Layout
Area of Contamination 43G

Legend

●	LTM Sample Well
●	LTM Well–Gauge Only
△	Piezometer–Abandoned
●	Monitoring Well
⊕	Monitoring Well–Abandoned
⊞	Monitoring Well–Presumed Destroyed
XGM-94-07X	Well/Piezometer Identification
—265—	Topographic Contour (ft amsl)
⬚	Approximate Historical Extent of Groundwater Contamination in Exceedance of Cleanup Goals (based on 1999 to 2011 analytical data)
🟩	Former Gasoline UST(s)
🟫	Former Waste Oil UST
🟨	Former Waste Oil AST
🟥	Former UST Area

Notes:
Topographic contours from www.mass.gov, dated 2003.

AST=above ground storage tank
ft amsl=feet above mean sea level
LTM=long-term monitoring
UST=underground storage tank

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Source: HGL, USACE, www.mass.gov,
ArcGIS Online Bing Maps Aerial*

Sovereign Consulting Inc.
HGL HydroGeoLogic, Inc

Sovereign and HGL—LTMMP
Former Fort Devens Army Installation and Sudbury Annex

Figure 1.5
Site Layout
Devens Consolidation Landfill

Legend

●	LTM Sample Well
●	LTM Well–Gauge Only
⊕	Gas Vent
LFM-99-01B	Well/Vent Identification
—380—	Topographic Contour (ft amsl) (contour interval=10 ft)

Notes:
Gas vent locations were approximated based upon the locations displayed in Figure 2 of USACE New England District's Devens Consolidation Landfill 2004 Annual Report.
Topographic contours from www.mass.gov, dated 2003.

ft amsl=feet above mean sea level
LTM=long-term monitoring

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Source: HGL, USACE, MACTEC, www.mass.gov,
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HGL
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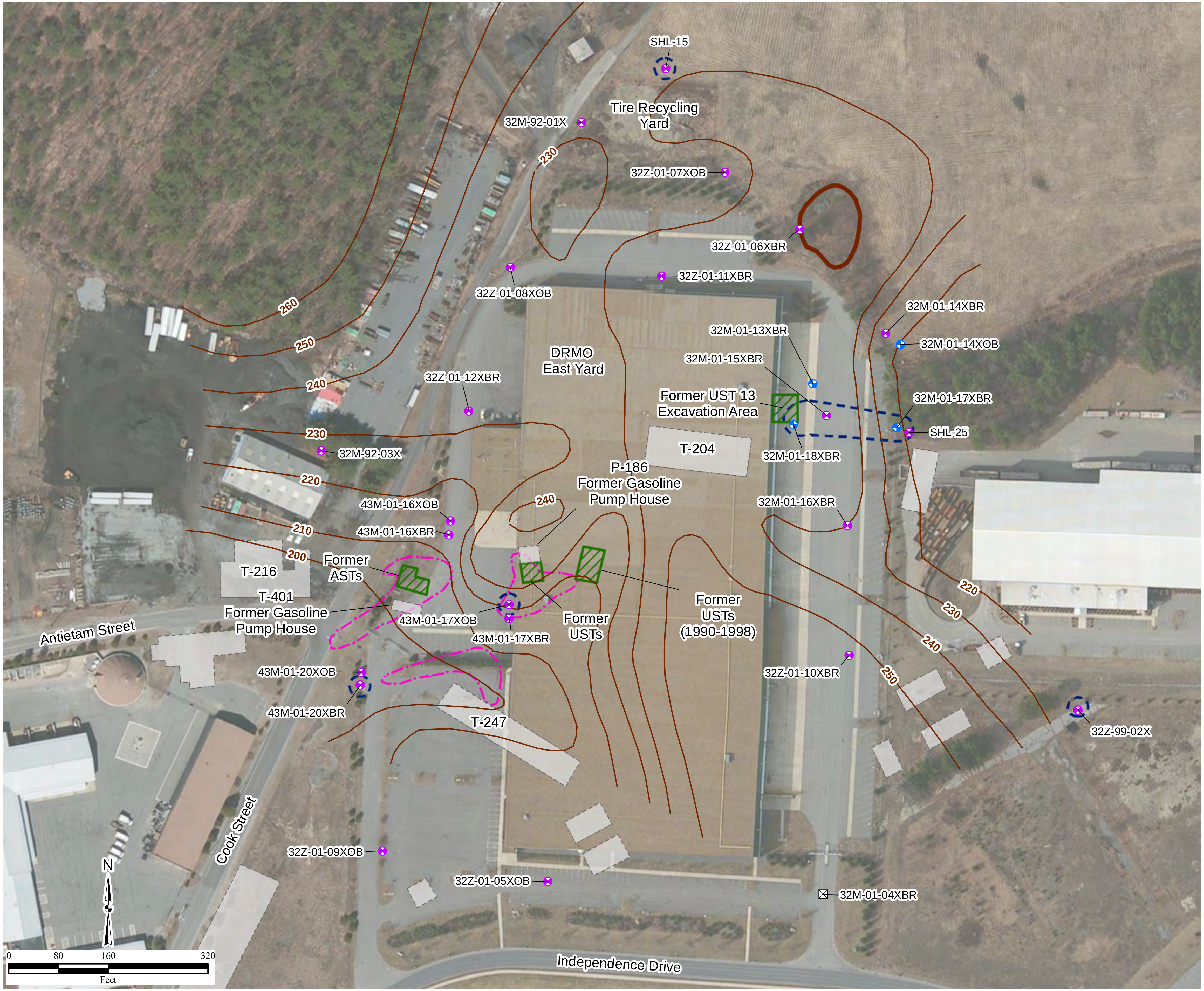

Sovereign and HGL—LTMMP
Former Fort Devens Army Installation and Sudbury Annex

Figure 1.6
Site Layout
Areas of Contamination 32 and 43A

Legend

●	LTM Sample Well
●	LTM Well–Periodic Gauge Only
☒	Monitoring Well–Paved Over
32M-92-01X	Well Identification
—240—	Post-Construction Bedrock Contour (ft amsl, contour interval=10 ft)
▨	Former Storage Tank(s)
▢	Former Building
T-247	Former Building Number
▢	Approximate Historical Extent of Groundwater Contamination in Exceedance of Cleanup Goals (based on April 2002 to October 2011 analytical data)
▢	TPHC Soil Contamination
▢	Remaining Bedrock Outcrop

Notes:
Source of post-construction bedrock contours:
Draft 2004 Annual Report, Area of Contamination 32 and 43A, Long Term Groundwater Monitoring, Devens, Massachusetts, USACE, 2005.

AST=above ground storage tank
DRMO=Defense Reutilization and Marketing Office
ft amsl=feet above mean sea level
LTM=long-term monitoring
TPHC=total petroleum hydrocarbons
UST=underground storage tank

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Source: HGL, USACE, MACTEC, CSM, ArcGIS Online Bing Maps Aerial

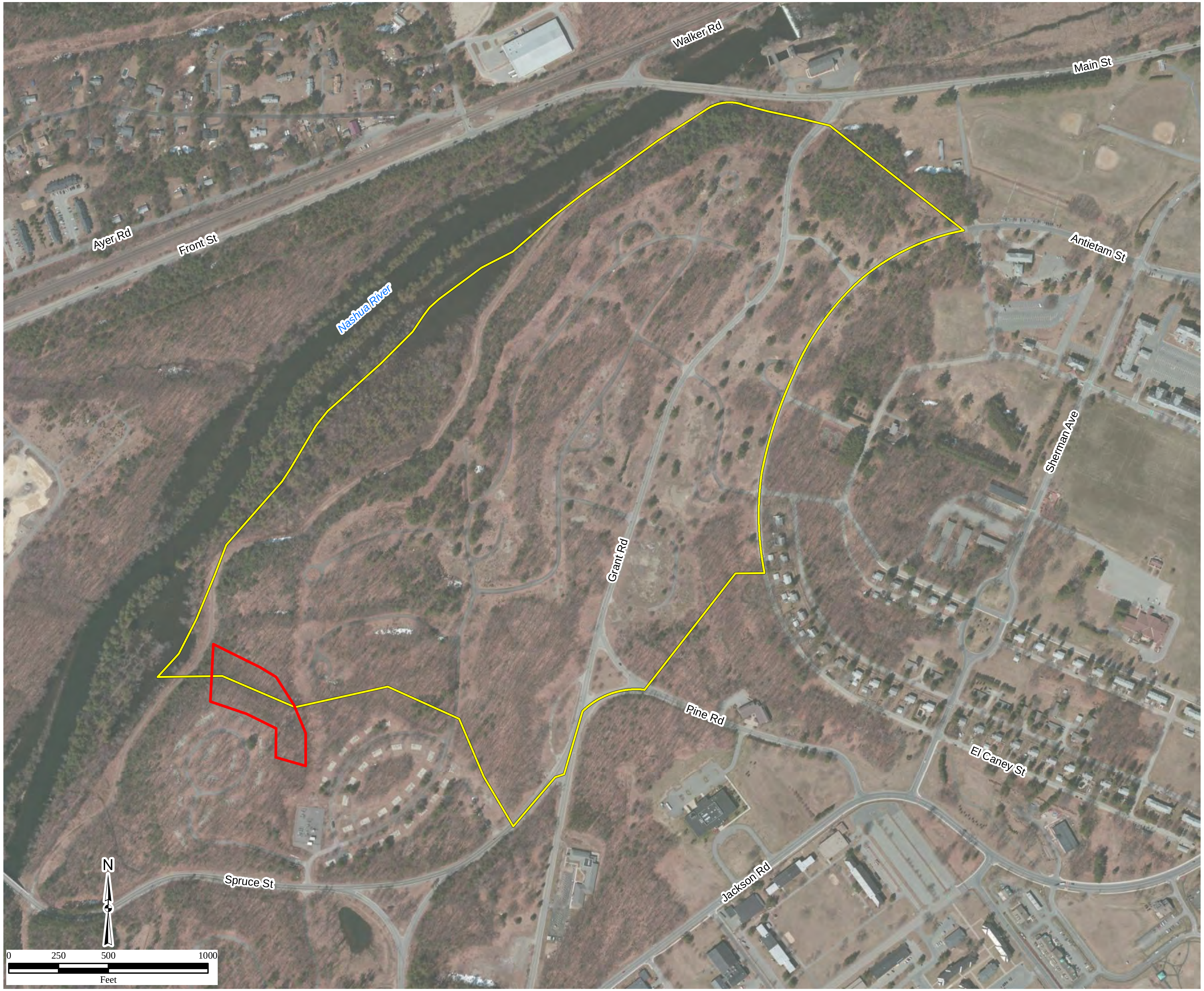

Figure 1.7
Site Layout
Grant Housing Area
and 37-mm Impact Area

Legend

🟨 Grant Housing Area Boundary

🟥 37-mm Impact Area

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Source: HGL, USACE, MACTEC, www.mass.gov,
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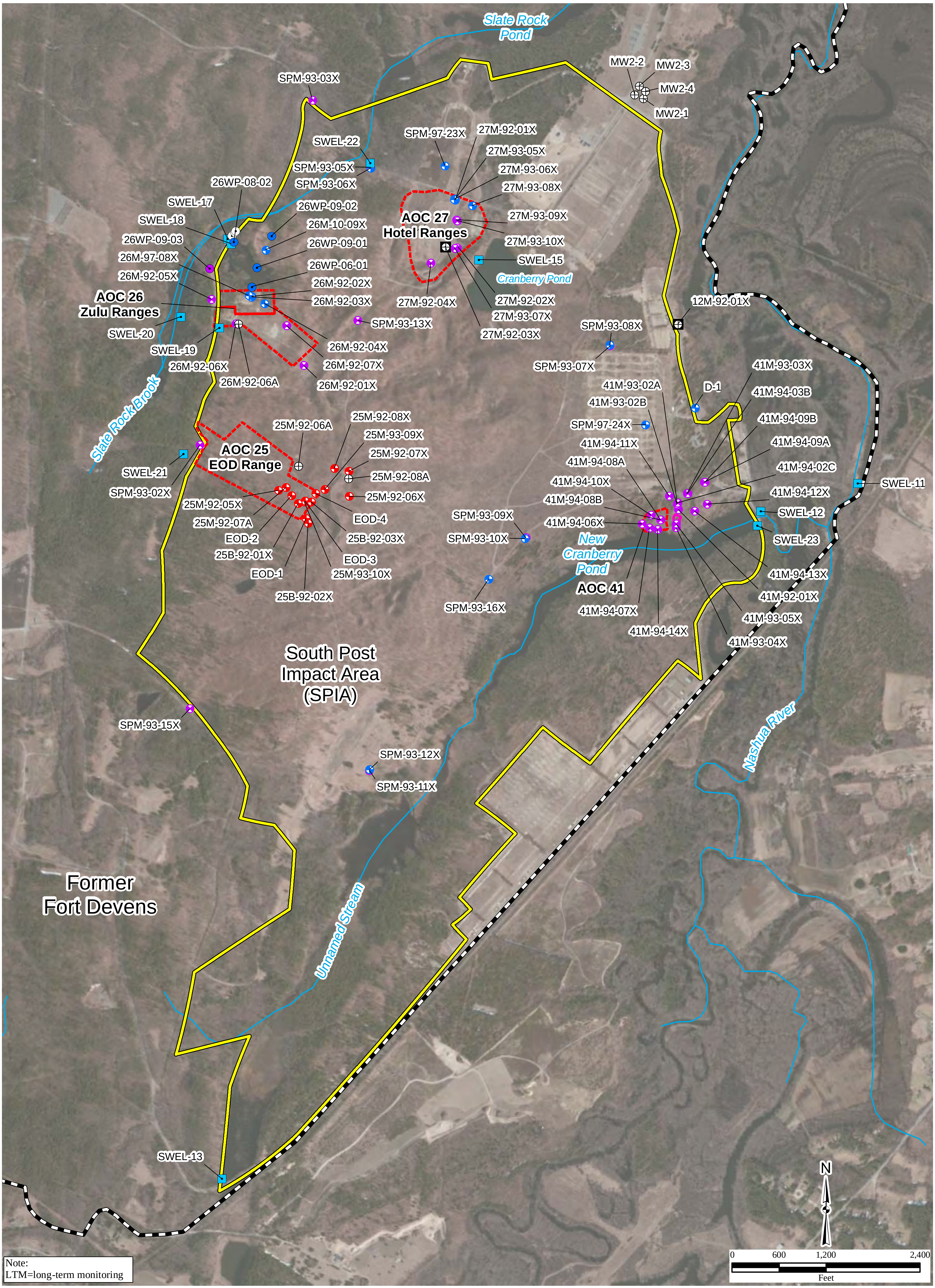

Note:
LTM=long-term monitoring

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5/27/2014 TB
Source: HGL, USACE,
ArcGIS Online Bing Maps Aerial

HGL HydroGeoLogic, Inc

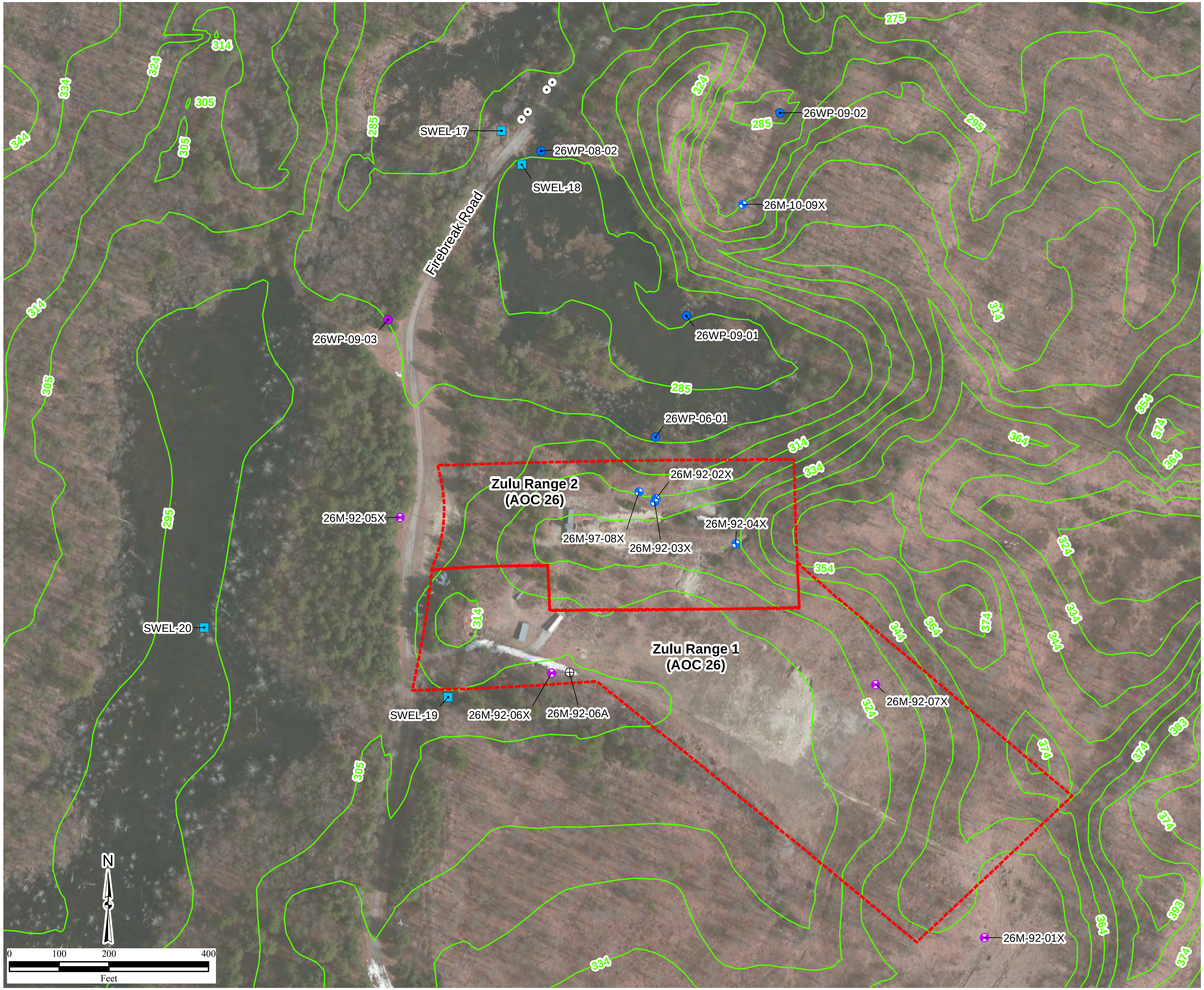
Sovereign Consulting Inc.

Legend

- ⊕ LTM Sample Well
- ● LTM Well–Periodic Gauge Only
- ● LTM Sample Well Point
- ⊕ Monitoring Well–Abandoned
- ⊙ Well Point Installation Location (Shallow Refusal)–Abandoned
- ⊞ Monitoring Well–Possibly Destroyed
- ● Well Point-Periodic Gauge Only
- ⊕ Monitoring Well
- ▣ Surface Water Elevation Location
- SWEL-12 Well/Elevation Location Identification
- — Surface Water Course
- ▬ Former Fort Devens Boundary
- ▭ Landfill Debris
- ▭ Area of Contamination (AOC)
- ▭ South Post Impact Area (SPIA)

Figure 1.8
Site Layout
South Post
Impact Area

Figure 1.9
Site Layout
South Post Impact Area
Area of Contamination 26
Zulu Ranges 1 and 2



Legend

●	LTM Sample Well
●	LTM Sample Well Point
●	LTM Well–Periodic Gauge Only
●	LTM Well Point–Gauge Only
⊕	Monitoring Well–Abandoned
⊙	Well Point Installation Location (Shallow Refusal)–Abandoned
▣	Surface Water Elevation Location
26M-92-03X	Well/Elevation Point Identification
—334—	Topographic Contour (ft amsl)
⬚	Area of Contamination (AOC)

Notes:
Topographic contours from www.mass.gov, dated 2003.

ft amsl=feet above mean sea level
LTM=long-term monitoring

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Source: HGL, USACE, www.mass.gov
ArcGIS Online Bing Maps Aerial

Figure 1.10
Site Layout
South Post Impact Area
Area of Contamination 27
Hotel Range

Legend

●	LTM Sample Well
●	LTM Well–Periodic Gauge Only
⊕	Monitoring Well–Abandoned
■	Surface Water Elevation Location
27M-93-10X	Well/Surface Water Elevation Identification
▭	Area of Contamination (AOC)

Note:
LTM=long-term monitoring

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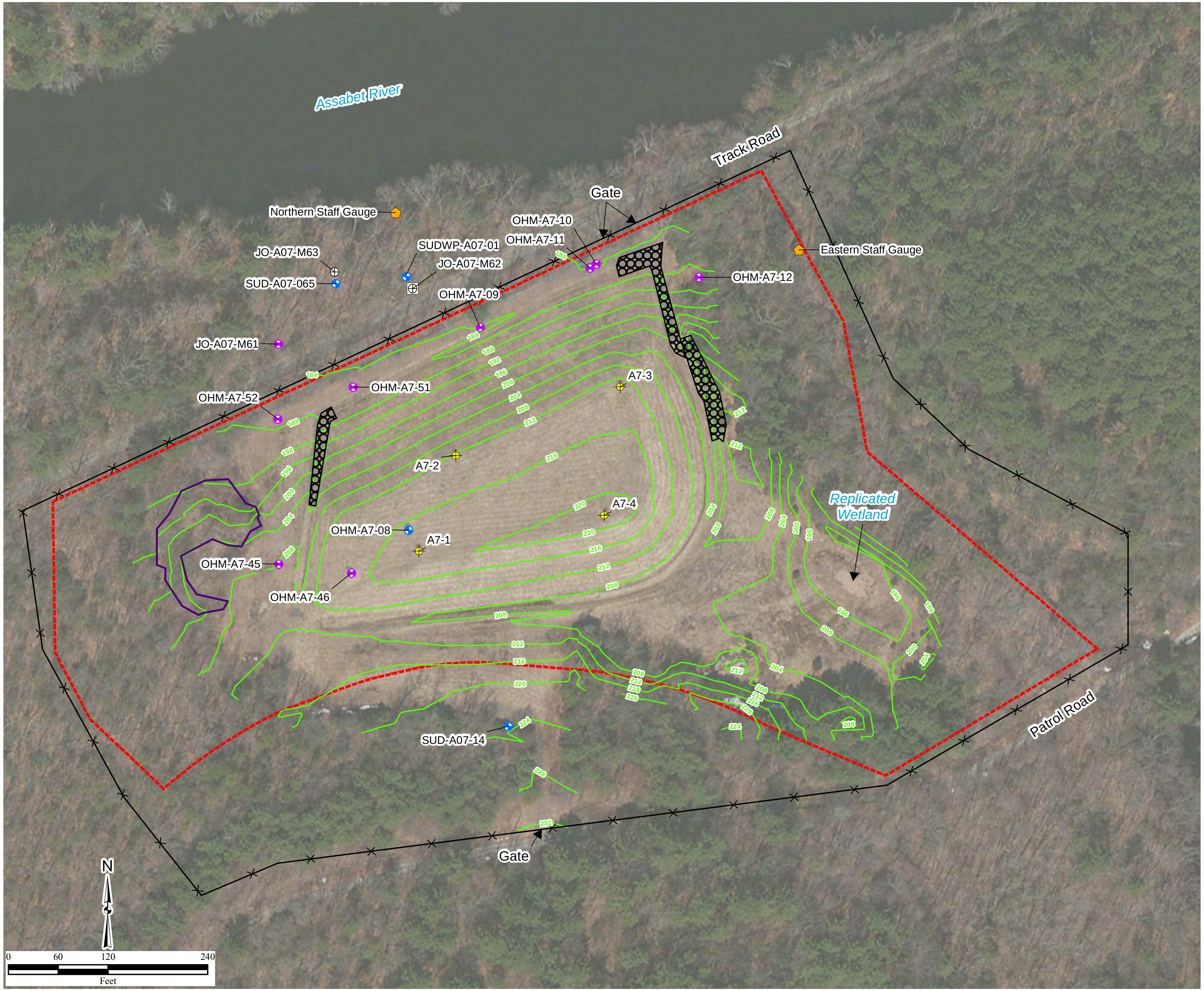

Sovereign and HGL—LTMMP
Former Fort Devens Army Installation and Sudbury Annex

Figure 1.11
Site Layout
Area of Contamination A7

Legend

⊕	LTM Sample Well
●	LTM Well–Gauge Only
⬟	Staff Gauge
⊕	Monitoring Well–Abandoned
⊞	Monitoring Well–Damaged
⊕	Gas Vent
OHM-A7-08	Well/Gauge/Vent Identification
—220—	Topographic Contour (ft amsl) (contour interval=4 ft)
✕—	Fence
☐	Stump Pile Area
▩	Toe Drain
⬚	Area of Contamination (AOC)

Note:
ft amsl=feet above mean sea level
LTM=long-term monitoring

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Source: HGL, USACE, www.mass.gov,
ArcGIS Online Bing Maps Aerial

TABLES

Key for Tables

General Terms

AOC	Area of Contamination
COD	chemical oxygen demand
CMR	Code of Massachusetts Regulations
EPH	extractable petroleum hydrocarbons
MCP	Massachusetts Contingency Plan
μg/L	Micrograms per liter
mg/L	Milligrams per liter
mV	Millivolts
NA	Not analyzed/available
NC	Not collected
ND	Not detected
NS	No standard established
NTU	Nephelometric turbidity units
ORP	Oxidation-reduction potential
SHE	Standard Hydrogen Electrode

Result Indicators (Laboratory Results Only)

Bold Text	Indicates a detected result above a background level.
Bold Text	Indicates a detected result above the associated site cleanup goal or GW-1 Standard.
Bold Text	Indicates a detected result above USEPA Water Quality Criteria.
Bold Text	Indicates a detected result above GW-3 Standard.

Data Qualifiers

J	Estimated detection
U	Not detected (at associated reporting limit)
UJ	Not detected; reporting limit is an estimate
R	Rejected due to serious deficiencies in associated QC. The presence or absence of the analyte cannot be verified.
EJ	Detected result reported at a concentration above the calibrated range of the instrument and is considered an estimate.

Table 3.1
Monitoring Wells, Well Points, Piezometers, Sumps, and Surface Water Locations Selected for Long-Term Monitoring

Monitoring Well/ Piezometer/ Surface Water ID	Location	Rationale	Screen Interval	Depth from Top of PVC to Top and Bottom of Well Screen	Top of PVC Elevation	Ground Surface Elevation	Sample Pump Intake Depth	Dedicated Bladder Pump[1]
			(feet NGVD)	(feet)	(feet NGVD)	(feet NGVD)	(feet TOC)	(Yes/No)
AOC 57 Sampling (Sample every 5 years)								
57M-03-01X	Area 2 - Upgradient location.	LTM water level only.	215.5 – 225.5	12.4 - 22.4	237.9	235.50	20.40	--
57M-03-02X	Area 2 - On west fringe of remedial excavation.	LTM water level only.	213.3 – 223.3	3.8 - 13.8	227.1	225.30	9.80	NO
57M-03-03X	Area 2 - On southern fringe of remedial excavation and at wetland limit.	LTM water level only.	210.34 – 220.34	3.3 - 13.3	223.64	222.34	8.00	NO
57M-03-04X	Area 2 – On southern fringe of remedial excavation and at wetland limit.	LTM water level only.	210.22 – 220.22	3.8 - 13.8	224.02	222.22	9.80	NO
57M-03-05X	Area 2 - On southeastern fringe of remedial excavation and at wetland limit.	LTM water level only.	210.43 – 220.43	3.9 - 13.9	224.33	222.43	10.00	NO
57M-03-06X	Area 2 – On east fringe of remedial excavation.	LTM water level only.	211.06 – 221.06	3.5 - 13.5	224.56	223.06	9.50	--
57M-95-05X	Area 2 - West of and upgradient of excavation limit.	LTM water level only.	214.87 – 224.87	12.44 - 22.44	237.31	234.87	--	--
57M-95-06X	Area 2 – West of and cross gradient of excavation limit.	LTM water level only.	212.34 – 222.34	14.22 - 24.22	236.56	234.42	--	--
57M-95-07X	Area 2 – East of and cross gradient of excavation limit.	LTM water level only.	210.36 – 220.36	4.21 - 14.21	224.57	223.36	--	--
57WP-05-01	Area 2 – Southwest of Staff Gauge 01.	LTM water level only.	0 – 2 ft bgs (2-4 ft TOC)	--	--	--	≈ 3	--
57WP-06-02	Area 2 - Adjacent to monitoring well 57M-03-03X.	LTM water level only.	19 – 24 ft bgs	20 - 25	--	--	--	--
57M-95-03X	Area 3 - Downgradient of source.	Sentry well. Monitor for decrease in COC concentration and decrease in the potential for off-site migration.	215.48 - 225.48	9.49 - 19.49	234.97	232.48	15.30	NO
57M-96-09X	Area 3 – Northwest of 1999 excavation area.	Well destroyed by construction.	216.05 - 226.05	16.58 - 26.58 (approximately)	242.63	NA	NA	NA
57M-96-10X	Area 3 – On west fringe of 1999 excavation area.	LTM water level only.	214.09 - 224.09	5.46 - 15.46	229.55	227.09	NA	NA
57M-96-11X	Area 3 – Downgradient well.	Monitor for decrease in COC concentration and decrease in the potential for off-site migration.	210.18 - 220.18	4.2 - 14.2	224.38	222.18	9.20	NO
57M-96-12X	Area 3 – West of and cross gradient of excavation limit.	LTM water level only.	212.82 - 222.82	5.05 - 15.05	227.87	224.82	NA	NA
57M-96-13X	Area 3 - West of and cross gradient of excavation limit.	LTM water level only.	213.06 - 223.06	4.67 - 14.67	227.73	225.06	NA	NA
57P-98-03X	Area 3 – Southeast of monitoring well 57M-96-11X.	LTM water level only.	NA	NA	222.58	NA	NA	NA
57P-98-04X	Area 3 - Southwest of monitoring well 57M-96-11X.	LTM water level only.	NA	NA	223.72	NA	NA	NA
57WP-06-03	Area 3 – Adjacent to monitoring well 57M-96-11X.	LTM water level only.	202.69 - 207.69	15 – 20	222.69	NA	NA	NA
SW-1	Area 3 – At downgradient fringe of excavation. Active seeps seem likely to be temporal.	Monitor for decrease in COC concentration and decrease in the potential for off-site migration.	NA	NA	NA	NA	NA	NA

Table 3.1
Monitoring Wells, Well Points, Piezometers, Sumps, and Surface Water Locations Selected for Long-Term Monitoring

Monitoring Well/ Piezometer/ Surface Water ID	Location	Rationale	Screen Interval	Depth from Top of PVC to Top and Bottom of Well Screen	Top of PVC Elevation	Ground Surface Elevation	Sample Pump Intake Depth	Dedicated Bladder Pump[1]
			(feet NGVD)	(feet)	(feet NGVD)	(feet NGVD)	(feet TOC)	(Yes/No)
AOC 69W (Annual Sampling)								
69W-94-13	North of paved area near source area.	Source area well. Monitor for decrease in COC concentrations.	211.30 - 221.30 (approximate)	6.49 - 16.49	227.79	225.30	11.49	NO
69W-94-14	Approx. 30 feet upgradient of Willow Brook wetlands.	Monitor for decrease in COC concentration and decrease in the potential for off-site migration.	212.53 - 222.53 (approximate)	5.49 - 15.49	228.02	225.53	11.09	NO
ZWM-95-15X	Near former underground concrete vault.	Sentry well. Monitor for decrease in COC concentration and decrease in the potential for off-site	209.94 - 219.94 (approximate)	5.87 - 15.87	225.81	222.94	10.87	NO
ZWM-95-18X	Approx. 120 feet downgradient of the concrete vault.	Sentry well. Monitor for off-site migration.	207.73 - 217.73 (approximate)	5.22 - 15.22	222.95	220.73	10.22	NO
ZWM-99-22X	Paved source area.	Replacement of destroyed well 69W-94-10. Monitor for decrease in COC concentrations.	212.89 - 222.89	4.63 - 14.63	227.52	227.69	9.63	NO
ZWM-99-23X	Downgradient well east of Willow Brook and northeast of 69W-94-14.	Sentry well. Monitor for decrease in COC concentration and decrease in the potential for off-site migration.	211.20 - 221.20	4.68 - 14.68	225.88	224.20	9.68	NO
ZWM-99-24X	Downgradient well east of Willow Brook and southwest of 69W-94-14.	Sentry well. Monitor for decrease in COC concentration and decrease in the potential for off-site migration.	211.13 - 221.13	5.52 - 15.52	226.65	223.63	10.52	NO
ZWM-01-25X	Downgradient well northeast of ZWM-95-15X.	Sentry well.	209.38 - 219.38	6.13 - 16.13	225.51	223.38	11.13	NO
ZWM-95-17X	Southeast of school.	Background well. Water level and quality parameters only.	213.87 - 223.87 (approximate)	14.76 - 24.76	238.63	236.07	19.76	NO
ZWM-01-26X	Northeast of ZWM-99-23.	Sentry well. Water level and quality parameters only.	211.16 - 221.16	6.45 - 16.45	227.61	225.16	11.48	NO
ZWP-95-01X	Along Willow Brook, west of ZWM-99-24X.	LTM water level only.	212.43 - 214.43 (approximate)	12.41 - 14.41	226.84	224.43	NA	NA
ZWP-95-02X	West side of Willow Brook, northwest of ZWM-95-15X.	LTM water level only.	209.21 - 211.21 (approximate)	12.42 - 14.42	223.63	220.71	NA	NA
69W-94-12	East of 69W-94-13.	LTM water level only.	NA	NA	228.94	226.45	NA	NA
ZWM-95-16X	Southeast of ZWM-99-22X, near loading dock.	LTM water level only.	212.71 - 222.71 (approximate)	5.67 - 15.67	228.38	229.01	NA	NA
Willow Brook Piezometer	Approximately ¼ mile north of site along Willow Brook.	LTM water level only.	NA	NA	218.97	217.60	NA	NA
69WP-08-01	Downgradient of ZWM-01-25X.	Sentry well point for manganese delineation.	208.5 - 211.5	10 - 13	221.5	NA	11.5	NO
69WP-13-01	Downgradient of 69WP-08-01.	Sentry well point for manganese delineation.	To Be Determined (TBD)	TBD	TBD	TBD	TBD	NO
AOC 43G (Annual Sampling)								
AAFES-2	East-southeast of former gasoline USTs.	Source well. Monitor intrinsic remediation.	269.50 - 284.50	18.3 - 33.3	302.8	300.70	27.88	NO
AAFES-5	East of former gasoline USTs.	LTM water level only.	270.70 - 285.70	15.22 - 30.22	300.92	301.20	26.19	NO
AAFES-6R	South of well XGM-93-02X.	LTM water level only.	270.6 - 280.6	16.97 - 26.97	299.54	297.57	22.82	NO
XGM-93-02X	South of former gasoline USTs.	Source well. Monitor intrinsic remediation.	272.60 - 282.60	28 - 38 ft bgs	309.6	310.60	33.22	NO
XGM-94-04X	Approx. 100 feet south of former gasoline USTs.	Sentry well. Monitor potential for off-site migration.	271.00 - 281.00	20.5 - 30.5	301.5	299.10	25.50	NO
XGM-94-07X	Approx. 180 feet east southeast of former gasoline USTs.	LTM water level only.	266.00 - 276.00	19.6 - 29.6	295.6	293.00	24.60	NO

Table 3.1
Monitoring Wells, Well Points, Piezometers, Sumps, and Surface Water Locations Selected for Long-Term Monitoring

Monitoring Well/ Piezometer/ Surface Water ID	Location	Rationale	Screen Interval	Depth from Top of PVC to Top and Bottom of Well Screen	Top of PVC Elevation	Ground Surface Elevation	Sample Pump Intake Depth	Dedicated Bladder Pump[1]
			(feet NGVD)	(feet)	(feet NGVD)	(feet NGVD)	(feet TOC)	(Yes/No)
AOC 43G (Annual Sampling) (continued)								
XGM-94-08X	Approx. 230 feet southeast of former gasoline USTs.	LTM water level only.	263.70 - 273.70	26.1 - 36.1	299.8	297.20	31.10	NO
XGM-94-10X	Approx. 250 feet south of former gasoline USTs.	LTM water level only.	268.90 - 278.90	23.8 - 33.8	302.7	300.40	NA	NO
XGM-97-12X	At location of former gasoline USTs.	Source well. Monitor intrinsic remediation.	275.63 - 285.63	24 - 34 ft bgs (approximate)	309.63	NA	29.35	NO
AAFES-7	Approx. 620 feet southeast of former gasoline USTs.	Monitor potential for manganese off-site migration.	242.4 - 252.4 ft msl	4.5 - 14.5 ft bgs	259.51	256.90	12.62	NO
Devens Consolidation Landfill (Semi-Annual Sampling)								
LFM-99-01B	West edge of property between landfill and Queenstown St.	LTM water level only.	317.4 – 326.7	24.77 - 34.07	351.47	350.00	NA	NA
LFM-99-02B	Southwest edge of property near intersection of Queenstown St. and Patton Rd.	Monitor for changes in downgradient conditions.	328.8 – 338.1	16.53 - 25.83	354.63	352.63	21.92	NO
LFM-99-03B	Northern edge of property.	LTM water level only.	293 – 302.3	40.58 - 49.88	342.88	340.50	NA	NA
LFM-99-05A	Near northeast toe of landfill.	Monitor for changes in downgradient conditions.	287.4 – 296.7	20.68 - 29.98	317.38	315.68	25.93	NO
LFM-99-05B	Near northeast toe of landfill.	LTM water level only.	259.9 – 264.2	53.18 - 57.48	317.38	315.68	NA	NA
LFM-99-06A	East of landfill and south of LFM-03-07.	Monitor for changes in downgradient conditions.	297.7 – 307.0	10.09 - 19.39	317.09	315.00	15.46	NO
LFM-03-07	East of the landfill and south of the channel to the collection pond.	Monitor for changes in downgradient conditions.	293.0 – 303.0	10.90 - 20.90	313.9	312.00	18.95	NO
AOCs 32 and 43A (Annual Sampling)								
32M-92-01X	North of the building on west edge of former Tire Recycling Yard.	LTM water level only.	234.7 – 244.7	16.23 - 26.23	260.93	258.40	NA	NA
32M-92-03X	West of the building and just north of former DRMO Warehouse.	LTM water level only.	225.8 – 235.8	25.19 - 35.19	260.99	258.80	NA	NA
32Z-99-02X (32M-92-02X)	East of the building.	LTM water level only.	228.9 – 243.9	16.89 - 31.89	260.79	258.40	28.50	NO
32Z-01-05XOB	Western end of parking lot to the south of the building.	LTM water level only.	226.3 – 236.3	25.1 - 35.1	261.4	261.75	NA	NA
32Z-01-06XBR	In vegetation north of northeast corner of the building.	LTM water level only.	234.1 – 244.1	18.6 - 28.6	262.7	260.80	NA	NA
32Z-01-07XOB	North of the building on southeast corner of former Tire Recycling Yard.	LTM water level only.	235.3 – 245.3	15.01 - 25.01	260.31	258.00	NA	NA
32Z-01-08XOB	Slightly northwest of the building.	LTM water level only.	236.8 – 246.8	14.53 - 24.53	261.33	258.80	NA	NA
32Z-01-09XOB	Western edge of parking lot near southwest corner of the building.	LTM water level only.	225.1 – 235.1	23.07 - 33.07	258.17	258.55	NA	NA
32Z-01-10XBR	In paved access road east of the building.	LTM water level only.	236.10 – 246.10	12.12 - 22.12	258.22	258.62	NA	NA
32Z-01-11XBR	In paved access road north of the building.	LTM water level only.	243.8 – 253.8	8.42 - 18.42	262.22	262.84	NA	NA
32Z-01-12XBR	In paved access road just north of truck bays on west side of the building.	LTM water level only.	220.9 – 230.9	27.78 - 37.78	258.63	259.08	NA	NA
SHL-15	North of the building on north edge of former Tire Recycling Yard.	LTM water level only.	234.0 – 244.0	16.3 - 26.3 (from metal casing)	260.30 (metal casing)	259.00	NA	NA

Table 3.1
Monitoring Wells, Well Points, Piezometers, Sumps, and Surface Water Locations Selected for Long-Term Monitoring

Monitoring Well/ Piezometer/ Surface Water ID	Location	Rationale	Screen Interval	Depth from Top of PVC to Top and Bottom of Well Screen	Top of PVC Elevation	Ground Surface Elevation	Sample Pump Intake Depth	Dedicated Bladder Pump[1]
			(feet NGVD)	(feet)	(feet NGVD)	(feet NGVD)	(feet TOC)	(Yes/No)
AOCs 32 and 43A (Annual Sampling) (continued)								
SHL-25	Outside of perimeter fence on east side of the building; adjacent to well 32M-01-17XBR.	LTM water level only.	224.1 – 234.1	25.0 - 35.0 (from metal casing)	259.10 (metal casing)	257.10	NA	NA
32M-01-13XBR	Between truck bays 33 and 34 on east side of the building.	Source area well.	235.4 – 245.4	13.25 - 23.25	258.65	259.07	22.30	YES
32M-01-14XOB	Outside of perimeter fence northeast of 32M-01-13XBR.	Downgradient well.	227.9 – 237.9	19.52 - 29.52	257.42	255.20	28.00	YES
32M-01-14XBR	Outside of perimeter fence northeast of 32M-01-13XBR.	LTM water level only.	211.1 – 221.1	35.81 - 45.81	256.91	255.10	43.81	YES
32M-01-15XBR	Southeast of 32M-01-13XBR in paved access road on east side of the building.	LTM water level only.	214.2 – 224.2	34.16 - 44.16	258.36	258.71	43.00	YES
32M-01-16XBR	Opposite from bay 20 on east side of the building.	LTM water level only.	227.5 – 237.5	20.79 - 30.79	258.29	258.52	29.00	YES
32M-01-17XBR	Just inside perimeter fence on east side of the building.	Downgradient well.	205.7 – 215.7	43.79 - 53.79	259.49	257.10	47.00	YES
32M-01-18XBR	Just east of the building at truck bay 29.	Source area well.	235.4 – 245.4	13.74 - 23.74	259.14	259.43	23.00	YES
43M-01-16XOB	Opposite door B5 on west side of the building.	LTM water level only.	223.9 – 233.9	23.75 - 33.75	257.65	257.92	NA	NA
43M-01-16XBR	Opposite door B5 on west side of the building.	LTM water level only.	200.3 – 210.3	47.27 - 57.27	257.57	257.84	NA	NA
43M-01-17XOB	Near door B4 on west side of the building.	LTM water level only.	225.9 – 235.9	22.97 - 32.97	258.87	259.37	NA	NA
43M-01-17XBR	Near door B4 on west side of the building.	LTM water level only.	201.8 – 211.8	47.25 - 57.25	259.05	259.34	NA	NA
43M-01-20XOB	Western edge of paved access road on west side of the building.	LTM water level only.	224.7 – 234.7	23.76 - 33.76	258.46	258.66	NA	NA
43M-01-20XBR	Western edge of paved access road on west side of the building.	LTM water level only.	180.4 – 190.4	67.71 - 77.71	258.11	258.66	NA	NA
AOC A7 (Annual Sampling)								
OHM-A7-08	Downgradient of former Lab Waste Area (west end of landfill cap).	Monitor for decrease in COC concentrations.	184.24 - 199.24	20.6-35.6	219.84	--	--	NO
OHM-A7-09	North of cap (at center) along Track Road.	LTM water level only.	171.31 - 179.31	6.9-14.9	186.21	--	--	NO
OHM-A7-10	Along Track Road, east of OHM-A7-9.	LTM water level only.	169.6 - 177.6	3.6-11.6	181.2	--	--	NO
OHM-A7-11	Adjacent to OHM-A7-10.	LTM water level only.	150.83 - 160.83	20.9-30.9	181.73	--	--	NA
OHM-A7-12	East of toe drain on eastern edge of landfill.	LTM water level only.	166.29 - 181.29	5.8-20.8	187.09	--	--	NA
SUD-A07-014	Background for AOC 47; replacement for OHM-A7-13. Well is inside the A7 enclosure, at the southern side of the site.	Monitor for changes in upgradient conditions.	204.37 - 214.37	12.0-22.0	226.37	--	--	NO
OHM-A7-45	West of cap near the west drainage ditch.	LTM water level only.	187.81 - 202.81	7.2-22.2	210.01	--	--	NA
OHM-A7-46	West end of cap; well-depth was measured on 10/17/2002 as 19.55 feet.	LTM water level only.	198.27 - 204.77	13.1-19.6	217.87	--	--	NA
OHM-A7-51	Northern boundary along Track Road, west end.	LTM water level only.	166.62 - 181.62	7.6-22.6	189.22	--	--	NO
OHM-A7-52	Northern boundary along Track Road, west end.	LTM water level only.	166.41 - 181.41	6.7-21.7	188.11	--	--	NA
JO-A07-M61	Between fence line and Assabet River, north of OHM-A7-52.	LTM water level only.	174.9 - 179.9	1.0-6.0 (measured depth 5.1 ft)	180.9	--	--	NA

Table 3.1
Monitoring Wells, Well Points, Piezometers, Sumps, and Surface Water Locations Selected for Long-Term Monitoring

Monitoring Well/ Piezometer/ Surface Water ID	Location	Rationale	Screen Interval	Depth from Top of PVC to Top and Bottom of Well Screen	Top of PVC Elevation	Ground Surface Elevation	Sample Pump Intake Depth	Dedicated Bladder Pump[1]
			(feet NGVD)	(feet)	(feet NGVD)	(feet NGVD)	(feet TOC)	(Yes/No)
AOC A7 (Annual Sampling) (continued)								
JO-A07-M62	Between fence line and Assabet River, east of JO-A07-M61.	Damaged.	174.57 - 179.57	2.0-7.0	181.57	--	--	NA
SUDWP-A07-01	Between fence line and Assabet River, east of JO-A07-M61.	Monitor for decrease in COC concentrations. Replacement for JO-A07-M62	TBD	3.93-6.93	TBD	--	--	NA
JO-A07-M63	Between fence line and Assabet River, between JO-A07-M61 and JO-A07-M62.	LTM water level only in 2007; decommissioned on November 13, 2007.	171.12 - 176.12	2.0-7.0	178.12	--	--	NA
SUD-A07-065	Replacement for JO-A07-M63; 15.1 feet south of M63; between fence line and Assabet River, between JO-A07-M61 and JO-A07-M62.	Monitor for decrease in COC concentrations.	169.12 - 174.12	4.5-9.5	178.62	--	--	NO
SPIA - AOC 25, EOD Range Water Level Measurement (every 5 years)								
EOD-1	Borders southeast corner of range.	Periodic LTM water level only.	NA	NA	NA	348.2	NA	NA
EOD-2	Eastern portion of range.	Periodic LTM water level only.	NA	NA	NA	348.2	NA	NA
EOD-3	Eastern portion of range.	Periodic LTM water level only.	NA	NA	NA	341.8	NA	NA
EOD-4	Northeastern corner of range.	Periodic LTM water level only.	NA	NA	NA	350.4	NA	NA
25M-92-05X	Eastern portion of range.	Periodic LTM water level only.	321.7 - 331.7	17.4 - 27.4	349.1	347.1	NA	NA
25M-92-06X	Downgradient of the range.	Periodic LTM water level only.	279 - 289	71 - 81	360.2	357.7	NA	NA
25M-92-07X	Northeast of eastern portion of range.	Periodic LTM water level only.	282 - 292	81.2 - 91.2	373.2	371.2	NA	NA
25M-92-08X	Northeast of eastern portion of range.	Periodic LTM water level only.	272.8 - 292.8	85.5 - 105.5	378.3	375.8	NA	NA
25M-93-09X	Borders northeastern corner of range.	Periodic LTM water level only.	313.5 - 323.5	36.8 - 46.8	360.3	358.2	NA	NA
25M-93-10X	Eastern portion of range.	Periodic LTM water level only.	302 - 312	31.9 - 41.9	343.9	341.7	NA	NA
SPIA - AOC 26, Zulu Ranges (Annual Sampling)								
26M-92-01X	Southeast of AOC 26, along side of dirt road.	Periodic LTM water level only.	305.2 - 315.2	17.5 - 27.5	332.7	331.3	NA	NA
26M-92-02X	Northern area of AOC 26.	Downgradient of impact area. Deep bedrock well.	244 - 264	52.5 - 72.5	315.7	314.00	63.5	YES
26M-92-03X	Northern area of AOC 26.	Downgradient of impact area. Water table well.	277 - 287	30.5 - 40.5	317.1	315.40	36.5	YES
26M-92-04X	Southeast of 26M-92-03X.	Deep bedrock well.	275.85 - 285.85	44.7 - 54.7	330.55	329.20	51.7	YES
26M-92-05X	West of AOC 26, west of Firebreak Road.	Periodic LTM water level only.	277.55 - 287.55	9.55 - 19.55	297.1	295.2	NA	NA
26M-92-06X	South of AOC 26 on fringe of Access Road.	Periodic LTM water level only.	281.47 - 291.47	11.2 - 21.2	302.67	300.8	NA	NA
26M-92-07X	Southeast of AOC 26.	Periodic LTM water level only.	280.25 -290.25	36.5 - 46.5	326.75	324.9	NA	NA
26M-97-08X	North of 26M-92-02X.	Intermediate depth, screened in sand and gravel layer.	265 - 275 (approximate)	40 - 50	312.04	NA	42	YES
26WP-06-01	North-northwest of 23M-92-02X, 26M-92-03X and 26M-97-08X.	Downgradient, shallow well point.	274.4 - 276.4	11 - 13	287.4	NA	≈ 12	NO
26WP-08-02	Northwestern area of AOC 26.	Downgradient, shallow well point.	271.77 - 274.77	10.5 - 13.5	285.27	NA	≈ 12	NO
26WP-09-01	Northeastern area of AOC 26.	Downgradient of impact area, shallow well point.	269.43 - 272.43	4.9 - 7.9	270.93	--	6.9	NO
26WP-09-02	Northern area of AOC 26.	Downgradient of impact area, shallow well point.	258.69 - 261.69	10 - 13	261.12	--	12	NO
26WP-09-03	Northwestern area of AOC 26.	Periodic LTM water level only.	286.25 - 289.25	4.8 - 7.8	291.05	--	--	--
26M-10-09X	Northeastern area of AOC 26, between 26WP-09-01 and 26WP-09-02.	Downgradient of impact area. Water table well.	259.21 - 269.21	16 - 26	285.21	283.21	25	YES

Table 3.1
Monitoring Wells, Well Points, Piezometers, Sumps, and Surface Water Locations Selected for Long-Term Monitoring

Monitoring Well/ Piezometer/ Surface Water ID	Location	Rationale	Screen Interval	Depth from Top of PVC to Top and Bottom of Well Screen	Top of PVC Elevation	Ground Surface Elevation	Sample Pump Intake Depth	Dedicated Bladder Pump[1]
			(feet NGVD)	**(feet)**	**(feet NGVD)**	**(feet NGVD)**	**(feet TOC)**	**(Yes/No)**
SPIA – AOC 27, Hotel Ranges (Biennual Sampling)								
27M-92-01X	Northern area of AOC 27.	Downgradient water table well.	224 - 235	10 - 20	245.10	245.20	16.00	YES
27M-92-02X	Southeast portion of AOC 27.	Periodic LTM water level only.	NA	NA	NA	NA	NA	NA
27M-92-03X	Southern portion of AOC 27, west of dirt road.	Periodic LTM water level only.	NA	NA	255.2	252.2	NA	NA
27M-92-04X	Southern portion of AOC 27, south of 27M-93-07X.	Periodic LTM water level only.	NA	NA	254.77	255.0	NA	NA
27M-93-05X	Northern area of AOC 27.	Downgradient bedrock well.	176 – 186	70 - 80	244.65	245.00	64.00	YES
27M-93-06X	Northern area of AOC 27.	Downgradient overburden well.	198 – 208	47 - 57	245.20	245.50	42.00	YES
27M-93-07X	Southern portion of AOC 27, south of 27M-92-02X.	Periodic LTM water level only.	212.48 - 222.48	29.8 - 39.8	252.28	251.8	NA	NA
27M-93-08X	Northern area of AOC 27.	Downgradient overburden well.	190 - 200	45 - 55	244.08	244.40	43.00	YES
27M-93-09X	Central portion of AOC 27.	Periodic LTM water level only.	206.02 - 216.02	33 - 43 (approximate)	249.02	248.9	NA	NA
27M-93-10X	Central portion of AOC 27.	Periodic LTM water level only.	224.61 - 234.61	14 - 24	248.61	248.5	NA	NA
SPIA – AOC 41 Water Level Measurement (every 5 years)								
41M-93-04X	Southwest of “landfill debris area”.	Periodic LTM water level only.	219.8 - 225.8	6 - 10	230.63	227.80	9.00	NO
SPIA – South Post Monitoring Wells (Annual Sampling)								
SPM-93-02X	West of AOC 25, west side of Firebreak Road.	Periodic LTM water level only.	301.8 - 311.8	13.9 - 23.9	325.7	323.5	NA	NA
SPM-93-03X	Northern edge of SPIA, south of Old Turnpike Road & Fire Break Road intersection.	Periodic LTM water level only.	226.3 - 236.3	27-37	261.3	259.3	NA	NA
SPM-93-05X	Northern area of SPIA, near Old Turnpike Road; near SPM-93-06X.	Periodic LTM water level only.	216.1 - 226.1	12.4 - 22.4	238.5	236.2	NA	NA
SPM-93-07X	North of Echo Range.	Periodic LTM water level only.	233 - 243	23.8 - 33.8	266.8	264.5	NA	NA
SPM-93-09X	Southeastern area of SPIA, west of New Cranberry Pond.	Periodic LTM water level only.	225.9 - 235.9	21.01 - 31.01	256.91	254.6	NA	NA
SPM-93-11X	Southeastern area of SPIA, Sierra Range near Old Harvard Road.	Periodic LTM water level only.	225.71 - 235.71	20.99 - 30.99	256.7	254.4	NA	NA
SPM-93-13X	Northwestern area of SPIA, between AOC 26 & AOC 27 near Access Road.	Periodic LTM water level only.	275.4 - 285.4	62.1 - 72.1	347.5	345.2	NA	NA
SPM-93-15X	Western edge of SPIA, downgradient of SA46, on eastern fringe of Firebreak Road.	Periodic LTM water level only.	343.5 - 353.5	7.1 - 17.1	360.6	358.5	NA	NA
SPM-93-06X	Northern area of SPIA.	Medium depth well, downgradient of AOC 27.	192 – 209	39.5 - 49.5	238.11	235.80	44.50	Yes
SPM-93-08X	Northeastern area of SPIA, north of Echo Range.	Medium depth well.	210 – 220	48 - 58	267.48	264.60	54.00	Yes
SPM-93-10X	Southeastern area of SPIA, west of New Cranberry Pond.	Medium depth well, downgradient of AOC 25.	201- 211	46.52 - 56.52	256.49	254.20	51.00	Yes
SPM-93-12X	Southeastern area of SPIA, Sierra Range.	Medium depth well, downgradient of AOC 25.	196 – 206	51.9 - 61.9	257.5	254.80	56.40	Yes
SPM-93-16X	Eastern area of SPIA, west of New Cranberry Pond.	Medium depth well, downgradient of AOC 25.	184 – 194	46.5 - 56.5	240.81	238.50	51.00	Yes

Table 3.1
Monitoring Wells, Well Points, Piezometers, Sumps, and Surface Water Locations Selected for Long-Term Monitoring

Monitoring Well/ Piezometer/ Surface Water ID	Location	Rationale	Screen Interval	Depth from Top of PVC to Top and Bottom of Well Screen	Top of PVC Elevation	Ground Surface Elevation	Sample Pump Intake Depth	Dedicated Bladder Pump[1]
			(feet NGVD)	(feet)	(feet NGVD)	(feet NGVD)	(feet TOC)	(Yes/No)
SPIA – South Post Monitoring Wells (Annual Sampling) (continued)								
SPM-97-23X	Approx. 300 feet north off Old Turnpike Rd.	Monitors groundwater as it leaves AOC 27 prior to entering wetland to north.	190 – 200	30 - 40	230.87 est.	NA	Not Accessible	Not Accessible
SPM-97-24X	Upgradient of drinking water well D-1 near Dixie Road.	Upgradient of drinking water well D-1.	190 – 200	65 - 75	264.83	NA	70.00	Yes
D-1	Dixie Road, near Echo Range.	Existing drinking water well.	192 - 197	NA	NA	NA	NA	NA
SPMWP-08-01	Northwestern area of SPIA, along northwestern fringe of AOC 26.	Shallow well point, downgradient of AOC 26.	Well point not installed; met refusal					NO

Table 3.2
AOC 57 - Spring LTM Sample Methods[1]

Description	Well/Sample Name	Sample Methods Total Metals (6010B)[2]	Sampling Frequency
Area 3 well	57M-95-03X	1	every 5 years
Area 3 well	57M-96-11X	1	every 5 years
Surface water Area 3	57-AREA 3-SW1	1	every 5 years
	Subtotal	**3**	
QA/QC	57M-Dup (57M-96-11X)	1	every 5 years
QA/QC	57SW-Dup	1	every 5 years
QA/QC	57M-95-03X MS	1	every 5 years
QA/QC	57M-95-03X-MSD	1	every 5 years
Total Samples per Method		**4**	

Notes:

[1] Area 2 wells 57M-03-01X, 57M-06-06X, well point 57M-05-01, Sumps 1-4, and Area 3 well 57M-06-09X were removed from the sampling program in 2008. The remaining Area 2 wells (57M-03-02X, 57M-03-03X, 57M-03-04X and 57M03-05X) and Area 2 surface water samples (57-Area2-SW2 and 57-Area2-SW3) were removed from the sampling program in 2014.

[2] Metals analyses include arsenic for Area 3 groundwater and surface water samples. Iron and manganese analyses evaluated annually. Dissolved metals sampling evaluated annually.

LTM = Long-Term Monitoring

MADEP = Massachusetts Department of Environmental Protection

Field Duplicates will be collected and analyzed at a frequency of 10%.

Matrix Spike/Matrix Spike Duplicates will be collected and analyzed at a frequency of 5% of the samples, or a minimum of 1 per sample event.

Rinsate Blanks are not required based on application of HydraSleeve™ technology for collection of groundwater samples.

Table 3.3
AOC 69W - Fall LTM Sample Methods

Description	**Well/Sample Name**	**Sample Methods**		**Sampling Frequency**
		EPH[2] (MADEP-EPH)	**Dissolved Metals[3] (6010 B)**	
Well	69W-94-13	1	1	Annual
Well	69W-94-14	1	1	Annual
Well	ZWM-95-15X	1	1	Annual
Well	ZWM-95-17X[1]			Annual
Well	ZWM-95-18X	1	1	Annual
Well	ZWM-99-22X	1	1	Annual
Well	ZWM-99-23X	1	1	Annual
Well	ZWM-99-24X	1	1	Annual
Well	ZWM-01-25X	1	1	Annual
Well	ZWM-01-26X[1]			Annual
Well Point	69WP-08-01		1	Annual
Well Point	69WP-13-01[4]		1	Annual
	Subtotal	**8**	**10**	
QA/QC	69W-Dup (ZWM-99-22X)	1	1	Annual
QA/QC	ZWM-95-18X-MS	1	1	Annual
QA/QC	ZWM-95-18X-MSD	1	1	Annual
QA/QC	69W-RB	1	1	Annual
	Total Samples per Method	**12**	**14**	

Notes:

[1] Note: Wells ZWM-95-17X and ZWM-01-26X only have water quality and water level data collected, no samples collected for analysis.

[2] EPH (MADEP Method) = Aliphatic Hydrocarbons [C9 - C18, C19 - C36], Aromatic Hydrocarbons [C11-C22]

[3] Metals samples for dissolved arsenic, iron and manganese are field filtered with a 0.45 micron in-line filter.

[4] 69WP-13-01 installed in fall 2013. Sample for manganese Only.

LTM = Long-Term Monitoring
EPH = Extractable Petroleum Hydrocarbon
MADEP = Massachusetts Department of Environmental Protection
RB = Rinsate Blank

Field Duplicates will be collected and analyzed at a frequency of 10% for all samples.

Matrix Spike/Matrix Spike Duplicates will be collected and analyzed at a frequency of 5% of the samples, or a minimum of 1 per sample event.

Rinsate Blanks will be submitted at a minimum frequency of 1 blank per sample event.

Table 3.4
AOC 43G - Fall LTM Sample Methods

Description	Well/Sample Name	Sample Methods			Sampling Frequency
		Alkalinity (2320B)[1]	**VPH (MADEP-VPH)**	**Total Metals (6010B)[2]**	
Well	XGM-94-04X	1	1	1	Annual
Well	AAFES-2	1	1	1	Annual
Well	XGM-93-02X	1	1	1	Annual
Well	XGM-97-12X	1	1	1	Annual
Well	AAFES-7			1[3]	Annual
	Subtotal	**3**	**3**	**4**	
QA/QC	43G-Trip Blank		1		Annual
QA/QC	43G-Dup (XGM-97-12X)	1	1	1	Annual
QA/QC	XGM-94-04X-MS	1	1	1	Annual
QA/QC	XGM-94-04X-MSD	1	1	1	Annual
	Total Samples per Method	**6**	**7**	**7**	

Notes:

[1] Alkalinity analyses evaluated biennially.

[2] Metals analyses include iron and manganese. Dissolved metals sampling evaluated annually.

[3] Manganese only at AAFES-7.

LTM = Long-Term Monitoring

VPH = Volatile Petroleum Hydrocarbon

MADEP = Massachusetts Department of Environmental Protection

Field Duplicates will be collected and analyzed at a frequency of one per AOC for all methods.

Matrix Spike/Matrix Spike Duplicates will be collected and analyzed at a frequency of 5% of the samples, or a minimum of 1 per sample event.

A set of Trip Blanks will be submitted with each cooler containing samples for VOC analyses.

Rinsate blanks no longer needed due to usage of Hydrasleeve™ technology to collect water samples.

Table 3.5
DCL –Fall LTM Sample Methods (Groundwater)

Well/Sample Name[1]	Sample Methods											Sampling Frequency[4]
	VPH (MADEP-VPH)	EPH (MADEP-EPH)	Pesticides (8081A)	Total Metals[2] (6010B)	TDS (160.1)	Anions[3] (300)	Nitrate/ Nitrite (353.2)	Alkalinity, Total (2320 B)	Total Cyanide (335.2)	COD (410.4)	PCBs[4] (8082)	
LFM-99-02B	1	1	1	1	1	1	1	1	1	1	1	Annual
LFM-99-05A	1	1	1	1	1	1	1	1	1	1	1	Annual
LFM-99-06A	1	1	1	1	1	1	1	1	1	1	1	Annual
LFM-03-07	1	1	1	1	1	1	1	1	1	1	1	Annual
Subtotal	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	
LFM-Trip Blank	1	-	-	-	-	-	-	-	-	-	-	Annual
LFM-99-02B-MS	1	1	1	1	1	1	1	1	1	1	1	Annual
LFM-99-02B-MSD	1	1	1	1	1	1	1	1	1	1	1	Annual
LFM-RB	1	1	1	1	1	1	1	1	1	1	1	Annual
LFM-DUP1 (LFM-99-05A)	1	1	1	1	1	1	1	1	1	1	1	Annual
Total Samples per Method	**9**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	

Notes:

[1] Sampling of three additional wells may be required if water levels rise beyond specified levels.

[2] Twelve metals in TAL list (arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, and silver.

[3] Anions include Sulfate and Chloride

[4] PCBs samples will be collected once every 5 years, immediately prior to five-year reviews. The next PCB sample event will be in 2014.

COD = Chemical Oxygen Demand
EPH = Extractable Petroleum Hydrocarbons
LTM = Long-Term Monitoring
MS = Matrix Spike
MSD = Matrix Spike Duplicate
PCBs = Polychlorinated Biphenyls
QA/QC = Quality Assurance/Quality Control
RB = Rinsate Blank
TDS = Total Dissolved Solids
VPH = Volatile Petroleum Hydrocarbons

Table 3.6
AOCs 32 and 43A - Spring LTM Sample Methods[1]

Description	Well/Sample Name	Sample Methods VOCs (8260B)	 VPH (MADEP-VPH)	 EPH (MADEP-EPH)	 Total Metals[2] (6010B)	Sampling Frequency
Well	32M-01-13XBR	1	1	1	1	Annual
Well	32M-01-14XOB	1	1	1	1	Annual
Well	32M-01-17XBR	1	1	1	1	Annual
Well	32M-01-18XBR	1	1	1	1	Annual
	Subtotal	**4**	**4**	**4**	**4**	
QA/QC	32M-Trip Blank	1	1	--	--	Annual
QA/QC	32M-Dup (32M-01-18XBR)	1	1	1	1	Annual
QA/QC	32M-01-17XBR-MS	1	1	1	1	Annual
QA/QC	32M-01-17XBR-MSD	1	1	1	1	Annual
Total Samples per Method		**8**	**8**	**7**	**7**	

Notes:

[1] Wells SHL-15 and 32M-92-01X were removed from the sampling program in 2007. Wells 32Z-99-2X (32-92-02x), 32M-01-19XBR, 32M-01-15XBR, and 32M-01-16XBR were removed from the sampling plan in 2013.

[2] Metals include arsenic and manganese. Dissolved metals analyses will be evaluated annually.

AOC = Area of Contamination
LTM = Long-Term Monitoring
VOC = Volatile Organic Compound
VPH = Volatile Petroleum Hydrocarbons
MADEP = Massachusetts Department of Environmental Protection
Field Duplicates will be collected and analyzed at a frequency of 10% for VOC and VPH samples.
Matrix Spike/Matrix Spike Duplicates will be collected and analyzed at a frequency of 5% of the samples, or a minimum of 1 per sample event.
A set of Trip Blanks will be submitted with each cooler containing samples for VOC or VPH analyses.
Rinsate Blanks no longer needed due to usage of Hydrasleeve™ Technology to collect groundwater samples.

Table 3.7
SPIA - Fall LTM Sample Methods

Description	Well/Sample Name	Sample Methods			Sampling Frequency
		TAL Total Metals (6010B) [1]	Explosives (8330) [2]	Perchlorate (332.0)	
AOC 26 Well	26M-92-02X	1	1	1	Annually
AOC 26 Well	26M-92-03X	1	1	1	Annually
AOC 26 Well	26M-92-04X	1	1	1	Annually
AOC 26 Well	26M-97-08X	1	1	1	Annually
AOC 26 Well Point	26WP-06-01		1	1	Annually
AOC 26 Well Point	26WP-08-02		1	1	Annually
AOC 26 Well	26M-10-09X	1	1	1	Annually
AOC 26 Well Point	26WP-09-01		1	1	Annually
AOC 26 Well Point	26WP-09-02		1	1	Annually
AOC 27 Well	27M-92-01X	1	1		Biennially
AOC 27 Well	27M-93-05X	1	1		Biennially
AOC 27 Well	27M-93-06X	1	1		Biennially
AOC 27 Well	27M-93-08X	1	1		Biennially
SPIA Well	SPM-93-06X	1	1	1	Annually
SPIA Well	SPM-93-08X	1	1		Annually
SPIA Well	SPM-93-10X	1	1		Annually
SPIA Well	SPM-93-12X	1	1		Annually
SPIA Well	SPM-93-16X	1	1		Annually
SPIA Well	SPM-97-23X	1	1		Annually
SPIA Well	SPM-97-24X	1	1		Annually
SPIA Hydrant	D-1		1		Annually
	Subtotal	16	21	10	
QA/QC	26M-DUP1 (26M-92-03X)	1	1		Annually
QA/QC	26M-DUP2 (26M-92-04X)			1	Annually
QA/QC	26M-DUP3 (26M-97-08X)	1	1		Annually
QA/QC	26WP-06-01-MS			1	Annually
QA/QC	26WP-06-01-MSD			1	Semi-Annually
QA/QC	SPM-93-12X-MS	1	1		Annually
QA/QC	SPM-93-12X-MSD	1	1		Annually
Total Samples per Method		20	25	13	

Notes:

[1] Metals (6010B) analyses to include 22-compound TAL.

[2] Explosives (8330) analyses to include 14-compound TAL.

LTM = Long-Term Monitoring

TAL = Target analyte list

Field Duplicates will be collected and analyzed at an average frequency of one per AOC for all methods.

Matrix Spike/Matrix Spike Duplicates will be collected and analyzed at a frequency of 5% of the samples, or a minimum of 1 per sample event.

Well point analyses (AOC 26) will include explosives and perchlorate.

Table 3.8
AOC A7 - Fall LTM Sample Methods

Description	Well/Sample Name	Sample Methods					Sampling Frequency
		VOCs (8260B)	Pesticides[1] (8081A)	Total Metals[1,2] (6010B)	COD (410.4)	Cyanide (9014)	
Well	OHM-A7-08	1	1	1	1	1	Annually
Well	SUD-A07-014	1	1	1	1	1	Annually
Well	SUD-A07-065	1	1	1	1	1	Annually
Well Point	SUDWP-A07-01	1	1	1	1	1	Annually
	Subtotal	**4**	**4**	**4**	**4**	**4**	
QA/QC	A7-Trip Blank	1	0	0	0	0	Annually
QA/QC	A7-Dup1 (OHM-A7-08)	1	1	1	1	1	Annually
QA/QC	SUD-A07-065-MS	1	1	1	1	1	Annually
QA/QC	SUD-A07-065-MSD	1	1	1	1	1	Annually
QA/QC	A7-RB (SUD-A07-065)[4]	1	1	1	0	1	Annually
Total Samples per Method		**9**	**8**	**8**	**7**	**8**	

Notes:

[1] Metals sampled every 5 years following next five-year review report. A recommendation for reduction from annual to 5 year sampling will be included in the next 5 year review report (CY2016 Five Year Report).

[2] Metals analyses include aluminum, antimony (by 7041), arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead (by 7421), magnesium, manganese, mercury (by 7470A), nickel, potassium, selenium, silver, sodium, thallium (by 7841), vanadium and zinc.

[3] SUDWP-A07-01 replaced well JO-A07-M62 in the fall 2013. Please note that JO-A07-M62 was damaged prior to fall 2012 event and as a one-time replacement, OHM-A7-10, was sampled in the fall 2012 event, however SUDWP-A07-01 is the permanent replacement for JO-A07-M62.

[4] Rinsate Blanks will be submitted at a minimum frequency of 1 blank per sampling event.

RB = Rinsate Blank

Field Duplicates will be collected and analyzed at a frequency of one per sample event for all methods.

Matrix Spike/Matrix Spike Duplicates will be collected and analyzed at a minimum of 1 per sample event.

A set of Trip Blanks will be submitted with each cooler containing samples for VOC analyses.

Table 3.9
DCL - Fall LTM Sample Methods (Leachate Discharge)

Well/Sample Name	Sample Methods							Sampling Frequency
	Total Metals[1] (6010B)	Total Cyanide (335.2)	Total Suspended Solids (160.2)	TPH as DRO (8015B)	pH (150.1)	Total Phenol (E420.1)	TTO[2]	
Leachate	1	1	1	1	1	1	1	Annual
LTM-Trip Blank							1[3]	Annual
Total Samples per Method	1	1	1	1	1	1	2	

Notes:

[1] Ten metals in TAL list (aluminum, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver and zinc).

[2] TTO = Total Toxic Organics [sum of VOCs (624), SVOCs (625), Pesticides (8081A) and PCBs (8082)]

[3] VOCs only

LTM = Long-Term Monitoring
PCBs = Polychlorinated Biphenyls
TSS = Total Suspended Solids
TPH = Total Petroleum Hydrocarbons
VOCs = Volatile Organic Compounds
SVOCs = Semi-Volatile Organic Compounds
DRO = Diesel Range Organics

Table 3.10
MassDevelopment Industrial Wastewater Discharge Permit No. 017 Limitations

Analytical Fraction	Parameter	Discharge Limitation (mg/L)
Metals Composite	Aluminum	NA
	Arsenic	0.20
	Chromium (total)	0.40
	Cadmium	0.045
	Copper	0.75
	Lead	0.20
	Nickel	0.60
	Silver	0.30
	Zinc	0.70
	Mercury	0.001
Cyanide	Cyanide (Total)	NL
TSS	Total Suspended Solids	400
TTO	Total Toxic Organics	5.0
TPH	Total Petroleum Hydrocarbons	NL
pH	pH (units)	5.5 - 9.5
Heptachlor – Pesticide		NL
Phenol - Pesticide		NL

Notes:

mg/L = milligrams per liter
NA = Not applicable
NL = No limit; for monitoring purposes only
TTO = Total Toxic Organics (Sum of VOCs, SVOCs, Pesticides and PCBs)
VOCs = Volatile Organic Compounds
SVOCs = Semi Volatile Organic Compounds
PCBs = Polychlorinated Biphenyls

Table 3.11
Sample Preparation and Analysis Methods, Containers, Holding Times and Preservatives

Site	Parameter	Preparation Method[1]	Analytical Method[1]	Contaminant of Concern[2]	Sample Container[3]	Preservative	Holding Time (VTS)[4]
AOC 57	Total Metals	200 Series	SW6010B	Arsenic	500 ml HDPE	HNO_3 to pH < 2; 4° +/- 2°C	180 Days
AOC 69W	EPH	None	MADEP-EPH-04-1.1	TAL	2 x 1-Liter Glass Amber	HCl to pH < 2	7 Days (extraction) 40 Days (analyses)
	Dissolved Metals	200 Series	E200.7	Manganese	500 ml HDPE	HNO_3 to pH < 2; 4° +/- 2°C	180 Days
	Dissolved Arsenic		E206.2	Arsenic			
AOC 43G	VPH	None	MADEP-VPH-04-1.1	Benzene	3 x 40-ml vials with teflon septa screw caps; no headspace	HCl to pH < 2; 4° +/- 2°C	14 Days
				Ethylbenzene			
				Xylenes			
	Total Metals	200 Series	SW6010B	Manganese	500 ml HDPE	HNO_3 to pH < 2; 4° +/- 2°C	180 Days
	Alkalinity	None	SM2320B	None	1 x 250-ml Polyethylene	Store at 4° +/-2°C	14 Days
AOC 26 (SPIA)	Explosives	8330	SW8330	TAL	1 x 1-Liter Amber with Teflon-lined lid	Store at 4° +/- 2°C	7 Days (extraction) 40 Days (analyses)
	Total Metals	3005A	SW6010B	TAL	1 x 1-Liter Polyethylene	HNO_3 to pH < 2; 4° +/- 2°C	6 Months (Mercury 28 days)
	Mercury		SW7470A	Mercury			
	Perchlorate	None	SW6860/332.0	Perchlorate	1 x 125-ml sterile high-density polyethylene (HDPE)	Store at 4° +/- 2°C	28 Days
AOC 27 (SPIA)	Explosives	8330	SW8330	TAL	1 x 1-Liter Amber with Teflon-lined lid	Store at 4° +/- 2°C	7 Days (extraction) 40 Days (analyses)
	Total Metals	3005A	SW6010B	TAL	1 x 1-Liter Polyethylene	HNO_3 to pH < 2; 4° +/- 2°C	6 Months (Mercury 28 days)
	Mercury		SW7470A	Mercury			
SPM Wells (SPIA)	Explosives	8330	SW8330	TAL	1 x 1-Liter Amber with Teflon-lined lid	Store at 4° +/- 2°C	7 Days (extraction) 40 Days (analyses)
	Total Metals	3005A	SW6010B	TAL	1 x 1-Liter Polyethylene	HNO_3 to pH < 2; 4° +/- 2°C	6 Months (Mercury 28 days)
	Total Mercury	3005A	SW7470A	Mercury			

Table 3.11
Sample Preparation and Analysis Methods, Containers, Holding Times and Preservatives

Site	Parameter	Preparation Method[1]	Analytical Method[1]	Contaminant of Concern[2]	Sample Container[3]	Preservative	Holding Time (VTS)[4]
Devens Consolidation Landfill (Groundwater)	VPH	5030B	MADEP-VPH-04-1.1	TAL	3 x 40-ml vials with teflon septa screw caps; no headspace	HCl to pH < 2; 4°+/- 2°C	14 Days
	EPH	3510C	MADEP-EPH-04-1.1	TAL	2 x 1-Liter Glass Amber	HCl to pH < 2	7 Days (extraction) 40 Days (analyses)
	Pesticides	3510C	8081A	TAL	2 x 1-Liter Glass Amber with Teflon-lined lid	Store at 4°+/- 2°C	7 Days (extraction) 40 Days (analyses)
	Total Metals[5]	3010A	6010B - Trace ICP or 7000 series (7470A for Mercury)	See footnote [5] below	300 ml Polyethylene	HNO_3 to pH < 2; 4°+/- 2°C	6 Months (Mercury 28 days)
	TDS	NA	160.1	None	1 x 500-ml Polyethylene	Store at 4°+/- 2°C	7 days
	Anions	NA	300.0	Chloride, Sulfate			48 hours for Nitrate; 28 days for Sulfate and Chloride
	Alkalinity	NA	2320B	None			14 Days
	Cyanide (Total)	NA	E335.4	Cyanide (Total)	250-ml Polyethylene	NAOH to pH > 12, Ascorbic Acid; 4°+/-	14 Days
	COD	NA	410.4	None	250-ml Polyethylene	H_2SO_4 to pH < 2; 4°+/- 2°C	28 Days
	PCBs[9]		8082	TAL	2 x 1-Liter Glass Amber	Store at 4°+/- 2°C	7 days
	Nitrate/Nitrite	NA	353.2	Nitrate/Nitrite (As N)	1 x 500-ml Poly	H2SO4 to pH < 2; 4°+/- 2°C	28 Days
Devens Consolidation Landfill (Leachate)	Total Metals[6]	3010A	6010B-Trace ICP	See footnote [6] below	300-ml Polyethylene	HNO_3 to pH < 2; 4°+/- 2°C	6 Months (Mercury 28 days)
	Cyanide (Total)	NA	E335.2	Cyanide (Total)	250-ml Polyethylene	NAOH to pH > 12, Ascorbic Acid; 4°+/- 2°C	14 Days
	TSS	None	160.2	None	1 x 1-Liter Polyethylene	Unpreserved	7 Days
	TPH	None	8015B	None	1 x 1 Liter Glass Amber	HCl to pH < 2; 4°+/- 2°C	14 Days
	pH	None	150.1	None	1 x 250-ml Polyethylene	Store at 4°+/- 2°C	--
	Phenol	None	420.1	Phenol	1 x 500-ml Amber	H2SO4 to pH < 2; 4°+/- 2°C	28 days
	TTO[7] - VOCs	5030B	624	TAL	3 x 40-ml vials with teflon septa screw caps; no headspace	HCl to pH < 2; 4°+/- 2°C	14 Days
	TTO[7] - SVOCs	None	625	TAL	2 x 1-Liter Glass Amber	$Na_2S_2O_3$, Store at 4°+/- 2°C	7 Days
	TTO[7] - Pesticides	3510C	8081A	TAL	2 x 1-Liter Glass Amber with with Teflon-lined lid	Store at 4°+/- 2°C	7 Days (extraction) 40 Days (analyses)

Table 3.11
Sample Preparation and Analysis Methods, Containers, Holding Times and Preservatives

Site	Parameter	Preparation Method[1]	Analytical Method[1]	Contaminant of Concern[2]	Sample Container[3]	Preservative	Holding Time (VTS)[4]
AOC 32/43A	VOCs	5030B	SW8260B	None	3 x 40-ml vials with teflon septa screw caps; no headspace	HCl to pH < 2; 4° +/- 2°C	14 Days
	VPH	None	MADEP-VPH-04-1.1	None	3 x 40-ml vials with teflon septa screw caps; no headspace	HCl to pH < 2; 4° +/- 2°C	14 Days
	EPH	None	MADEP-EPH-04-1.1	C_{11}-C_{22} Aromatics	1-Liter Glass Amber	HCl to pH < 2	7 Days (extraction) 40 Days (analyses)
	Total Metals	200 Series	SW6010B	Arsenic Manganese	500 ml HDPE	HNO_3 to pH < 2; 4° +/- 2°C	180 Days
Sudbury Landfill (AOC A7)	VOCs	5030B	SW8260B	TAL	3 x 40-ml vials with teflon septa screw caps; no headspace	HCl to pH < 2; 4° +/- 2°C	14 days
	Pesticides	3510C	8081A	TAL	2 x 1-Liter Glass Amber	Store at 4° +/- 2°C	7 days to extract 40 days to analyze
	TAL Metals (3)	3005A	6010C	TAL[8]	500 ml HDPE	HNO_3 to pH < 2; 4° +/- 2°C	180 days (except Hg) 28 days (Hg)
	Antimony	3005A	6020				
	Lead	3005A	6010C				
	Thallium	3005A	6020				
	Mercury	3005A	7470A				
	COD	NA	410.4	None	1 x 250-ml Polyethylene	H_2SO_4 to pH < 2; 4° +/- 2°C	28 days
	Cyanide	NA	9014	Cyanide	500 ml HDPE	NAOH to pH > 12; 4° +/- 2°C	14 days

Notes:

[1] "Methods for Chemical Analysis of Water and Wastes", Cincinnati, OH, March 1979, EPA 600-4-79-020.
"Test Methods for Evaluating Solid Waste, Physical and Chemical Methods", U.S. EPA SW-846, 3rd Edition.

[2] "None" indicates that the ROD did not specify COCs for the indicated method and the cleanup goal is the MCP GW-1 standard.

[3] Additional sample containers/volume is reuired for matrix quality control samples.

[4] VTS = Verified Time when the Sample was collected.

[5] Total Metals include: Arsenic, Barium, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Selenium, and Silver.

[6] Total Metals include: Aluminum, Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Silver and Zinc.

[7] TTO = Total Toxic Organics (sum of VOCs, SVOCs and Pesticides)

[8] Sudbury TAL metals = 23 metals per table B.17 of QAPP.

[9] PCBS at DCL will be sampled every 5 years.

AOC = Area of Contamination
TAL = Site-specific Target Analyte List
SPIA = South Post Impact Area
VOCs = Volatile Organic Compounds
EPH = Extractable Petroleum Hydrocarbons

VPH = Volatile Petroleum Hydrocarbons
MADEP = Massachusetts Department of Environmental Protection
PCBs = Polychlorinated Biphenyls
TDS = Total Dissolved Solids
COD = Chemical Oxygen Demand
TPH = Total Petroleum Hydrocarbons
TSS = Total Suspended Solids
TPH = Total Petroleum Hydrocarbons
NA = Not Applicable
TSS = Total Suspended Solids
-- = Analyze as soon as possible

Table 3.12
Action Levels

Chemical of Concern	MCP GW-1 (μg/L)	MCP GW-3 (μg/L)	Background[1] (μg/L)	SMCL (μg/L)	MCL[2] (μg/L)	MMCL[3] (μg/L)	Action Level (μg/L)
AOC 69W							
Arsenic	10	NA	10.5	NS	10	10	10.5
Iron	NS	NA	9,100	300	NS	NS	9,100[4,5]
Manganese	NS	NA	291	50	NS	NS	375[6]
VPH							
C5-C8 Aliphatic Hydrocarbons	300	NA	NS	NS	NS	300	300
C9-C12 Aliphatic Hydrocarbons	700	NA	NS	NS	NS	700	700
C9-C10 Aromatic Hydrocarbons	200	NA	NS	NS	NS	200	200
EPH							
C9-C18 Aliphatic Hydrocarbons	700	NA	NS	NS	NS	NS	700
C19-C36 Aliphatic Hydrocarbons	14,000	NA	NS	NS	NS	NS	14,000
C11-C22 Aromatic Hydrocarbons	200	NA	NS	NS	NS	NS	200
Bis (2-ethylhexyl) phthalate	6	NA	NS	NS	6	6	6
AOC 43G							
Iron	9,100	NS	9,100	300	NS	NS	9,100
Manganese	375	NS	291	50	NS	NS	291
VOCs							
Benzene	5	10,000	ND	NS	5	5	5
Toluene	1,000	40,000	ND	NS	1,000	1,000	1,000
Ethylbenzene	700	5,000	ND	NS	700	700	700
Xylenes (total)	10,000	5,000	ND	NS	10,000	10,000	10,000
VPH							
C5-C8 Aliphatic Hydrocarbons	300	NA	NS	NS	NS	300	300
C9-C12 Aliphatic Hydrocarbons	700	NA	NS	NS	NS	700	700
C9-C10 Aromatic Hydrocarbons	200	NA	NS	NS	NS	200	200
AOC 57 Area 3, Floodplain (Most stringent of all potential uses for upland and floodplain sub areas)							
Arsenic	10	900	10.5	NS	10	10	10.5
1,4-dichlorobenzene	5	8,000	NS	NS	75	5	5

Table 3.12
Action Levels

Chemical of Concern	**MCP GW-1 (µg/L)**	**MCP GW-3 (µg/L)**	**Background[1] (µg/L)**	**SMCL (µg/L)**	**MCL[2] (µg/L)**	**MMCL[3] (µg/L)**	**Action Level (µg/L)**
Tetrachloroethene	5	30,000	NS	NS	5	5	5
AOCs 32 and 43A							
Arsenic	10	900	10.5	NS	10	10	10.5
Manganese	NS	NS	3,500	50	NS	NS	3,500
VOCs							
Vinyl Chloride	2	50,000	NS	NS	2	2	2
1,2-dichloroethene (trans)	100	50,000	NS	NS	100	100	100
1,2-dichloroethene (cis)	55	50,000	NS	NS	70	70	55
1,1,1-trichloroethane	200	20,000	NS	NS	200	5	5
Trichloroethene	5	5,000	NS	NS	5	5	5
1,2-dichlorobenzene	600	2,000	NS	NS	600	600	600
1,3-dichlorobenzene	40	50,000	NS	NS	NS	NS	40
1,4-dichlorobenzene	5	8,000	NS	NS	75	NS	5
VPH							
Benzene	5	10,000	NS	NS	5	5	5
Ethylbenzene	700	5,000	NS	NS	700	700	700
Xylenes, total	10,000	5,000	NS	NS	10,000	10,000	10,000
Toluene	1,000	40,000	NS	NS	1,000	1,000	1,000
C5-C8 Aliphatic Hydrocarbons	300	50,000	NS	NS	NS	NS	300
C9-C12 Aliphatic Hydrocarbons	700	50,000	NS	NS	NS	NS	700
C9-C10 Aromatic Hydrocarbons	200	50,000	NS	NS	NS	NS	200
EPH							
C9-C18 Aliphatic Hydrocarbons	700	50,000	NS	NS	NS	NS	700
C19-C36 Aliphatic Hydrocarbons	14,000	50,000	NS	NS	NS	NS	5,000
C11-C22 Aromatic Hydrocarbons	200	5,000	NS	NS	NS	NS	200
DCL							
VPH							
C5-C8 Aliphatic Hydrocarbons	300	50,000	NS	NS	NS	NS	300

Table 3.12
Action Levels

Chemical of Concern	**MCP GW-1 (µg/L)**	**MCP GW-3 (µg/L)**	**Background[1] (µg/L)**	**SMCL (µg/L)**	**MCL[2] (µg/L)**	**MMCL[3] (µg/L)**	**Action Level (µg/L)**
C9-C12 Aliphatic Hydrocarbons	700	50,000	NS	NS	NS	NS	700
C9-C10 Aromatic Hydrocarbons	200	50,000	NS	NS	NS	NS	200
Methyl tert-butyl ether	70	50,000	NS	NS	NS	NS	70
Benzene	5	10,000	NS	NS	5	5	5
Toluene	1,000	40,000	NS	NS	1,000	1,000	1,000
Ethylbenzene	700	5,000	NS	NS	700	700	700
Xylenes, total	10,000	5,000	NS	NS	10,000	10,000	10,000
Naphthalene	140	20,000	NS	NS	NS	NS	140
EPH							
C9-C18 Aliphatic Hydrocarbons	700	50,000	NS	NS	NS	NS	700
C19-C36 Aliphatic Hydrocarbons	5,000	50,000	NS	NS	NS	NS	5,000
C11-C22 Aromatic Hydrocarbons	200	5,000	NS	NS	NS	NS	200
Target PAH Analytes							
2-Methylnaphthalene	10	20,000	NS	NS	NS	NS	10
Acenaphthene	20	6,000	NS	NS	NS	NS	20
Acenaphthylene	30	40	NS	NS	NS	NS	30
Anthracene	60	30	NS	NS	NS	NS	60
Benzo(a)anthracene	1	1,000	NS	NS	NS	NS	1
Benzo(a)pyrene	0.2	500	NS	NS	0.2	0.2	0.2
Benzo(b)fluoranthene	1	400	NS	NS	NS	NS	1
Benzo(g,h,i)perylene	50	20	NS	NS	NS	NS	50
Benzo(k)fluoranthene	1	100	NS	NS	NS	NS	1
Chrysene	2	70	NS	NS	NS	NS	2
Dibenzo(a,h)anthracene	0.5	40	NS	NS	NS	NS	0.5
Fluoranthene	90	200	NS	NS	NS	NS	90
Fluorene	30	40	NS	NS	NS	NS	30
Indeno(1,2,3-cd)pyrene	0.5	100	NS	NS	NS	NS	0.5
Naphthalene	140	20,000	NS	NS	NS	NS	140

Table 3.12
Action Levels

Chemical of Concern	**MCP GW-1 (µg/L)**	**MCP GW-3 (µg/L)**	**Background[1] (µg/L)**	**SMCL (µg/L)**	**MCL[2] (µg/L)**	**MMCL[3] (µg/L)**	**Action Level (µg/L)**
Phenanthrene	40	10,000	NS	NS	NS	NS	40
Pyrene	80	20	NS	NS	NS	NS	80
Pesticides							
Hexachlorobenzene	1	6,000	NS	NS	1	1	1
4,4’-DDD	0.2	50	NS	NS	NS	NS	0.2
4,4’-DDE	0.05	400	NS	NS	NS	NS	0.05
4,4’-DDT	0.3	1	NS	NS	NS	NS	0.3
Aldrin	0.5	20	NS	NS	NS	NS	0.5
alpha-BHC	500	NS	NS	NS	NS	NS	500
alpha-Chlordane	2	2	NS	NS	NS	NS	2
beta-BHC	100	NS	NS	NS	NS	NS	100
delta-BHC	100	NS	NS	NS	NS	NS	100
Dieldrin	0.1	0.5	NS	NS	NS	NS	0.1
Endosulfan I	0.1	NS	NS	NS	NS	NS	10
Endosulfan II	10	2	NS	NS	NS	NS	0.1
Endosulfan sulfate	0.1	NS	NS	NS	NS	NS	0.1
Endrin	2	5	NS	NS	2	2	2
Endrin aldehyde	100	NS	NS	NS	NS	NS	100
Endrin ketone	100	NS	NS	NS	NS	NS	100
Gamma-BHC(1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer or Lindane)	0.2	4	NS	NS	0.2	0.2	0.2
Heptachlor	0.4	1	NS	NS	0.4	0.4	0.4
Heptachlor epoxide	0.2	2	NS	NS	0.2	0.2	0.2
Methoxychlor	40	10	NS	NS	40	40	40
Total Chlordane	2	2	NS	NS	2	2	2
Toxaphene	100	NS	NS	NS	3	3	100

Table 3.12
Action Levels

Chemical of Concern	MCP GW-1 (µg/L)	MCP GW-3 (µg/L)	Background[1] (µg/L)	SMCL (µg/L)	MCL[2] (µg/L)	MMCL[3] (µg/L)	Action Level (µg/L)
Metals							
Arsenic	10	900	NS	NS	10	10	10
Barium	2,000	50,000	NS	NS	2,000	2,000	2,000
Cadmium	5	4	NS	NS	5	5	5
Chromium	100	300	NS	NS	100	100	100
Copper	NS	NS	NS	1,000	1,300	1,300	1,300
Iron	NS	NS	NS	300	NS	NS	300
Lead	15	10	NS	NS	15	15	15
Manganese	NS	NS	NS	50	NS	NS	50
Silver	100	7	NS	100	NS	NS	100
Selenium	50	100	NS	NS	50	50	50
Mercury	2	20	NS	NS	2	2	2
Wet Chemistry							
Solids, Total Dissolved	NS	NS	NA	500,000	NS	NS	500,000
Anions							
Chloride	NS	NS	NA	250,000	NS	NS	250,000
Sulfate	NS	NS	NA	250,000	NS	NS	250,000
Nitrate/Nitrite							
Nitrate/Nitrite (as N)	NS	NS	NS	NS	10,000	10,000	10,000
Alkalinity, Total							
As CaCO3	NS	NS	NS	NS	NS	NS	NS
Cyanide							
Cyanide, total	200	30	NS	NS	200	200	200
COD							
Chemical Oxygen Demand	NS	NS	NS	NS	NS	NS	NS
Sudbury Annex (AOC A7)							
VOCs							
1,1,1,2-Tetrachloroethane	5	50,000	NS	NS	NS	NS	5

Table 3.12
Action Levels

Chemical of Concern	MCP GW-1 (μg/L)	MCP GW-3 (μg/L)	Background[1] (μg/L)	SMCL (μg/L)	MCL[2] (μg/L)	MMCL[3] (μg/L)	Action Level (μg/L)
1,1,1-Trichloroethane	200	20,000	NS	NS	200	5	5
1,1,2,2-Tetrachloroethane	2	50,000	NS	NS	NS	NS	2
1,1,2-Trichloroethane	5	50,000	NS	NS	NS	NS	5
1,1-Dichloroethane	70	20,000	NS	NS	NS	NS	70
1,1-Dichloroethene	7	30,000	NS	NS	NS	NS	7
1,1-Dichloropropene	NS	NS	NS	NS	NS	NS	NS
1,2,3-Trichlorobenzene	NS	NS	NS	NS	NS	NS	NS
1,2,3-Trichloropropane	NS	NS	NS	NS	NS	NS	NS
1,2,4-Trichlorobenzene	70	50,000	NS	NS	NS	NS	70
1,2,4-Trimethylbenzene	NS	NS	NS	NS	NS	NS	NS
1,2-Dibromo-3-chloropropane (DBCP)	NS	NS	NS	NS	NS	NS	NS
1,2-Dibromoethane (EDB)	0.02	50,000	NS	NS	NS	NS	0.02
1,2-Dichlorobenzene	600	2,000	NS	NS	NS	NS	600
1,2-Dichloroethane	5	20,000	NS	NS	NS	NS	5
1,2-Dichloropropane	5	20,000	NS	NS	NS	NS	5
1,3,5-Trimethylbenzene	NS	NS	NS	NS	NS	NS	NS
1,3-Dichlorobenzene	40	50,000	NS	NS	NS	NS	40
1,3-Dichloropropane	0.4	10	NS	NS	NS	NS	0.4
1,4-Dichlorobenzene	5	8,000	NS	NS	NS	NS	5
2,2-Dichloropropane	NS	NS	NS	NS	NS	NS	NS
2-Butanone	4,000	50,000	NS	NS	NS	NS	4,000
2-Chlorotoluene	NS	NS	NS	NS	NS	NS	NS
2-Hexanone	NS	NS	NS	NS	NS	NS	NS
4-Chlorotoluene	NS	NS	NS	NS	NS	NS	NS
4-Isopropyltoluene	NS	NS	NS	NS	NS	NS	NS
4-Methyl-2-Pentanone (MIBK)	350	50,000	NS	NS	NS	NS	350
Acetone	6,300	50,000	NS	NS	NS	NS	6,300
Benzene	5	10,000	NS	NS	NS	NS	5

Table 3.12
Action Levels

Chemical of Concern	MCP GW-1 (µg/L)	MCP GW-3 (µg/L)	Background[1] (µg/L)	SMCL (µg/L)	MCL[2] (µg/L)	MMCL[3] (µg/L)	Action Level (µg/L)
Bromobenzene	NS	NS	NS	NS	NS	NS	NS
Bromochloromethane	NS	NS	NS	NS	NS	NS	NS
Bromodichloromethane	3	50,000	NS	NS	NS	NS	3
Bromoform	4	50,000	NS	NS	NS	NS	4
Bromomethane	10	800	NS	NS	NS	NS	10
Carbon Disulfide	NS	NS	NS	NS	NS	NS	NS
Carbon Tetrachloride	5	5,000	NS	NS	NS	NS	5
Chlorobenzene	100	1,000	NS	NS	NS	NS	100
Chloroethane	NS	NS	NS	NS	NS	NS	NS
Chloroform	70	20,000	NS	NS	NS	NS	70
Chloromethane	NS	NS	NS	NS	NS	NS	NS
cis-1,2-Dichloroethene	70	50,000	NS	NS	NS	NS	70
cis-1,3-Dichloropropene	0.4	200	NS	NS	NS	0.4	0.4
Dibromochloromethane	2	50,000	NS	NS	NS	NS	2
Dibromomethane	NS	NS	NS	NS	NS	NS	NS
Dichlorodifluoromethane (Freon 12)	NS	NS	NS	NS	NS	NS	NS
Ethylbenzene	700	5,000	NS	NS	NS	NS	700
Hexachlorobutadiene	0.6	3,000	NS	NS	NS	NS	0.6
Isopropylbenzene	NS	NS	NS	NS	NS	NS	NS
m-Xylene & p-Xylene	10,000	5,000	NS	NS	NS	NS	10,000
Methyl tert-Butyl Ether	70	50,000	NS	20-40	NS	NS	70
Methylene Chloride	5	50,000	NS	NS	NS	NS	5
Naphthalene	140	20,000	NS	NS	NS	NS	140
n-Butylbenzene	NS	NS	NS	NS	NS	NS	NS
n-Propylbenzene	NS	NS	NS	NS	NS	NS	NS
o-Xylene	10,000	5,000	NS	NS	NS	NS	5,000
sec-Butylbenzene	NS	NS	NS	NS	NS	NS	NS
Styrene	100	6,000	NS	NS	NS	NS	100

Table 3.12
Action Levels

Chemical of Concern	MCP GW-1 (μg/L)	MCP GW-3 (μg/L)	Background[1] (μg/L)	SMCL (μg/L)	MCL[2] (μg/L)	MMCL[3] (μg/L)	Action Level (μg/L)
tert-Butylbenzene	NS	NS	NS	NS	NS	NS	NS
Tetrachloroethene	5	30,000	NS	NS	5	5	5
Toluene	1,000	40,000	NS	NS	1,000	1,000	1,000
trans-1,2-Dichloroethene	100	50,000	NS	NS	NS	NS	100
trans-1,3-Dichloropropene	0.4	200	NS	NS	NS	NS	0.4
Trichloroethene	5	5,000	NS	NS	5	5	5
Trichlorofluoromethane (Freon 11)	NS	NS					
Vinyl Chloride (chloroethene)	2	50,000	NS	NS	2	2	2
Pesticides							
4,4’-DDD	0.2	50	NS	NS	NS	NS	0.2
4,4’-DDE	0.05	400	NS	NS	NS	NS	0.05
4,4’-DDT	0.3	1	NS	NS	NS	NS	0.3
Aldrin	0.5	20	NS	NS	NS	NS	0.5
alpha-BHC	500	NS	NS	NS	NS	NS	500
alpha-Chlordane	2	2	NS	NS	NS	NS	2
beta-BHC	100	NS	NS	NS	NS	NS	100
delta-BHC	100	NS	NS	NS	NS	NS	100
Dieldrin	0.1	0.5	NS	NS	NS	NS	0.1
Endosulfan I	0.1	NS	NS	NS	NS	NS	10
Endosulfan II	10	2	NS	NS	NS	NS	0.1
Endosulfan sulfate	0.1	NS	NS	NS	NS	NS	0.1
Endrin	2	5	NS	NS	2	2	2
Endrin aldehyde	100	NS	NS	NS	NS	NS	100
Endrin ketone	100	NS	NS	NS	NS	NS	100
Gamma-BHC(1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer or Lindane)	0.2	4	NS	NS	0.2	0.2	0.2
gamma-Chlordane	2	NS	NS	NS	NS	NS	2

Table 3.12
Action Levels

Chemical of Concern	MCP GW-1 (µg/L)	MCP GW-3 (µg/L)	Background[1] (µg/L)	SMCL (µg/L)	MCL[2] (µg/L)	MMCL[3] (µg/L)	Action Level (µg/L)
Heptachlor	0.4	1	NS	NS	0.4	0.4	0.4
Heptachlor epoxide	0.2	2	NS	NS	0.2	0.2	0.2
Methoxychlor	40	10	NS	NS	40	40	40
Total Chlordane	2	2	NS	NS	2	2	2
Toxaphene	100	NS	NS	NS	3	3	100
TAL Metals							
Aluminum	NS	NS	NS	50-200	NS	NS	50-200
Antimony	5	6	NS	NS	NS	NS	5
Arsenic	10	900	10.5	NS	10	10	10.5
Barium	2,000	50,000	NS	NS	2,000	2,000	2,000
Beryllium	4	4	NS	NS	NS	NS	4
Cadmium	5	4	NS	NS	5	5	5
Calcium	NS	NS	NS	NS	NS	NS	NS
Chromium	100	300	NS	NS	100	100	100
Cobalt	NS	NS	NS	NS	NS	NS	NS
Copper	NS	NS	NS	1,000	1,300	1,300	1,300
Iron	NS	NS	NS	300	NS	NS	300
Lead	15	10	NS	NS	15	15	15
Magnesium	NS	NS	NS	NS	NS	NS	NS
Manganese	NS	NS	NS	50	NS	NS	50
Mercury	2	20	NS	NS	2	2	2
Nickel	100	200	NS	NS	NS	NS	100
Potassium	NS	NS	NS	NS	NS	NS	NS
Selenium	50	100	NS	NS	NS	NS	50
Silver	100	7	NS	100	NS	NS	7
Sodium	NS	NS	NS	NS	NS	NS	NS
Thallium	2	3,000	NS	NS	NS	NS	2
Vanadium	30	4,000	NS	NS	NS	NS	30

Table 3.12
Action Levels

Chemical of Concern	**MCP GW-1 (µg/L)**	**MCP GW-3 (µg/L)**	**Background[1] (µg/L)**	**SMCL (µg/L)**	**MCL[2] (µg/L)**	**MMCL[3] (µg/L)**	**Action Level (µg/L)**
Zinc	5,000	900	NS	500	NS	NS	900
Cyanide							
Cyanide, total	200	30	NS	NS	200	200	200
COD							
Chemical Oxygen Demand	NS	NS	NS	NS	NS	NS	NS

Notes:

[1] Background concentrations determined from wells at selected locations in each AOC. Refer to Remedial Investigation Report for each AOC.

[2] Drinking Water Regulations and Health Advisories", October 1996, USEPA Office of Water.

[3] Drinking Water Standards & Guidelines for Chemicals in Massachusetts Drinking Waters", May 1998, Massachusetts Department of Environmental Protection.

NA = Not applicable.
ND = Non-detect.
NS = No standard.
MCL = Maximum Contaminant Level.
MMCL = Massachusetts Maximum Contaminant Level.
SMCL = Secondary MCL based on aesthetics.

Table 3.13
Surface Water Quality Criteria

Chemical of Concern	Units	USEPA Water Quality Criteria[1]
AOC 57 Area 3		
Metals		
Arsenic, Dissolved	µg/L	150
Iron, Dissolved	µg/L	1,000
Manganese, Total	µg/L	NS

Notes:

All general terms, laboratory indicators and data qualifiers are defined on the Key for Tables found at the beginning of this section.
[1] Criterion Continuous Concentration

Water Quality Criteria published by USEPA pursuant to Section 304(a) of the Clean Water Act and provide guidance for states and tribes to use in adopting water quality standards.
For Contaminants of Concern (COCs) without Water Quality Criteria a qualitative comparison will be made between the detected concentrations in groundwater and COC concentrations in surface water to determine if groundwater discharge is impacting surface water.
NS = No standard.

Table 3.14
SPIA Groundwater Quality Comparison Values

Chemical of Potential Concern	MCP GW-1 (μg/L)	MCP GW-3 (μg/L)	Background[1] (μg/L)	SMCL (μg/L)	MCL[2] (μg/L)	MMCL[3] (μg/L)
AOC 26, AOC 27 and SPM Wells						
Metals						
Aluminum	NS	NS	6,870	50-200	NA	NA
Antimony	6	8,000	3.03	NS	6	6
Arsenic	10	900	10.5	NS	10	10
Barium	2,000	50,000	39.6	NS	2,000	2,000
Beryllium	4	200	5	NS	4	4
Cadmium	5[4]	4	4.01	NS	5	5
Calcium	NS	NS	14,700	NS	NS	NS
Chromium	100	300	14.7	NS	100	100
Cobalt	NS	NS	25	NS	NS	NS
Copper	NS	NS	8.09	1,000	1,300	1,300
Iron	NS	NS	9,100	300	NS	NS
Lead	15	10	4.25	NS	15	15
Magnesium	NS	NS	3,480	NS	NS	NS
Manganese	NS	NS	291	50	NS	NS
Mercury	2	20	0.243	NS	2	2
Nickel	100	200	34.3	NS	NS	NS
Potassium	NS	NS	2,370	NS	NS	NS
Selenium	50	100	3.02	NS	50	50
Silver	100[5]	7	4.6	100	NS	100
Sodium	NS	NS	10,800	NS	NS	NS
Thallium	2	3,000	6.99	NS	2	2
Vanadium	30	4,000	11	NS	NS	NS
Zinc	5,000[4]	900	21.1	5,000	NS	NS
Explosives						
1,3,5-Trinitrobenzene	NS	NS	NS	NS	NS	NS
1,3-Dinitrobenzene	NS	NS	NS	NS	NS	NS
2,4,6-Trinitrotoluene	NS	NS	NS	NS	NS	NS
2,4-Dinitrotoluene	30	50,000	NS	NS	NS	NS

Table 3.14
SPIA Groundwater Quality Comparison Values

Chemical of Potential Concern	**MCP GW-1 (μg/L)**	**MCP GW-3 (μg/L)**	**Background[1] (μg/L)**	**SMCL (μg/L)**	**MCL[2] (μg/L)**	**MMCL[3] (μg/L)**
2,6-Dinitrotoluene	NS	NS	NS	NS	NS	NS
2-Amino-4,6-dinitrotoluene	NS	NS	NS	NS	NS	NS
2-Nitrotoluene	NS	NS	NS	NS	NS	NS
3-Nitrotoluene	NS	NS	NS	NS	NS	NS
4-Amino-2,6-Dinitrotoluene	NS	NS	NS	NS	NS	NS
4-Nitrotoluene	NS	NS	NS	NS	NS	NS
Cyclonite (RDX)	1[4]	50,000	NS	NS	NS	NS
HMX	200[4]	50,000	NS	NS	NS	NS
Nitrobenzene	NS	NS	NS	NS	NS	NS
Tetryl	NS	NS	NS	NS	NS	NS
AOC 26 only						
Perchlorate	2[5]	1,000	NS	NS	NS	2[5]

Notes:

[1] Metals background levels were adapted from Devens from Final Remedial Investigation Report Area of Contamination (AOC) 57 Appendix L.

[2] Drinking Water Regulations and Health Advisories", October 1996, USEPA Office of Water.

[3] Drinking Water Standards & Guidelines for Chemicals in Massachusetts Drinking Waters", May 1998, Massachusetts Department of Environmental Protection.

[4] Revised GW-1 standard effective February 14, 2008.

[5] From final changes to the MCP-310 CMR 40.0000, July 28,2006.

NA = Not applicable.
NS = No standard.
MCL = Maximum Contaminant Level.
SMCL = Secondary MCL based on aesthetics.
MMCL = Massachusetts Maximum Contaminant Level.

Table 3.15
Sampling and Analytical Summary
IDW Sampling and Disposal

Sample Type/ Matrix	Analytical Parameter (Method Number)	Number of Field Samples	Field QC Samples				Holding Times	Preservation Requirements	Sample Containers (per sample)	Total Sample Containers
			Duplicates	Equipment Rinsate	MS/ MSD	Trip Blanks				
Decontamination and well purge water to be stored in 55-gallon drums or other approved containers	RCRA VOCs (SW8260B)	1	0	0	0	0	14 Days	Ice to 4 °C, HCl	Two 40-ml GSV	3
	RCRA SVOCs (SW8270C)	1	0	0	0	0	7 Days	Ice to 4 °C	One 1-L Amber Glass	1
	RCRA Metals (SW6010B)	1	0	0	0	0	6 Months	Ice to 4 °C HNO_3	One 1-L Poly	1
	RCRA Pesticides (SW8081A)	1	0	0	0	0	14 Days	Ice to 4 °C	Two 1-L Amber Glass	2
	RCRA Herbicides (SW8151A)	1	0	0	0	0	7 Days	Ice to 4 °C, $Na_2S_2O_3$	Two 1-L Amber Glass	2
	Ignitability, water (SW1030)	1	0	0	0	0	30 Days	None	One 200-ml Glass	1
	Corrosivity, water (SW9040C)	1	0	0	0	0	Analyze Immediately	None	One 50-ml Plastic or Glass	1
	Cyanide (SW9012B)	1	0	0	0	0	14 Days	NaOH	One 500-ml Plastic	1
	Sulfide (SW9030B)	1	0	0	0	0	None	Ice to 4 °C	One 100-g Glass	1
	Mercury (SW7470A)	1	0	0	0	0	28 Days	HNO_3	One 500-ml Plastic or Glass	1

Notes:

°C – degree Celsius
GSV – Glass Septum Vial
HCl – Hydrochloric Acid
L – Liter
ml – Milliliter
HNO_3 – Nitric Acid
MS - Matrix Spike
oz – ounce
Poly – Polyethylene Bottle
RCRA – Resource Conservation and Recovery Act
QC – Quality Control
VOC – Volatile Organic Compound
SVOC - Semi-volatile Organic Compound
MSD - Matrix Spike Duplicate

Table 4.1 - ROD Objective LUCs

Site	Site specific ROD objective LUCS	Site specific implementation elements per LTMMP to meet ROD objective elements	Documents[1] used to implement/monitor/enforce LUCs
AOC 57	Prohibit the potable use of groundwater and residential use of floodplain property are currently in effect at AOC 57.	I Site Information II Documentation & Records III Physical On-site Inspection IV Interview V Response Actions	ROD 2001; LIFOC agreement (May 1996) that included AOC 57 property[2]
AOC 69W	Prohibit potable use of groundwater and prevent unrestricted use of the property.	I Site Information II Documentation & Records III Physical On-site Inspection IV Interview V Response Actions	ROD 1999; FOST, Parcel A.15_November 2006[2]
AOC 43G	The property can not be used for residential purposes and prohibits the use of groundwater beneath the site.	I Site Information II Documentation & Records III Physical On-site Inspection IV Interview V Response Actions	ROD 1996; Real Property Master Plan Long Range Component for Devens Reserve Forces Training Area Addendum – September 2007
DCL	Restriction of residential development within the three sites (AOCs 9, 40, and SA 13).	I Site Information II Documentation & Records III Physical On-site Inspection IV Interview V Response Actions	ROD 1999; FOST, AOCs 9, 40, and SA 13_March 2006[2]
AOCs 32 and 43A	Ensure that exposure to and extraction of groundwater from the site for industrial and/or potable water supply would not be permitted.	I Site Information II Documentation & Records III Physical On-site Inspection IV Interview V Response Actions	ROD 1998; FOST_May 2000[2]
Grant Housing Area and 37-mm Impact Area	(1) Public education to property owners, residents, as well as any construction and/or utility contractors conducting ground intrusive activities on the property; and (2) A deed notice will be inserted by MassDevelopment into any Grant Housing deeds in which conveys that there is no evidence of additional UXO present at the site, but that the possibility does remain that UXO could be discovered in the future.	I Site Information II Documentation & Records III Physical On-site Inspection IV Interview V Response Actions	ROD 2009; LUCIP 2011
Sudbury Annex (A7)	Prohibit the use of site groundwater as drinking water at AOC A7.	I Site Information II Documentation & Records III Physical On-site Inspection IV Interview V Response Actions	ROD 1995; ROD 1997; Memorandum of Agreement (MOA) between the Army and the USFWS dated 28 September 2000
SPIA	There are no current or future plans for installation of potable water wells within the SPIA. The Army will maintain possession of the SPIA for the foreseeable future. If the property transfers in the future, LUCs will be incorporated into the property deed or other instrument of property transfer.	I Documentation & Records II Physical On-site Inspection III Interview	Real Property Master Plan Long Range Component for Devens Reserve Forces Training Area Addendum – September 2007

Notes:

* All sites have annual reporting and five-year site reviews.

[1] Referenced document or pertinent excerpt included in Appendix G.

[2] Administrative LUCs would be developed and detailed within FOST and included in Deed prior to transfer of the land parcels.

Table 5.1
Summary of Sampling and Reporting Requirements

Report/Sample	Frequency
AOC 57	
Site Inspection/Groundwater Sampling/Institutional Control Inspection	Every 5 Years[1]
Groundwater Analytical Data to USEPA and MassDEP	Within 60 Days of Sampling
Annual Data Report to USEPA and MassDEP	Every 5 Years
Annual Institutional Control Interview	Every 5 Years
Site Review/Report	Every 5 Years
AOCs 32 and 43A	
Site Inspection/Groundwater Sampling (LTM)	Annual[1]
Groundwater Analytical Data to USEPA and MassDEP	Within 60 Days of Sampling
Annual Data Report to USEPA and MassDEP	Annual
Annual Institutional Control Interview	Annual
Site Review/Report	Every 5 Years
AOC 69W, and SPIA (AOC 26 and SPM wells)	
Site Inspection/Groundwater Sampling	Annual[2]
Groundwater Analytical Data to USEPA and MassDEP	Within 60 Days of Sampling
Site Review/Report	Every 5 Years
Annual Data Report to USEPA and MassDEP	Annual
AOC 27	
Site Inspection/Groundwater Sampling	Biennial[2]
Groundwater Analytical Data to USEPA and MassDEP	Within 60 Days of Sampling
Site Review/Report	Every 5 Years
Annual Data Report to USEPA and MassDEP	Biennial
AOC 43G	
Site Inspection/Groundwater Sampling	Annual[2]
Groundwater Analytical Data to USEPA and MassDEP	Within 60 Days of Sampling
Site Review/Report	Every 5 Years
Annual Data Report to USEPA and MassDEP	Annual
Devens Consolidation Landfill	
Groundwater Sampling	Semi-annual[2]
Groundwater Analytical Data to USEPA and MassDEP	Within 60 Days of Sampling
Leachate Effluent Sampling	Annual[2]
Leachate Sampling Data to MassDev	By January 5th of the Following Year
Site Review/Report	Every 5 Years
Annual Data Report to USEPA and MassDEP	Annual
Site Inspection	Annual[1]
Sudbury Landfill, AOC A7	
Groundwater Sampling	Annual[2]
Groundwater Analytical Data to USEPA	Within 60 Days of Sampling
Site Inspection	Annual[2]
Annual Data Report to USEPA	Annual[2]
Annual Institutional Control Interview	Annual[2]
Site Review	Every 5 Years
AOCs P31 and P58	
Institutional Control Inspection	Annual[2]
Site Review/Report	Every 5 Years
Grant Housing Area and 37-mm Impact Area	
LUC Inspection	Annual
LUC Compliance Report	Annual

Notes:
[1] April/May
[2] October/November

APPENDIX A

OPTIMIZATION EVALUATION FOR LONG-TERM MONITORING AND MAINTENANCE FORMER FORT DEVENS ARMY INSTALLATION AND SUDBURY ANNEX

OPTIMIZATION EVALUATION
FOR
LONG-TERM MONITORING
AND MAINTENANCE
FORMER FORT DEVENS ARMY INSTALLATION
AND
SUDBURY ANNEX

FORMER FORT DEVENS ARMY INSTALLATION, DEVENS, MA
SUDBURY ANNEX, SUDBURY, MA

FEBRUARY 2015

Prepared for:
U.S. Army Corp of Engineers
New England District
Concord, Massachusetts

Prepared by:
Sovereign Consulting Inc.
and HydroGeoLogic, Inc.
Contract No.: W912WJ-10-D-0003
Task Order: 004

NOTICE

The United States Department of Defense, Department of Army, funded wholly or in part the preparation of this document and work described herein under Contract No. W912WJ-10-D-0003 and Task Order 004. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

OPTIMIZATION EVALUATION FOR LONG-TERM MONITORING AND MAINTENANCE FORMER FORT DEVENS ARMY INSTALLATION AND SUDBURY ANNEX

February 2015

CERTIFICATION:

I hereby certify that the enclosed Report, shown and marked in this submittal, is that proposed to be incorporated with Contract Number W912WJ-10-D-0003 TO#004. This document was prepared in accordance with the U.S. Army Corps of Engineers (USACE) Scope of Work and is hereby submitted for Government Approval.

Reviewed By:

2/20/2015

Sovereign Project Manager **Date**

Eric D. Simpson 2/20/2015

Sovereign Quality Control Manager **Date**

Received By:

2/24/2015

USACE Project Manager

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LIST OF ACRONYMS AND ABBREVIATIONS

AAFES	Army Air Force Exchange Service
ABB	ABB Environmental Services, Inc.
AOC	area of contamination
ARAR	applicable or relevant and appropriate requirements
AREE	Areas Requiring Environmental Evaluation
Army	U.S. Army
AST	above-ground storage tanks
ATEC	ATEC Environmental Consultants
bgs	below ground surface
BLRA	Baseline Risk Assessment
BRAC	Base Realignment and Closure
BTEX	benzene, toluene, ethylbenzene, xylenes
CA	cost analysis
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CMR	Code of Massachusetts Regulations
COC	contaminant of concern
COPC	chemicals of potential concern
CSM	conceptual site model
cy	cubic yards
DCB	dichlorobenzene
DCL	Devens Consolidation Landfill
Devens	former Fort Devens Army Installation
DFAE	Directorate of Facilities and Engineering
DoD	Department of Defense
DRFTA	Devens Reserve Forces Training Area
DRMO	Defense Reutilization and Marketing Office
EE	engineering evaluation
EOD	explosive ordinance discharge
EPH	extractable petroleum hydrocarbons
ESD	Explanation of Significant Difference
FS	feasibility study
ft/day	feet per day
ft^2	square feet
GPS	global positioning system
GUVD	Groundwater Use and Value Determination
HGL	HydroGeoLogic, Inc.
HLA	Harding Lawson Associates
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazo

INRMP	Integrated Natural Resources Management Plan
ITRC	Interstate Technology and Regulatory Council
LCRS	leachate collection and recovery system
LEL	lower explosive limit
LTM	long-term monitoring
LTMM	long-term monitoring and maintenance
LTMP	Long-Term Monitoring Plan
LTMMP	Long-Term Monitoring and Maintenance Plan
LTMO	long-term monitoring optimization
LUC	Land-Use Control
µg/L	micrograms per liter
MAROS	Monitoring and Remediation Optimization System
MassDEP	Massachusetts Department of Environmental Protection
MCL	maximum contaminant level
MCP	Massachusetts Contingency Plan
mg/kg	milligrams per kilogram
MMCL	Massachusetts Maximum Contaminant Level
NAPL	non-aqueous phase liquid
NDCEE	National Defense Center for Energy and Environment
NFA	no further action
NPL	National Priorities List
O&M	operations and maintenance
OER	Optimization Evaluation Report
ORP	oxidation-reduction potential
%	percent
PAH	polynuclear aromatic hydrocarbons
PCB	polychlorinated biphenyls
PCC	post closure care
PCE	tetrachloroethene
POL	petroleum, oils, and lubricant
RCRA	Resource Conservation and Recovery Act
RDX	1,3,5-trinitroperhydro-1,3,5-triazine
RI	remedial investigation
ROD	record of decision
RPD	relative percent difference
SA	study area
Sovereign	Sovereign Consulting Inc.
SOW	Statement of Work
SPIA	South Post Impact Area
SPM	south post monitoring

SVE	soil vapor extraction
SVOC	semi-volatile organic compounds
TAL	target analyte list
TCE	trichloroethene
TCL	target compound list
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
UST	underground storage tank
VOC	volatile organic compound
VPH	volatile petroleum hydrocarbons

EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (USACE)-New England District contracted Sovereign Consulting Inc. (Sovereign) to perform an optimization evaluation of the long-term monitoring (LTM) program at the Main and South Post areas of contamination (AOC) at the former Fort Devens Army Installation (Devens) located in Devens, Massachusetts, and the Sudbury Annex located in Sudbury, Massachusetts. The purpose of the optimization evaluation is to evaluate the Devens and Sudbury AOCs with the goal of optimizing the LTM program. The optimization was performed using quantitative and qualitative analyses of LTM data collected from 2009 through 2011 and appended to LTM data presented in the 2008 Long-Term Monitoring Plan (LTMP) for the Main Post and SPIA AOCs and the 2009 Long Term Monitoring and Maintenance Plan (LTMMP) for the Sudbury Annex AOC. The 2008 and 2009 documents presented detailed qualitative analyses of data trends and provided recommendations for LTM optimization. Most of the optimization recommendations presented in the 2008 LTMP have been implemented. The 2009 through 2012 data were added to the previous LTM data set and evaluated to determine if additional optimization was warranted or if new trends were evident that potentially supported performing further optimization, including eliminating sites from the LTM program. The scope of this optimization did not involve detailed statistical analyses, additional risk assessments or modeling of data to determine future trends; however, analyses of select data using the Monitoring and Remediation Optimization System (MAROS) was performed to substantiate qualitative interpretations.

In the most recent version of the LTMP, the U.S. Army (Army) recommended LTM optimization with the intent of proceeding to eventual site closure. The Army's rationale for implementing LTM optimization included the following:

- The LTM sites do not pose a risk to human health and the environment based on the lack of an exposure pathway. This is based on the fact that institutional controls (IC) are in place. In addition, historical groundwater monitoring data indicate that the concentrations of contaminants of concern (COC) are either stable, or in most cases, steadily declining since monitoring inception.
- The LTM site conditions (as established by prior removal actions), remaining source/groundwater COC concentrations, and current and historical monitoring data do not indicate (and are not conducive to) any significant contaminant migration beyond the boundary of the monitoring networks.

This document updates the recommendations provided in the former Fort Devens LTMP and Sudbury Annex LTMMP and incorporates the Army's rationale for optimization as stated above. The scope of this document includes LTM activities at Main Post AOC 57, AOC 69W, AOC 43G, the South Post Impact Area (SPIA) AOCs, the Devens Consolidation Landfill (DCL), AOCs 32 and 43A, and Sudbury Annex. The active SPIA AOCs consist of AOC 26 and AOC 27. Depth to water measurements at SPIA AOC 25 and AOC 41 are collected on a 5-year cycle only. AOC 41 was approved for closure following the 2006 calendar year LTM cycle. A brief description of each site included within the scope of this project follows.

- AOC 57: Located between Barnum Road and Cold Spring Brook on the northeast side of what was formerly the Main Post of Devens and what was used primarily as a storage and maintenance area for military vehicles. The main portion of the site is a former solar panel manufacturing facility. The active portions of AOC 57 consist of Area 2 and Area 3.
- AOC 69W: Located at the northeast corner of the intersection of Jackson Road and Antietam Street on the northern portion of what was formerly the Main Post at Devens. AOC 69W consists of the former Devens Elementary School (Building 215) and its associated parking lot and adjacent lawn, extending approximately 300 feet northwest to Willow Brook.
- AOC 43G: Located in the central portion of the former main post of Devens and consists of the former Army Air Force Exchange Service (AAFES) gas station and historical post gas station. This AOC remains entirely within the Army Garrison property.
- SPIA: Located in the area known as the South Post of former Fort Devens. The SPIA is a 964-acre area actively used for firearm and grenade training, as well as open burning and detonation of explosives.
- DCL: Located in the former Main Post of Devens and constructed at the location of the former golf course driving range between 2000 and 2002 to provide an on-site landfill for debris from six individual remedial areas.
- AOCs 32 and 43A: AOCs 32 and 43A were known as the Defense Reutilization and Marketing Office (DRMO) Yard, and the petroleum, oils and lubricant (POL) storage areas, respectively. AOC 32 consisted of three fenced areas (DRMO west yard, DRMO east yard, and tire recycling area) along Cook Street. AOC 43A was located across Market Street from AOC 32. AOC 43A consisted of a fenced lot located within an industrial area and served as the distribution point for all gasoline and other fuels at Devens from the 1940s to 1996.
- Sudbury Annex: AOC A7 is located at the former Sudbury Training Annex in Sudbury, Massachusetts. AOC A7 is a former waste disposal site in the northern portion of the former training annex. The Resource Conservation and Recovery Act (RCRA) Subtitle C landfill cap was installed in 1996.

The environmental programs at each of the sites are mature. Remedial Investigations (RI), Feasibility Studies (FS), and Record of Decisions (ROD) were completed for each of the sites. In addition, active remediation has been conducted at most of these sites. In accordance with the RODs, LTM activities consisting of environmental monitoring and land use control (LUC) inspections are routinely conducted. To date, the LTM program implemented at the sites has spanned several years. **Table ES-1** summarizes the results of the LTM program evaluation.

In addition to the trend evaluation, sampling procedures and technology were evaluated for optimization potential. At several sites, HydraSleeve™ sampling can replace traditional low-flow sampling technology. HydraSleeve™ is a proven, no-purge groundwater sampling method that significantly reduces sampling time and equipment needs. (Studies have been performed demonstrating that the analytical results of samples collected using the HydraSleeve™ compare well with samples collected by the low-flow method.)

Based on an evaluation of trends in contaminant concentrations, the following sites are recommended for a reduction in monitoring frequency: AOC 43G, AOCs 32 and 43A, AOC 57, and the DCL.

The following is a summary of the recommended optimization:

AOC 57:

- Change the groundwater monitoring frequency at Area 3 from annual to every 5 years to coincide with the five-year reviews.
- Use HydraSleeve™ technology to perform groundwater sampling at Area 3.
- Eliminate volatile organic compounds (VOC) from the groundwater and surface water COC list for Area 3.
- Discontinue sampling of surface water and groundwater from all wells at Area 2.
- Decommission sumps at Area 2.
- Prepare technical memorandum for AOC 57 presenting site specific information that supports justification for site closure and path forward.

AOC 69W:

- Eliminate volatile petroleum hydrocarbons (VPH) carbon ranges and target analytes from the LTM program.
- Install an additional sentry wellpoint downgradient of the existing wellpoint 69WP-08-01 to characterize manganese concentrations in groundwater.
- Prepare technical memorandum for AOC 69W presenting site specific information that supports conditions defined within the MCP revision for petroleum release sites within a GW-1 groundwater area, justification for site closure, and path forward.

AOC 43G:

- Based on results of the MAROs Mann-Kendall analyses of manganese concentration trends discontinue sampling at monitoring wells AAFES-5 (only exceedance was in 1999), AAFES-6R (decreasing) XGM-94-07X (stable), and XGM-94-08X (decreasing).
- Reduce TAL for metals (reduce TAL to report only manganese) and VPH (reduce VPH TAL to report only aliphatics) analyses for “alternate” year annual sampling events (CY2015, CY2017, etc.)
- Non-alternate year (CY2014, CY2016, etc.) annual sampling events will continue with current full TAL for both metals and VPH.
- Use HydraSleeve™ technology to perform groundwater sampling at AOC 43G.
- Prepare technical memorandum for AOC 43G presenting site specific information for reclassification of groundwater from GW-1 to GW-3, justification for site closure, and path forward.

SPIA:

- Discontinue metals analyses for well points 26WP-06-01 and 26WP-08-02.
- Evaluate extent of perchlorate at AOC 26.
- Remove well 41M-93-04X from the SPM analytical sampling network.
- Discontinue all groundwater gauging from AOC 41 wells with the exception of well 41M-93-04X and decommission the wells.

DCL:

- Modify the leachate collection and recovery system (LCRS) to allow discharge on-site instead of to the MassDevelopment sewer system.
- Revise the LTM frequency from semi-annually to annually (fall event) after demonstrating that discharge of leachate to ground surface is not impacting groundwater.

AOCs 32 and 43A:

- Discontinue the fall performance monitoring event.
- Reduce the number of monitoring wells sampled during the primary spring event to the four wells sampled for performance monitoring, with the exception of substituting 32M-01-14XOB in place of 32M-01-15XBR. The other three sampled wells are 32M-01-13XBR, 32M-01-17XBR, and 32M-01-18XBR.
- Reduce frequency of site-wide depth to water collection from annual to every 5 years prior to five-year reviews.
- Discontinue all groundwater gauging at non-LTM program wells following the next five year review (2015) and decommission all non-LTM program wells west of the groundwater divide.
- Remove the extractable petroleum hydrocarbon (EPH) carbon ranges from the COC list.
- Use HydraSleeve™ technology to collect groundwater samples.
- Prepare technical memorandum for AOCs 32 and 43A presenting site specific information for reclassification of groundwater from GW-1 to GW-3, justification for site closure, and path forward.

Sudbury (AOC A7):

- Remove metals analyses from fall 2016 LTM program via a recommendation in the next five-year review report.
- Remove well OHM-A7-51 from the fall 2016 LTM sampling program via a recommendation in the next five-year review document, based on the last groundwater analytical exceedance documented in October 2003 (PCE) and a compliance point, per 310 CMR 19.132 (2), that is located hydraulically downgradient (SUD-A07-065).

- Remove well OHM-A7-09 from the LTM sampling program based on no historical groundwater analytical exceedances and a compliance point, per 310 CMR 19.132(1)(b), is located hydraulically downgradient (SUDWP-A07-01).
- Continue sampling OHM-A7-08 and SUD-A07-065 on an annual basis until the next five-year review; and revise sampling frequency to biennial if a downward trend is maintained.
- Continue sampling upgradient monitoring well SUD-A07-14 on an annual basis and revise sampling frequency to biennial, based on no groundwater analytical exceedances, after the next five-year report (CY2016).
- Recommend reducing the landfill gas vent monitoring from an annual frequency to every 5 years prior to the five-year review report.
- Continue sampling well point SUDWP-A07-01 on an annual basis until a trend can be established to allow for the adjustment of the sampling frequency.
- Utilize global positioning system (GPS) coordinates and a GPS unit to locate surface water gauges during the annual sampling event.

The Army's long-term optimization strategy is site closure for AOC 57, AOC 69W, AOC 43G, and AOCs 32 and 43A. The ROD for each of these AOCs requires that maximum contaminant levels (MCL) are achieved prior to site closure. The currently approved Groundwater Use and Value Determination (GUVD), dated March 2003, evaluated Devens and the surrounding areas as a single, comprehensive review area resulting in a "high use and value" classification for the entire Devens area and the application of GW-1 criteria throughout the former Fort Devens. However, the Army believed that a more focused evaluation of the Devens AOCs reveals that several of the AOCs, including AOCs 57, 32/43A, and 43G should be designated solely under a GW-3 groundwater category based on the Massachusetts Contingency Plan (MCP) legal requirements under 310 Code of Massachusetts Regulations (CMR) 40.0932. Conditions at each of the sites were evaluated against eight evaluation criteria established by the U.S. Environmental Protection Agency (USEPA) (USEPA, 1996) as part of the detailed draft GUVD analyses. Massachusetts Department of Environmental Protection (MassDEP) agreed to re-evaluate the GUVD for the noted sites and a draft GUVD was subsequently submitted by the Army to MassDEP in December 2010 for review. MassDEP reviewed the draft GUVD in early 2011 and suggested that cleanup goals for AOCs 57, AOC 69W, AOC 43G, and AOCs 32 and 43A could be reconsidered using a site-by-site approach, rather than attempting to revise the approved GUVD. The site-by-site approach would allow cleanup goals to be established based on an analysis of site-specific information (e.g., aquifer protection districts, current and future ownership, and future uses) instead of the broad regional view of groundwater resources in the approved GUVD. Per MassDEP, a site-by-site approach would allow for the decision makers to jointly compile and consider the relevant site-specific data needed to properly classify groundwater under the MCP, ensure cleanup goals conform to the Devens reuse plan, and, if appropriate, document changes in a site-specific CERCLA document (e.g., ESD).

Furthermore, the Army believes that AOC 69W currently meet the requirements and/or the general intent of the recently promulgated MCP revisions for petroleum hydrocarbons in GW-1 areas, for GW-1 areas defined solely on the basis of being located in a Zone II or an Aquifer

Protection District that overlays or is contiguous with a Zone II, [310 CMR 40.0924(2)(b)3 and 310 CMR 40.096(8)], whereby it is recognized that biodegradation and attenuation occur within a short distance of a release, such that the constituents do not generally migrate substantial distances in groundwater. Under such conditions, AOC 69W can achieve site closure based on current conditions that demonstrate adequate source removal, diminishing groundwater concentrations based on monitoring data, and other relevant site conditions with respect to any potential impact on a public water supply well. It is recommended that a technical memorandum for each of the sites be prepared to present site specific information, justification for site closure and path forward. The path forward may include the preparation of an ESD to the current ROD for each site followed by site closure upon approval of each ESD.

The optimization strategy for several sites addressed in this Optimization Evaluation Report is based, in part, on data trends over time relative to site cleanup goals. Recommendations involving reducing sampling frequency, eliminating analytes, and reducing the number of wells sampled at most AOCs can be implemented through and documented within a revised LTMMP. Changing sampling procedures, such as replacing low-flow sampling with HydraSleeve™ technology, can be implemented after a one event test period where samples are collected by both methods to confirm the validity of the sampling procedure for the site’s COCs.

Table ES-1
LTM Optimization Evaluation Summary

AOC	Site COCs	Evaluation Criteria				Optimization Strategy
		Source Persistence	Risk Assessment		Optimization Rationale	
			Current Risk	Future Land Use		
AOC 57	• Arsenic • VOCs	Soil removal actions were performed and no principal threat wastes remain.	Human and ecological risks are within USEPA acceptable range.	Remedial alternative includes deed covenants that prohibit potable use of groundwater.	Arsenic – overall concentrations are not increasing and show a decreasing or stable trend - Diminished anthropogenic carbon source VOCs – diminished - No additional contaminant source areas Site closure –In accordance with strategy presented within technical memorandum	- Continue LTM with optimization. - Reduce LTM sampling to every 5 years for Area 3. - Discontinue LTM sampling at Area 2. - Remove VOCs from COC list for Area 3. Decommission sumps at Area 2. - Use HydraSleeve™ technology for metals groundwater sampling at Area 3. - Prepare a technical memorandum for AOC 57 presenting site specific information that supports justification for site closure and path forward.

Table ES-1
LTM Optimization Evaluation Summary

AOC	Site COCs	Evaluation Criteria			Optimization Rationale	Optimization Strategy
		Source Persistence	Risk Assessment			
			Current Risk	Future Land Use		
AOC 69W	• Arsenic • C_{11}-C_{22} Aromatics • C_9-C_{10} Aromatics	Soil removal actions were performed and limited principal threat wastes remain.	Human and ecological risks are within USEPA's acceptable range.	Remedial alternative includes deed covenants that prohibit potable use of groundwater.	Arsenic – overall concentrations show a stable trend C_{11}-C_{22} – decreasing concentrations Metals – variable metals concentrations related to petroleum hydrocarbon degradation. . Site closure –In accordance with strategy presented within technical memorandum.	- Continue LTM with optimization. Recommend removing VPH from LTM program. Install an additional sentry wellpoint downgradient of the existing wellpoint 69WP-08-01 to characterize manganese concentrations in groundwater. - Prepare technical memorandum for AOC 69W presenting site specific information that supports conditions defined within the MCP revision for petroleum release sites, justification for site closure, and path forward.

Table ES-1
LTM Optimization Evaluation Summary

AOC	Site COCs	Evaluation Criteria				Optimization Strategy
		Source Persistence	Risk Assessment		Optimization Rationale	
			Current Risk	Future Land Use		
AOC 43G	• Benzene • Manganese • Iron • C_5-C_8 Aliphatics • C_9-C_{10} Aromatics • C_9-C_{12} Aliphatics	Soil removal actions were performed and no principal threat wastes remain.	Human and ecological risks are within USEPA's acceptable range.	Active facility. LUCs are in place.	Benzene – decreasing Manganese – decreasing and is not migrating off-site C_5-C_8 – decreasing or stable C_9-C_{10} – decreasing or stable C_9-C_{12} – increasing but not migrating Site closure –In accordance with strategy presented within technical memorandum.	- Continue LTM with optimization. - Based on results of the MAROs Mann-Kendall analyses of manganese concentration trends discontinue sampling at monitoring wells AAFES-5 (only exceedance was in 1999), AAFES-6R (decreasing), XGM-94-07X (stable) and XGM-94-08X (decreasing). - Laboratory analyzes samples for reduced TAL every-other year for metals (reduce TAL to report only manganese) and VPH (reduce TAL to report only aliphatics). - Use HydraSleeve™ technology for remaining groundwater sampling. - Prepare technical memorandum for AOC 43G presenting site specific information for reclassification of groundwater from GW-1 to GW-3, justification for site closure, and path forward.

Table ES-1
LTM Optimization Evaluation Summary

AOC	Site COCs	Evaluation Criteria				Optimization Strategy
		Source Persistence	Risk Assessment		Optimization Rationale	
			Current Risk	Future Land Use		
SPIA						
AOC 26	• Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) • 1,3,5-Trinitroperhydro-1,3,5-triazine (RDX) • Perchlorate	This is an active facility with some potential for ongoing releases.	Human and ecological risks are within USEPA's acceptable range.	Active facility. LUCs are in place.	RDX – decreasing or stable concentrations HMX – stable trends Perchlorate – Increasing concentrations in some wells	- Continue LTM with optimization. - Eliminate metals sampling from well points 26WP-06-01 and 26WP-08-01. - Add perchlorate analysis for existing LTM sampling program monitoring wells 26M-92-02X, 26M-92-03X, 26M-97-08X and SPM-93-06X. - Add explosives and metals analyses for existing LTM sampling program monitoring well 26M-10-09X. - Evaluate extent of perchlorate.
AOC 27	• RDX	This is an active facility with some potential for ongoing releases.	Human and ecological risks are within USEPA's acceptable range.	Active facility. LUCs are in place.	RDX – decreasing trend LTM performed biennially	- Continue existing LTM program.
SPM Well Network	• RDX • VOCs (41M-93-04X only)	This is an active facility with some potential for ongoing releases.	Human and ecological risks are within USEPA's acceptable range.	Active facility. LUCs are in place.	VOCs – decreasing trend	- Remove monitoring well 41M-93-04X from LTM program but retain for 5-year review gauging events. - Decommission all monitoring wells at AOC 41 except for well 41M-93-04X.

Table ES-1
LTM Optimization Evaluation Summary

AOC	Site COCs	Evaluation Criteria				Optimization Strategy
		Source Persistence	Risk Assessment		Optimization Rationale	
			Current Risk	Future Land Use		
DCL	• None	Closed landfill.	Human and ecological risks are within USEPA's acceptable range.	Landfill monitoring and LUCs are in place.	Interstate Technology and Regulatory Council (ITRC) groundwater monitoring module evaluation of analytical data indicates LTM frequency can be revised from semi-annual to annual, as permitted under 310 CMR 19.132(1)(d). ITRC leachate management module indicates leachate collection and recovery system (LCRS) can be modified based on an evaluation of leachate analytical data.	- Continue LTM with optimization. - Modify LCRS to allow discharge on-site to groundwater instead of to MassDevelopment sewer system - Detail modification feasibility in a technical memo and upon approval, prepare an explanation of significant differences (ESD). - Revise the LTM frequency from semi-annually to annually (fall event) after demonstrating that discharge of leachate to ground surface is not impacting groundwater.

Table ES-1
LTM Optimization Evaluation Summary

AOC	Site COCs	Evaluation Criteria				Optimization Strategy
		Source Persistence	Risk Assessment		Optimization Rationale	
			Current Risk	Future Land Use		
AOCs 32 and 43A	• Arsenic • Manganese • C_9-C_{10} • Chlorobenzene • 1,2-dichlorobenzene (DCB) • 1,3-DCB • 1,4-DCB	Soil removal actions were performed and no principal threat wastes remain. Sodium persulfate injection to augment intrinsic remediation.	Human and ecological risks are within USEPA's acceptable range.	Remedial alternative includes LUCs.	- Active remediation performed to treat remnant source area. - Inorganic COCs diminished or decreasing. - Organic COCs diminished or decreasing. - Site closure – In accordance with strategy presented within technical memorandum.	- Continue LTM with optimization. - Reduce analyte list. - Discontinue fall performance monitoring event. - Reduce number of monitoring wells sampled during spring LTM event to four wells. - Reduce site-wide collection of depth to water data frequency from annual to 5 year event. - Use Hydrasleeve™ technology for remaining groundwater sampling. - Prepare technical memorandum for AOCs 32 and 43A presenting site specific information for reclassification of groundwater from GW-1 to GW-3, justification for site closure, and path forward.

Table ES-1
LTM Optimization Evaluation Summary

AOC	Site COCs	Evaluation Criteria				Optimization Strategy
		Source Persistence	Risk Assessment		Optimization Rationale	
			Current Risk	Future Land Use		
Sudbury Annex (A7)	Although there are no COCs or cleanup goals identified in the ROD, the 1994 risk assessment did identify the chemicals of potential concern (COPC) for human health. The site COCs include both COPC contaminants identified in the risk assessment as well as other contaminants not on the COPC list that were found during the monitoring program. The 2009 LTMMP identifies site COCs as: • tetrachloroethene (PCE) • trichloroethene (TCE) • 1,1,2,2-tetrachloroethane • Lindane	Closed landfill	Human and ecological risks are within USEPA's acceptable range.	Landfill monitoring and LUCs are in place.	ITRC groundwater monitoring module evaluation indicates metals can be removed from analyte list. ITRC confirmation sampling every 5 years until end of post closure care (PCC). Analyte list can be modified per 310 CMR 19.132(1)(H). Army and USEPA agreed upon criteria to reduce sampling frequency and analyses and number of compliance monitoring locations, as detailed in Section 2.9.2.2. Surface water staff gauges are difficult to locate.	- Continue LTM with optimization. - Remove wells OHM-A7-51 and OHM-A7-09 from the LTM sampling program. - Continue sampling OHM-A7-08 and SUD-A07-065 on an annual basis until the next five-year review and revise sampling frequency to biennial if a downward trend in analytical data is maintained. - Continue sampling upgradient monitoring well SUD-A07-14 on an annual basis and revise sampling frequency to biennial, based on no groundwater analytical exceedances, after the next five-year report (CY2016) - Continue sampling new well point SUDWP-A07-01 on an annual basis to establish a dataset for trend analysis. - Recommend reducing landfill gas monitoring from annually to every 5 years for the Five-Year Review Report. - Utilize GPS coordinates and a GPS unit to locate surface water samples during the annual sampling event.

OPTIMIZATION EVALUATION
FOR
LONG-TERM MONITORING AND MAINTENANCE
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS
SUDBURY ANNEX
SUDBURY, MASSACHUSETTS

1.0 INTRODUCTION

1.1 BACKGROUND

The U.S. Army Corps of Engineers (USACE)-New England District contracted Sovereign Consulting Inc. (Sovereign) to complete environmental remediation services required to meet the objectives of the Statement of Work (SOW) for Contract Number W912WJ-10-D-0003. Sovereign and their subcontractor, HydroGeoLogic, Inc. (HGL), hereinafter referred to as the Sovereign team, have prepared this Optimization Evaluation Report (OER) to present a recommendation for optimization of the long-term monitoring (LTM) program based on an evaluation of contaminant trends, current site conditions, and the latest regulatory requirements. The Devens Main Post and South Post Impact Area (SPIA) sites evaluated under this report located in Devens, Massachusetts, are presented on **Figure 1.1a** and the Sudbury Annex site located in Sudbury, Massachusetts, is presented on **Figure 1.1b**.

1.2 SITE DESCRIPTION – FORMER FORT DEVENS ARMY INSTALLATION AND SUDBURY ANNEX

Devens is located in the towns of Ayer and Shirley in Middlesex County and Harvard and Lancaster in Worcester County, Massachusetts, approximately 35 miles northwest of Boston, Massachusetts. The installation occupied approximately 9,260 acres. Prior to the official base closure, Devens was divided into the North Post, Main Post, and South Post. Route 2 divides the South Post from the Main Post. The Nashua River runs through the North, Main, and South Posts. The area surrounding Devens is largely rural residential property.

Devens was identified for cessation of operations and closure under Public Law 101-510, the Defense Base Realignment and Closure (BRAC) Act of 1990, and officially closed in March 1996. As part of the Devens BRAC program, portions of the property formerly occupied by Fort Devens were retained by the U.S. Army (Army) for reserve forces training and renamed the Devens Reserve Forces Training Area (DRFTA). Areas not retained as part of DRFTA were, or are in the process of being, transferred to new owners for reuse and redevelopment.

A total of 325 environmental investigation sites have been addressed at Devens under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Twenty-one sites were defined as areas of contamination (AOC), 63 were defined as Study Areas (SA) and 241 sites were defined as Areas Requiring Environmental Evaluation (AREE) sites. Each of the 241 AREE sites have been addressed in final No Further Action (NFA) Decision Documents. Sixty of the 63 SA sites have been addressed in final NFA Decision Documents and the remaining three SA sites have been addressed in final Records of Decision (ROD). Twenty of the AOCs have been addressed in final RODs and the remaining AOC (AOC 72, Plow Shop Pond), which is not a part of this LTM program, is currently in the Remedial Investigation (RI)/Feasibility Study (FS) phase with the ROD pending. The AOC 72 RI report was approved in May 2011 and an Engineering Evaluation (EE)/Cost Analysis (CA) for follow-up actions was submitted later in 2011.

The Sudbury Annex occupies approximately 4.3 square miles in the Massachusetts towns of Hudson, Marlborough, Maynard, Stow and Sudbury. A site location map indicating the general site location and physical setting is presented in **Figure 1.1b**. Hudson Road divides the installation into a larger northern section and a smaller southern section. The Sudbury Annex became part of Fort Devens, now the DRFTA, in 1982. On May 13, 1991, the U.S. Environmental Protection Agency (USEPA) and the Army signed the two-party interagency agreement, as required by CERCLA. The interagency agreement was finalized on November 15, 1991. The Sudbury Annex was a National Priorities List (NPL) site under the CERCLA until January 2002.

A comprehensive site description, including more detailed individual AOC histories, is provided in the 2008 Long-Term Monitoring Plan (LTMP) for the Devens Main Post Sites and the SPIA and the 2009 Long-Term Monitoring and Maintenance Plan (LTMMP) for the Sudbury Annex. The following subsections provide historical summaries, including previous and ongoing remedial or LTM activities within the AOCs evaluated in this OER.

1.2.1 Area of Contamination 57

AOC 57 is located between Barnum Road and Cold Spring Brook on the northeast side of what was formerly the Main Post of Devens in the town of Harvard, Massachusetts (**Figure 1.1a**). The portion of the former Devens site that includes AOC 57 was used primarily as a storage and maintenance area for military vehicles. AOC 57 consists of three sub areas (Area 1, Area 2, and Area 3) that are located south to southeast of Building 3713 and former buildings 3756, 3757, and 3758. The sub areas received storm water runoff and waste from vehicle maintenance at former vehicle storage yards related to Building 3713 and former Buildings 3757 and 3758. This OER focuses on optimization of activities performed in Area 2 and Area 3, as Area 1 was approved for NFA following the removal of contaminated soil in 1997 to address polycyclic aromatic hydrocarbons (PAH) in the soil. Each sub area includes an upland area that slopes downward to a delineated wetland area bordering Cold Spring Brook. The ROD specified elevation 228 feet as the border between the upland and the 100-year flood plain for Cold Spring Brook. The floodplain boundary is located approximately 260 feet from Cold Spring Brook in Area 2 and approximately 400 feet from Cold Spring Brook in Area 3. Area 2 and Area 3 are depicted on **Figures 1.2a and 1.2b**, respectively.

The site is currently on an annual LTM schedule with groundwater sampling performed at Areas 2 and 3 in the spring.

1.2.2 Area of Contamination 69W

AOC 69W is located at the northeast corner of the intersection of Jackson Road and Antietam Street on the northern portion of what was formerly the Main Post at Devens (**Figure 1.1**). AOC 69W is comprised of the former Devens Elementary School (Building 215) and its associated parking lot and adjacent lawn, extending approximately 300 feet northwest to Willow Brook. The building is currently home to the Francis W. Parker Charter Essential School. Contamination at AOC 69W is attributed to two separate releases of No. 2 Heating Oil in 1972 and 1978. It is estimated that 7,000 to 8,000 gallons of No. 2 Heating Oil was released into soil from each release.

The layout of AOC 69W is depicted on **Figure 1.3**. AOC 69W is sampled annually in the fall.

1.2.3 Area of Contamination 43G

AOC 43G is located in the central portion of the former main post of Fort Devens. It consists of the former Army Air Force Exchange Service (AAFES) gas station and historic gas station. The historic gas station was used as a motor pool to support military operations during World War II. Each of the identified underground storage tanks (UST) at AOC 43G has been removed, although petroleum contamination has been observed in soil and groundwater.

Quarterly groundwater sampling was performed between March 1997 and December 1998 in support of an Intrinsic Remediation Assessment. The layout of AOC 43G is depicted on **Figure 1.4.** AOC 43G is sampled annually in the fall.

1.2.4 South Post Impact Area

SPIA is located within the 4,800-acre area known as the South Post of former Fort Devens and is depicted on **Figure 1.5**. SPIA is a 964-acre area that includes two AOCs to be addressed in this OER, AOCs 26 and 27. AOC 26 is known as the Zulu Range and includes the Zulu 1 and 2 firing ranges. AOC 27 is known as the Hotel Range. Close-up views of AOCs 26 and 27 are depicted on **Figures 1.6 and 1.7**, respectively. SPIA was historically used for small firearms and grenade training and also for open burning and detonation of explosives. SPIA is currently an active weapons and ordnance discharge area that is used by the U.S. Army Reserves, the Massachusetts National Guard and civilian law enforcement agencies. In 2011, because SPIA is an active facility, fiscal and administrative responsibility of the SPIA LTM program was transferred from the Army BRAC Division to the U.S. Army Garrison, Fort Devens.

Groundwater sampling is performed annually at AOC 26 and the South Post Monitoring (SPM) well network. Groundwater at AOC 27 is sampled on a biennial basis. All sampling is performed in the fall. There is no active LTM related activity at SPIA AOCs 25 and 41.

1.2.5 Areas of Contamination 32 and 43A

AOC 32 was known as the Defense Reutilization and Marketing Office (DRMO) Yard and consisted of three fenced areas. The West Yard, located on the west side of Cook Street, was a paved area used for the storage of used equipment with lead-acid batteries, telecommunications and administrative equipment. The East Yard, located on the east side of Cook Street, was a paved area used for disassembling vehicles for reusable parts and previously contained scrap metal, tires, stored items for sale, and used photographic solutions. The third fenced area was an unpaved area located just north of the East Yard. It was used for the storage and recycling of tires. AOC 32 also contains a former UST site located just northeast of Building T-204, although that site is monitored under a separate regime.

AOC 43A was known as the petroleum, oils and lubricate (POL) storage area, and located across Market Street from AOC 32. AOC 43A consisted of a fenced lot located within an industrial area and served as the distribution point for all gasoline and other fuels at Fort Devens from the 1940s to 1996. AOCs 32 and 43A are depicted on **Figure 1.8**.

Groundwater sampling is currently performed for eight monitoring wells at AOC 32. The long-term monitoring event is conducted in the spring and includes gauging wells for depth to water (AOCs 32 and 43A) and groundwater sampling (AOC 32).

1.2.6 Devens Consolidation Landfill

The Devens Consolidation Landfill (DCL) was constructed on the Devens golf course driving range to accommodate excavated material from seven remedial areas consisting of two SAs, four AOCs, and one pesticide removal project at three Devens housing areas. A map illustrating the location of the DCL is presented on **Figure 1.9**. The seven DCL sites were:

- SA 12: A half-acre location where construction debris and yard waste were deposited (approximately 8,700 cubic yards [cy]);
- SA 13: A one-acre area used from 1965 to the mid-1990s for yard-waste (approximately 10,000 cy);
- AOC 9: An area used for storing wood, concrete, asphalt, metal, brick, glass, and tree stumps (approximately 121,000 cy);
- AOC 11: A former landfill used from 1975 to 1980 for disposal of wood-frame hospital demolition debris (approximately 35,000 cy);
- AOC 40: Four acres used for construction debris, ash, stumps, and logs (approximately 125,400 cy);
- AOC 41: A one quarter-acre landfill in the SPIA that was used until the 1950s for disposal of non-explosive material and household debris (approximately 1,500 cy); and
- Grant, Locust, and Cavite Housing Areas: Soil and walling material contaminated with pesticides or volatile organic compounds (VOC) (approximately 2,290 tons of soil and approximately 1,240 tons of concrete).

The USEPA approved the ROD for landfill remediation of the first six areas in July 1999. It included provisions for either on-site or off-site disposal options. The on-site landfill construction alternative was selected as the best value. Construction of the DCL commenced in September 2000 and was completed in November 2002. The Remedial Action Closure Report prepared by Shaw Environmental (formerly Stone & Webster, Inc.) in September 2003 was accepted, certifying that the DCL was constructed and capped in accordance with the ROD, and met the performance standards and/or response objectives in the ROD.

The Remedial Action Closure Report provides the operations and maintenance manual for the DCL. USACE is responsible for operating and inspecting the landfill facility and Sovereign is responsible for groundwater and gas vent monitoring and leachate discharge sampling. Leachate is still being generated with permitted wastewater discharge to the Devens sewage system by the terms of the authorized industrial wastewater discharge permit. Effluent criteria and reporting requirements are specified in the leachate discharge permit, which was updated July 29, 2009. The volume of effluent has been diminishing over time. Currently, the DCL is sampled on a semi-annual schedule in the spring and fall.

1.2.7 Sudbury Annex

Site AOC A7 is the only site remaining at the Sudbury Annex that requires environmental monitoring. This site is depicted on **Figure 1.10**. AOC A7 is a former waste disposal site in the northern portion of the former training annex that was used as a dump for general refuse, demolition debris and chemical lab waste disposal. The lab waste area was limited to a pit of about 5,000 square feet (ft^2). General refuse was reportedly buried at shallow depths from 1941 until the 1980s, with occasional burning to reduce volume. The laboratory waste was excavated in 1996 and transported off-site for treatment and disposal at an approved facility. The laboratory waste was removed because it is considered to be the primary source of groundwater contamination at the site. The site had a Resource Conservation and Recovery Act (RCRA) Subtitle C landfill cap installed in 1996 following the removal of the waste. The environmental restoration program at the site is mature. RIs, FSs and RODs have been completed, and long-term monitoring and maintenance (LTMM) has been performed for several years.

Currently, AOC A7 is sampled on an annual basis with sampling activities performed in the fall.

2.0 OPTIMIZATION EVALUATION OF LTM PROGRAM

As discussed in Section 1.1, a detailed evaluation of the LTM program for the sites described in Section 1.2 was performed during development of the previous 2008 LTMP (Devens) and 2009 LTMMP (Sudbury). Several of the LTM program recommendations presented in the previous document remain valid. Many of the recommendations presented in the current Main Devens/SPIA LTMP and Sudbury Annex LTMMP documents have been implemented and the recommendations presented in this OER are additional optimization recommendations based on changes in site conditions. Recommendations provided under the individual AOCs that involve reducing sampling frequency, eliminating analytes, and eliminating wells can be implemented on approval of a revised LTMMP. Recommendations involving substituting sampling techniques, such as replacing low flow sampling with HydraSleeve™ technology, should be validated through confirmatory sampling involving the collection of analytical samples by both means over one sampling event and comparing the results using relative percent difference (RPD) calculations. Previous studies have indicated that HydraSleeve™ sampling is a suitable substitute for low-flow sampling (Parsons, 2005; Fernandes and Roberts, 2001; MWH, 2009; MWH, 2010; NDCEE, 2012). The recommendation for site closure at AOC 69W can be made once manganese in groundwater is delineated downgradient and demonstrated to be limited in extent.

The technical approach that was applied to complete the evaluation is consistent with the USEPA and Department of Defense (DoD) guidance presented in *Roadmap to Long-Term Monitoring Optimization* (USEPA and USACE, 2005). A discussion of the technical approach that was applied to conduct the evaluation is presented in Section 2.1. The evaluation for each site is presented in Sections 2.3 through 2.9. Recommendations for future environmental monitoring are included in these sections.

2.1 TECHNICAL APPROACH AND DECISION-MAKING CRITERIA

The following technical approach was applied to evaluate the LTM program at each site:

- Evaluate recent and historical monitoring data;
- Update the conceptual site model (CSM), as needed;
- Determine whether site closure is warranted;
- Determine whether LTM optimization is appropriate; and
- Optimize the LTM program, as needed.

At the beginning of the project, an environmental monitoring database developed by the USACE was updated by the Sovereign team to include laboratory results from sampling events (i.e., 2005 through 2011). The updated database was used to develop an understanding of environmental conditions at each individual site. Data contained in the database were analyzed to evaluate trends in contaminant concentrations and to gain a better understanding of the factors controlling contaminant migration in groundwater.

Consistent with the optimization procedure outlined by USEPA and USACE (2005), the Sovereign team reviewed existing data and the CSM developed for each of the sites. The initial

CSM was typically documented in the RI/Baseline Risk Assessment (BLRA) reports prepared for each site. Updated CSMs are included in the 2008 LTMP (HGL, 2008) for the Devens Main Post and SPIA sites and the 2009 LTMMP (HGL, 2009) for Sudbury site A7. The CSMs were reviewed in conjunction with the latest environmental monitoring data and the most recent hydrogeologic data.

The *Roadmap to Long-Term Monitoring Optimization* (USEPA and USACE, 2005) suggests the following seven step program for LTM optimization (LTMO):

1. Clearly define and document the current monitoring program;
2. Examine existing data;
3. Determine if the site is a candidate for LTM evaluation;
4. Determine the type of evaluation;
5. Select the LTMO methods/tools;
6. Perform the optimization; and
7. Assess and implement the results.

These steps were performed for each of the sites included in the current LTM program. Qualitative methods were used to identify redundant sampling locations, identify unnecessary analytes, and determine whether the sampling frequency is appropriate. The MAROS Mann-Kendall statistical analysis was used to verify contaminant trends.

In addition, the Sovereign Team evaluated sampling technologies that could be used to optimize the current sampling procedures implemented at the site. In particular, the substitution of the low-flow sampling procedure by a less resource-intensive technology was given precedence. In many cases, based on frequency of sampling and the analytes collected at a particular well location, HydraSleeve™ technology was found to be a suitable substitute for traditional low-flow sampling. HydraSleeve™ technology is a no-purge, single-use, device that provides formation quality samples. As mentioned in Section 2.0, previous studies indicated that HydraSleeve™ sampling is a suitable substitute for low-flow sampling of VOCs, metals, PAHs, and anions (Parsons, 2005; Fernandes and Roberts, 2001; MWH, 2009; MWH, 2010; National Defense Center for Energy and Environment [NDCEE], 2012). Analytical data obtained from HydraSleeve™ sampling has demonstrated to be either equivalent to or biased higher than analytical data obtained through low-flow sampling methods. It is anticipated that the Devens analytical data evaluations will add additional support to the replacement of low-flow methods with HydraSleeve™ methods. Additional details are provided in **Attachment A.**

The following information was evaluated during the evaluation of the LTM program at each of the AOCs:

1. Observed trends in contaminant concentrations;
2. Recent sampling results (last four to six sampling events);
3. Constituent properties (retardation, decay, solubility, toxicity);

4. Well location information (construction information, well location relative to source and receptors or point of compliance);
5. Site knowledge (groundwater flow direction and velocity, hydrologic structure);
6. Monitoring objectives;
7. Chosen remedy and its effectiveness;
8. Potential for further contamination due to site activity; and
9. Uncertainty in any of the above.

These lines of evidence are considered along with professional judgment to arrive at optimization recommendations that are protective of human health and the environment.

The Federal Safe Drinking Water Act Standards maximum contaminant levels (MCL) are included as applicable or relevant and appropriate requirements (ARAR) within the RODs approved for each site. Consequently, achievement of MCLs is currently a regulatory requirement for site closure. The requirement to achieve MCLs is based on the assumption that the groundwater would potentially be used as a source of drinking water. This is not consistent with current or future land use at any of the sites, based on conditions at the time site RODs were prepared and the most recent five year review. Furthermore, land use controls are in place at each of the sites to prohibit the use of groundwater.

Several of the LTM sites (AOC 43G, AOCs 32 and 43A, AOC 57, SPIA AOC 26, and the DCL) are considered GW-3 groundwater category sites, based on the current Massachusetts Contingency Plan (MCP) legal requirements under 310 CMR 40.0932. The Army requested that the Massachusetts Department of Environmental Protection (MassDEP) amend the current Groundwater Use and Value Determination (GUVD) for Devens (MassDEP, 2003) to specifically address the LTM sites. MassDEP reviewed the draft GUVD in early 2011 and suggested that cleanup goals for AOCs 57, AOC 69W, AOC 43G, and AOCs 32 and 43A could be reconsidered using a site-by-site approach, rather than attempting to revise the approved GUVD. The site-by-site approach would allow cleanup goals to be setup based on an analysis of site-specific information (e.g., aquifer protection districts, current and future ownership, and future uses) instead of the broad regional view of groundwater resources in the approved GUVD. Per MassDEP, a site-by-site approach would allow for the decision makers to jointly compile and consider the relevant site-specific data needed to properly classify groundwater under the MCP, ensure cleanup goals conform to the Devens reuse plan, and, if appropriate, document changes in a site-specific CERCLA document (e.g., ESD).

In addition, it is expected that AOC 69W would meet the requirements and/or the general intent of the revised MCP for petroleum hydrocarbons in GW-1 Areas, for GW-1 areas defined solely on the basis of being located in a Zone II or an Aquifer Protection District that overlays or is contiguous with a Zone II, [310 Code of Massachusetts Regulations [CMR] 310 CMR 40.0924(2)(b)3 and 310 CMR 40.096(8)], whereby it is recognized that biodegradation and attenuation occur within a short distance of a release, such that the constituents do not generally migrate substantial distances in groundwater. Under such conditions, AOC 69W can achieve site closure based on current conditions that demonstrate adequate source removal, diminishing groundwater concentrations based on monitoring data, and other relevant site conditions with respect to any potential impact on a public water supply well. It is recommended that a technical memorandum for each of the sites be prepared to present site specific information, justification for site closure and path forward. The path forward may include the preparation of an ESD to the current ROD for each site followed by site closure upon approval of each ESD.

The Army will continue to utilize the previously referenced methodology to evaluate further decreases in LTM or the elimination of monitoring at LTM sites in the future. Future LTMO or closure recommendations will be based on the combination of long-term data trends and data from the most recent monitoring events to determine overall compliance with groundwater cleanup goals or decreasing contaminant trends at specific monitoring locations.

2.2 BASEWIDE CONCEPTUAL MODEL

A detailed and current CSM was provided in the LTMP (HGL, 2008) and LTMMP (HGL, 2009) and will not be repeated in this OER. The CSM included a discussion of geologic conditions, groundwater flow patterns, contaminant release mechanisms, topography, and chemical properties of the contaminants of concern (COC) and surrounding media. Elements of the CSM that are specific to individual AOCs and are pertinent to the optimization discussion are provided in subsequent sections, as needed. Data graphs and Mann-Kendall statistical analysis summaries used to evaluate data trends are presented in Attachments B and C, respectively.

2.3 AREA OF CONTAMINATION 57

2.3.1 Site Information

2.3.1.1 Contaminant Release

On February 13, 1977, Devens personnel at Building 3713 noticed No. 4 fuel oil flowing from an overfilled UST into a nearby storm drain [Biang et al., 1992; Directorate of Facilities and Engineering (DFAE), 1977]. An estimated 50 to 100 gallons of oil entered Cold Spring Brook through the Area 1 outfall. Containment dikes and absorbent booms were set across Cold Spring Brook adjacent to Area 2, and approximately 3,000 gallons of mixed oil and water were recovered from the swamp (DFAE, 1977). A portion of the spill reportedly flowed across Barnum Road to Area 2. However, topographic relief in the spill area and Area 2 prohibited oil from flowing overland to Cold Spring Brook. Area 3 is located approximately 600 feet northeast of Area 2 on a strip of land between the former fenced area in motor pools to the north and the forested Cold Spring Brook floodplain to the south. This area was the site of past disposal of vehicle- and maintenance-related wastes. Maps showing Areas 2 and 3 are provided on Figures 1.2a and 1.2b, respectively.

2.3.1.2 Contaminants of Concern

The ROD identifies groundwater COCs for Area 2 and Area 3 as arsenic, tetrachloroethene (PCE), cadmium and 1,4-dichlorobenzene (DCB) with remediation goals of 50 micrograms per liter (µg/L), 5 µg/L, 5 µg/L, and 5 µg/L, respectively. The 2004 Explanation of Significant Difference (ESD) added polychlorinated biphenyls (PCB) and the extractable petroleum hydrocarbon (EPH) C_{11}-C_{22} aromatic carbon range to the Area 2 COC list, with remediation goals of 0.5 µg/L and 200 µg/L, respectively. The remediation goal for arsenic was revised from 50 µg/L to 10 µg/L to match the current groundwater GW-1 standard established by the MCP in January 2006.

2.3.1.3 Selected Remedy

The ROD for AOC 57 was approved in 2001 and the remedy selected for Areas 2 and 3 consisted of soil excavation, institutional controls (IC), and LTM for groundwater (USACE, 2001). The ICs consist of continued zoning that prohibits residential use of the Area 2 property and deed restrictions that prohibit potable use of Area 2 and 3 groundwater and residential use of the property. The intent of the ROD was primarily to address petroleum contaminated soils and groundwater. The ROD indicates that groundwater monitoring is a relevant and appropriate response to confirm that contaminant concentrations are decreasing, the potential for off-site migration via the groundwater to surface water discharge pathway is evaluated, and that Federal MCLs and Massachusetts groundwater quality standards are met.

2.3.1.4 Site Hydrogeology

The most significant hydrological feature at AOC 57 is Cold Spring Brook, which originates in the central part of the former Main Post at Devens. The creek's headwaters are formed by runoff and groundwater discharge in the vicinity of the former Ammunition Storage Point and Cold Spring Brook landfill. Further downstream, the creek flows north through woodlands and wetlands and passes beneath the B&M Railroad right-of-way at Barnum Road. From there the brook is fed by runoff and groundwater discharge from the former Army property south of Barnum Road. It is at this point that the brook passes to the south of AOC 57 and continues to flow northeast off the Devens property, where it ultimately discharges to Grove Pond.

2.3.1.5 Current Extent of Contamination

Per **Table 2.1**, arsenic was detected above the current GW-1 standard in several monitoring wells located outside the wetlands area in Areas 2 (57M-03-05X) and Area 3 (57M-95-03X and 57M-96-11X). The exceedance at Area 2 (11 µg/L) was only slightly above the 10 µg/L MCL.

No VOCs constituents in groundwater were above the remediation goals for AOC 57 in 2012. No trichloroethene (TCE) exceedances have been observed in the annual samples collected at AOC 57 since the spring 2008 LTM event, no PCE exceedances have been observed since the spring 2007 LTM event and no 1,4-DCB exceedances have been observed since the spring 2011 event.

Although periodic low-level exceedances of 1,4-DCB have been observed in well 57M-95-03X, 1,4,-DCB detections have generally been below the cleanup standard, and there is no discernible trend for this compound.

The PCE and TCE concentrations in groundwater at well 57M-03-02X are generally below the MCP GW-1 standard of 5 µg/L, with sporadic, low-level exceedances of this standard. Based on an evaluation of the data graphs and the Mann-Kendall analysis (**Attachment B and Attachment C**), PCE and TCE concentrations at well 57M-03-02X reveal no discernible trend; however, the diminished PCE and TCE concentrations suggest that attenuation is proceeding as concentrations of both compounds are currently below the 5 µg/L GW-1 standard. The LTM program is currently in its ninth year, leaving ample time for the attenuation of any residual PCE and TCE concentrations and the associated degradation by-products. Overall, LTM data has confirmed the effectiveness of the remedy.

There is no documented disposal of inorganic constituents at AOC 57, and no apparent disposal areas or source areas of inorganic contamination were identified during the RI. The detection of inorganic constituents in groundwater and wetland soils is likely caused by leaching of naturally-occurring metals, such as arsenic, iron and manganese. Reducing conditions would enhance the leaching of inorganic constituents from soil to groundwater and the mobility of the constituents thereafter. On discharge to surface water, however, these metals tend to oxidize and rebind to soil or sediment, becoming less mobile. This cycle of reduction/migration/ discharge/oxidation could account for inorganic constituent detections in groundwater and wetland soils.

The most uncertain aspect of the AOC 57 conceptual model is the origin and mobility of arsenic. In 2006, the USACE conducted an "Arsenic Evaluation" to determine the probable mobilization mechanism liberating sequestered/bound natural arsenic, and whether it is related to site contaminants or natural conditions (USACE, 2006). Groundwater at AOC 57 flows toward Cold Spring Brook, and discharges to the wetland soils as seeps and small ponded areas when the groundwater level is high. Elevated concentrations of arsenic have been detected in monitoring wells located in and around the wetland area. Monitoring wells containing elevated arsenic concentrations additionally exhibit geochemical parameters, specifically low/negative oxidation-reduction potential (ORP) and low dissolved oxygen, which indicate reducing conditions in groundwater. The USACE 2006 report cites several studies (e.g., Harding ESE, 2001, Harding Lawson Associates [HLA], 2000b) concluding that the most probable source of arsenic in Cold Brook Springs is a natural upgradient source (groundwater) or an upstream anthropogenic source (surface water). The USACE report notes that naturally occurring arsenic in alluvial/fluvial sediments is often associated with iron oxyhydroxides which can be subsequently mobilized by changes in the in-situ environment to more reducing conditions, caused either by the biodegradation of fuel compounds or a progressive microbial degradation of the organic constituents (a carbon source) within the wetland environment and/or substrate. Within the wetland, the USACE report indicates that arsenic could be due to a combination of an upward vertical gradient in the wetland and reducing conditions in deeper groundwater below the wetland.

To assist in determining the mobilization mechanism of arsenic in groundwater at AOC 57, the USACE performed a temporal and spatial trend analysis on monitoring well historical data at Areas 2 and 3 (USACE, 2006). The authors concluded that there appeared to be no clear correlation with regards to the biodegradation of fuel hydrocarbons and mobilization of natural arsenic. Evidence for their assertion is based on the random nature of the temporal trends and suggested that seasonal variations as well as monitoring well location are the main contributing factor to low/negative ORP conditions. The data also suggested that upwelling of deeper upgradient groundwater as well as seasonal variations in precipitation and water levels in the adjacent surface water body may have significant influence with regard to in-situ ORP conditions. The authors believe that this is clearly evident in Area 2, where there are consistently high ORP values accompanied by high arsenic concentrations at downgradient monitoring well 57M-03-04X.

Area 3 had two monitoring locations that had consistently low ORP values with arsenic concentrations that exceeded the regulatory limit of 10 µg/L (USACE, 2006). The USACE further concluded that the temporal trend analysis of the historical data did not illustrate a definitive correlation between arsenic concentration and ORP results, and fuel compounds or degradation products. The causative mechanism for the reducing conditions observed locally in Area 3 were inconclusive based on the spatial and temporal analysis.

Although there is uncertainty with respect to the mechanism for the elevated arsenic concentrations at AOC 57, the most relevant consideration is whether the risks will ultimately reach unacceptable levels or whether exposure is likely. To gain some perspective on future arsenic concentrations at AOC 57, trends in arsenic concentrations in groundwater were evaluated to determine whether they are likely to increase. As shown in **Table 2.1**, arsenic concentrations in Area 2 groundwater have declined since 2003, with arsenic concentrations below or slightly above the 10 µg/L GW-1 standard in 2012. A similar analysis was conducted for the two monitoring wells in Area 3 that have historically been associated with elevated arsenic. Although the arsenic concentrations in wells 57M-95-03X and 57M-96-11X have declined significantly from the highs in 2003 and 2004, from 2005 through 2012, the arsenic concentrations in groundwater fluctuated with no discernible trend. The arsenic concentration detected in surface water has been below the 150 µg/L Federal ambient water quality criteria throughout the LTM monitoring period.

There are at least three possibilities that could explain the elevated arsenic concentrations within Area 3 and the transient arsenic detections at Area 2: (1) a natural upgradient source (groundwater) or an upstream anthropogenic source (surface water); (2) biodegradation of fuel hydrocarbons and mobilization of natural arsenic; and/or (3) an upward vertical gradient in the wetland and reducing conditions in deeper groundwater below the wetland, which allows the arsenic to mobilize.

> USEPA observed in their March 16, 2006 comments that, "*the data are insufficient, at this time, to establish a link between contamination at the site (caused by a fuel release) and the low-ORP conditions that are responsible for the observed elevated arsenic in site groundwater.* The USEPA also remarks that *if it is assumed that the observed arsenic concentrations are attributable to site impact, and the cause (fuel contaminated soil) has been removed, then site groundwater conditions can only improve (i.e., they will not get worse because there is no longer an organic source to sustain low-ORP conditions leading to reductive dissolution of ferric oxides and release of sorbed arsenic)".* However, the USEPA concludes, "*it is not clear from the data that the ORP conditions and the associated dissolved arsenic levels are related to fuel constituents. Also, the limited data set is inadequate to make projections about the time scale on which the redox potential of the system will rebound to an unimpacted state, if a site-related release is in fact the cause of the present condition.*"

The significance of USEPA's observations are that if hypothesis 2 explains the arsenic mobilization then the observed arsenic concentrations are attributable to site impact, and since the cause (fuel contaminated soil) has been removed, then site groundwater conditions can only improve. If, however, the arsenic is being mobilized by natural processes, as described in hypotheses 1 and 3 above, then the arsenic concentrations will fluctuate based on prevailing geochemical conditions. Although there is insufficient data to determine which hypothesis (or combination) is correct there are really just two possibilities with respect to risk: (1) either the risk will go down as the fuel-related compounds are degraded; or (2) the risk will fluctuate as arsenic is mobilized due to natural groundwater conditions. In either case, the results obtained from continued monitoring will not contribute to any substantive decisions made with respect to the site.

Since land use restrictions are in place, the only potential exposure pathway is from the accumulation of oxyhydroxides (iron, manganese, and arsenic) that may occur at the surface water/groundwater interface. This possibility is already addressed with respect to risk. If metals mobilization (iron, manganese, and arsenic) is naturally occurring, the system should be more or less in a steady state, and the introduction of metals to Cold Spring Brook in the future will be similar to that in the past. Since the ecological risk assessment concluded that existing concentrations of metals in the sediment were not above acceptable levels, continued discharge at the current concentrations should not increase the ecological risks. The site no longer poses an ecological risk based on past removal actions, current groundwater and surface water conditions, and the lack of visual discharge impacts.

The arsenic mass-loading rate calculated during previous assessments (HGL, 2008) was estimated at 0.4 milligrams per kilogram (mg/kg) per year, and based on this rate, it would take approximately 50 years to approach the 20 mg/kg MCP soil category S-1 standard. Given the conservative nature of the mass-loading calculations, the lack of dissolved arsenic in groundwater closest to the spring, and that contaminant concentrations are declining throughout AOC 57, arsenic accumulation in sediment is not considered a significant concern. Therefore, based on the trends and fate and transport discussions above, the arsenic cleanup goals for Area 2 will likely be achieved within the 30-year ROD timeframe.

2.3.2 Long-Term Monitoring Program

2.3.2.1 <u>Current Program</u>

Groundwater and surface water samples are collected annually in the spring (April/May). The purpose of the LTM program is to monitor the potential for off-site migration of contaminants and verify that elevated concentrations of contaminants are decreasing over time. Beginning in 2008, groundwater at AOC 57 has been sampled annually. Wells sampled as part of the LTM program include Area 2 wells (57M-03-02X, 57M-03-03X, 57M-03-04X, and 57M-03-05X) and Area 3 wells (57M-95-03X and 57M-96-11X). Depth to water is also measured in the following vicinity wells, piezometers and well points that were not sampled: 57M-03-01X, 57M-03-06X, 57M-95-05X, 57M-95-06X, 57M-95-07X, 57M-96-10X, 57M-96-12X, 57M-96-13X, 57P-98-03X, 57P-95-04X, 57WP-06-02 and 57WP-06-03. In addition to the well sampling and depth to water monitoring activities, the four groundwater sumps located at Area 2 are visually inspected for petroleum sheen or the presence of a non-aqueous phase liquid (NAPL). No petroleum sheen, NAPL, or petroleum odor was observed within the sumps during recent LTM activities.

Two surface water locations are sampled at Area 2 on the fringe of the marsh close to the edge of the former removal action excavation limit. One surface water location is sampled at Area 3 on the downstream edge of the former excavation area.

2.3.2.2 LTM Program Evaluation

The Sovereign team applied the approach described in Section 2.1 to determine whether optimization is warranted at AOC 57. Based on the previous remedial activities performed at the site and evaluation of the available monitoring data, elimination of monitoring is recommended for Area 2 and reduced monitoring at Area 3. The site currently does not pose an exposure risk and is not expected to pose a risk in the future.

The recommendation for elimination of monitoring activities at Area 2 is based on the following:

- Human health and ecological risks are acceptable under current land use conditions;
- The source of contamination has been removed;
- ROD COC concentrations are diminished, the remaining concentrations are steady, and there is limited potential for off-site migration of ROD COCs via the groundwater to surface water discharge pathway;
- If the source of arsenic is the result of site-related groundwater contaminants, then conditions will continue to improve; and
- With the exception of arsenic, all COCs are at or below their respective cleanup goals.

In summary, according to the ROD the presence of flood plain and wetland conditions and existing zoning preclude residential use of the area and exposure to contaminated soil and groundwater. Upland portions of AOC 57 are zoned for rail, industrial, and trade related use. In addition, the former Evergreen Solar manufacturing facility was constructed adjacent to the remaining AOC 57 areas and significantly restricts easy access to the sites. Flood plain portions are zoned for recreation and no development of these areas is likely. Residential construction is not permitted. The removal actions performed by the Army eliminated the majority of the petroleum-contaminated soils that would otherwise be continuing sources of contamination at Areas 2 and 3.

Furthermore, this optimization approach is in accordance with the remedial alternative components outlined in the ROD as well as the primary, balancing and modifying criteria applied in their development. This strategy is also consistent with risk management decisions that attempt to balance the overall goals of protecting human health and the environment with practical realities involving the allocation of resources.

Other AOCs at Devens have been closed under similar circumstances. For instance, a NFA decision was made for SA 43O Historic Gas Station Site at Devens (ABB Environmental Services, Inc. [ABB], 1996). This decision was based, in part, on the fact that although TCE levels were above remediation goals they were declining; furthermore, if the levels continued to decline, eventually these values will fall below the Federal MCL, reducing the potential human health risk to acceptable levels. Another consideration in the NFA decision was that the planned reuse of this portion of Devens is for commercial/industrial activities, which would likely limit future exposures to site groundwater. Therefore, the Historic Gas Station site was closed based on three primary assumptions: (1) the site did not present unacceptable current risks; (2) risks in the future would decrease as a function of declining contaminant concentrations; and (3) land use would maintain future risks at acceptable levels.

At AOC 57, these same three assumptions hold true. Both the human health and ecological risk assessments indicate that the existing risks are acceptable. The removal of the contaminant source has led to lower risks associated with the site, and deed covenants will maintain future risks at acceptable levels. In addition, in September 2007, the MassDEP granted MassDevelopment a NFA on an AOC 57 monitoring well (unidentified) that contained petroleum hydrocarbon (volatile petroleum hydrocarbon [VPH] and EPH) exceedances based on a lines-of-evidence rationale that included proximity to nearest public water supply well (1/2 mile), previous source removal, no NAPL, no bedrock contamination, and the exceedances were "close to the MCP standards". The conditions at the remaining AOC 57 sites meet these criteria.

Furthermore, the intent of the ROD was primarily to address petroleum contaminated soils and groundwater. The ROD indicates that AOC 57 is currently not within a Zone I or II/Interim Wellhead Protection Area and that ICs will be utilized until the environmental monitoring program indicates that Massachusetts Maximum Contaminant Levels (MMCL) have been achieved for at least three years. Since land use restrictions will be in place for the foreseeable future, long-term monitoring will not provide any additional protection to human health or the environment.

Until full site closure is achieved, the following changes are recommended to the LTM program at AOC 57:

- Change the groundwater monitoring frequency at Area 3 from annual to every 5 years to coincide with the five-year review;
- Use HydraSleeve™ technology to perform groundwater sampling at Area 3;
- Reduce surface water sampling to every 5 years at Area 3 to coincide with the five-year review.
- Decommission sumps at Area 2;
- Discontinue sampling of surface water and groundwater from all wells at Area 2.
- Eliminate VOCs from the groundwater and surface water COC list for Area 3; and
- Prepare technical memorandum for AOC 57 presenting site specific information that supports justification for site closure and path forward.

2.4 AREA OF CONTAMINATION 69W

2.4.1 Site Information

2.4.1.1 Contaminant Release

Contamination identified adjacent to the elementary school foundation is attributed to heating oil, which leaked from underground piping in two separate incidents in 1972 and 1978. It is estimated that approximately 7,000 to 8,000 gallons of fuel oil were released into the soil during each incident.

2.4.1.2 Contaminants of Concern

COCs for AOC 69W include arsenic and MassDEP VPH and EPH carbon ranges and analytes, with the monitoring criteria at levels established by Federal MCLs and the MCP. The monitoring criterion for arsenic was revised from 50 µg/L to 10 µg/L to match the current GW-1 standard established by the MCP in January 2006. Manganese has also been tracked over the course of the LTM program as a byproduct of groundwater conditions created by the COC degradation, although it is not a COC.

2.4.1.3 Selected Remedy

The ROD for AOC 69W was signed on June 30, 1999. "Limited Action" was the selected remedy for AOC 69W groundwater and subsurface soils (HLA, 1999).
The Limited Action alternative includes the following key components:

- ICs, including deed and/or use restrictions, are established and enforced restricting or preventing potential human exposure to site soil and groundwater contaminants left in place.
- A LTMP for groundwater is developed to monitor for potential off-site migration of contaminants and verify that elevated concentrations decrease over time. It was anticipated that arsenic and MassDEP EPH/VPH (carbon ranges and target analyte lists) would be the monitored analytes.
- Five-year reviews are conducted to review the data collected and assess the effectiveness of the remedy.

The 2000 HLA LTMP (HLA, 2000a) states that if there is indication that contaminants are migrating downgradient from the former source area, the Army, in conjunction with MassDEP and USEPA representatives, will evaluate the need for additional action. Under the LTMP, downgradient migration is defined by the presence of COC concentration(s) above the respective action level in groundwater samples collected from any of the sentry wells (ZWM-95-15X, ZWM-95-18X, ZWM-99-23X, and ZWM-99-24X).

The intent of the ROD was primarily to address soils and groundwater contaminated with heating and fuel oil. To meet Federal MCLs and Massachusetts Drinking Water Regulations 310 CMR 22, the ROD specifies that two actions are to be undertaken. First, long-term groundwater monitoring is to be applied to ensure that contaminants do not migrate off-site, and second, ICs are to be implemented to prohibit the installation of drinking water wells and prevent exposure. These actions are also qualified by the statement "In addition, arsenic concentrations are expected to decrease following the soil removal which eliminated the source." According to the ROD, the LTM program was implemented to ensure that contaminants do not migrate off-site, rather than demonstrate that cleanup goals are met.

2.4.2 Site Hydrogeology

The water table occurs in the overburden aquifer underlying AOC 69W. Groundwater flow is predominately south-southeast to north-northwest toward Willow Brook. Depth to groundwater at AOC 69W ranges from approximately 4 to 5 feet below ground surface (bgs) on the north side of the school building to approximately 1 foot bgs adjacent at Willow Brook. The hydraulic conductivity was determined to be 45 feet per day (ft/day), with a groundwater flow velocity of 0.7 ft/day.

The groundwater beneath AOC 69W is not used as a source of drinking water and is not expected to be in the future. It flows in the general direction of the MacPherson groundwater supply well, which is located approximately 3,000 feet downgradient of AOC 69W. The RI concludes that the contamination in the groundwater at AOC 69W does not affect the same aquifer that the MacPherson well intercepts.

2.4.2.1 Current Extent of Contamination

AOC 69W Organics

Since fall 2002 per **Table 2.2**, EPH carbon ranges have only been detected in source area wells 69W-94-13 and ZWM-99-22X and sentry well ZWM-99-23X. During the fall 2012 sampling event, EPH C_{11}-C_{22} aromatics were only detected above the 200 µg/L MCP GW-1 monitoring criteria in wells 69W-94-13 (379 µg/L) and ZWM-99-22X (308 µg/L). Based on linear regressions of the hydrograph (**Attachment B**) and Mann-Kendall plots (**Attachment C**), the C_{11}-C_{22} aromatics have generally decreased at AOC 69W since the 2000 sampling event.

Since the AOC 69W LTM program was initiated in 2000, VPH has only been detected in source area wells 69W-94-13 and ZWM-99-22X and sentry well ZWM-99-23X. The C_9-C_{10} aliphatic carbon fraction was not detected above the 200 µg/L MCP GW-1 monitoring criteria during the fall 2012 sampling event. Both the hydrograph (**Attachment B**) and Mann-Kendall plots (**Attachment C**) indicate that the C_9-C_{10} aromatic fraction has declined in wells 69W-94-13 and ZWM-99-22X and remained below the 200 µg/L monitoring criteria since fall 2009. For well ZWM-99-23X, the C_9-C_{10} aromatics have fluctuated without an apparent upward or downward trend, although the concentrations have remained below the 200 µg/L monitoring criteria.

AOC 69W Metals

During the fall 2012 sampling event per **Table 2.2**, arsenic was detected above the 10 µg/L current monitoring criteria in source area wells 69W-94-13 and ZWM-99-22X and sentry wells ZWM-95-15X, ZWM-99-23X and ZWM-99-25X. By comparison, the arsenic results for all monitored wells at AOC 69W have historically remained either non-detect or below the monitoring criteria. Per the hydrograph (**Attachment B**) and Mann-Kendall plots (**Attachment C**), the linear regression statistics indicate that arsenic concentrations for wells 69W-94-13 and ZWM-99-23X have no definitive trend established. However, source well ZWM-99-22X exhibits an overall increasing trend, with a high concentration of 408 µg/L recorded for the fall 2009 sampling event.

Since LTM monitoring began in 2000, the manganese results for source area wells 69W-94-13 and ZWM-99-22X and sentry wells ZWM-95-15X, ZWM-99-23X, and ZWM-01-25X have primarily remained above the monitoring criteria of 375 µg/L. In addition manganese was detected above the monitoring criteria at well point 69WP-08-01 for the first time in fall 2011 but showed a significant decrease in fall 2012. The overall trend, according to linear regressions of the hydrograph plots (**Attachment B**) and Mann-Kendall statistical analyses (**Attachment C**), in manganese concentrations for wells ZWM-95-15X, 69W-94-13, ZWM-99-22X and ZWM-99-23X is either steady or potentially decreasing slightly. By comparison, manganese concentrations at well ZWM-01-25X are statistically and graphically increasing, which may explain the first-time detection at nearby wellpoint 69WP-08-01 in 2011.

To determine the arsenic and manganese mobilization mechanism in the groundwater, ORP was evaluated against concentration. If fuel compound biodegradation was mobilizing natural arsenic and manganese, then consistently low ORP values would be expected with some correlation between fuel oils and metals concentrations downgradient from the historic fuel contamination. There does not seem to be a significant correlation between ORP and arsenic or manganese. There does, however, appear to be a correlation between elevated petroleum and manganese concentrations. Between seven and ten groundwater monitoring wells have been sampled on a semi-annual basis from 2000 through 2005; in 2006 sampling was reduced to an annual frequency. Exceedances from 2000 to 2012 are presented in **Table 2.2**. As shown in the table, monitoring wells in which arsenic and manganese are regularly exceeded are the same wells where fuel hydrocarbons also exceed monitoring criteria. These observations suggest that metals mobility in groundwater is controlled by the geochemical changes caused by the biodegradation of the fuel hydrocarbons. This apparent inconsistency, in which high manganese concentrations are not correlated with low ORP values but are correlated with elevated petroleum concentrations, may be due to ORP readings and manganese concentrations being disproportionately affected by seasonal variations in geochemistry.

Groundwater elevations depicted in **Figure 2.2** of the 2011 Annual Report (Sovereign and HGL, 2012), indicate that groundwater flow is towards the northwest. Monitoring well ZWM-95-18X is situated approximately 350 to 400 feet downgradient from where the contaminant source was excavated (**Figure 1.3**). To further delineate manganese concentrations, well point 69WP-08-01 were installed further downgradient of the former source area. As stated, a manganese concentration above the monitoring criteria was found for the first time at 69WP-08-01 during the fall 2011 sampling event but declined significantly based on the fall 2012 sampling event. Well point 69WP-13-01 was installed for the fall 2013 sampling event. The results from this sampling event will help[further characterize manganese concentration in groundwater. To date, fuel-related COCs have not been detected at appreciable concentrations in well ZWM-95-18X. Furthermore, based on an estimated average velocity of 0.7 ft/day, the groundwater should have migrated 7,400 feet from the spill area since the second fuel oil release in 1978. Since fuel-related contaminants and arsenic have not been detected in appreciable concentrations beyond 350 to 400 feet from the source area, the aquifer system appears to be effectively attenuating contaminant migration; however, a reductive zone generated by the degradation of the organic contaminants likely extends downgradient of the hydrocarbon impacted area, as evidenced by the exceedance of the manganese monitoring criteria value at 69WP-08-01.

2.4.3 Long-Term Monitoring Program

2.4.3.1 Current Program

The purpose of the LTM program is to monitor the potential for off-site migration of contaminants and verify that elevated concentrations of contaminants are decreasing over time. Site reviews are conducted every 5 years to insure that the remedy continues to provide adequate protection of human health and the environment. Sampling began on a semi-annual basis in May 2000 and has been conducted on an annual basis since 2006. Groundwater and surface water samples are currently collected annually in the fall (October/November). Well point 69WP-08-01 was added to the LTM program in 2008 due to exceedances of groundwater manganese criteria in downgradient monitoring wells. Upgradient monitoring well ZWM-95-17X and side-gradient monitoring well ZWM-01-26X are only monitored for geochemical parameters during LTM events. Collection of laboratory samples ceased at these two monitoring well locations based on consistent analytical results that were non-detects.

2.4.3.2 LTM Program Evaluation

The Sovereign team applied the technical approach described in **Section 2.1** to determine whether site closure or other optimization actions are appropriate at AOC 69W. The site currently does not pose a risk and is not expected to pose a risk in the future. More specifically, conditions at AOC 69W meet the following criteria:

- Human health and ecological risks are acceptable under current land use conditions;
- The source of contamination has been substantially removed;
- Groundwater quality is improving and will continue to improve;
- The potential for EPH/VPH and arsenic off-site migration has decreased over time; and
- Future land use and deed restrictions will eliminate potential future risks.

The removal actions performed by the Army mostly eliminated the petroleum-contaminated soils that would otherwise be continuing sources of contamination; however, a portion of the impacted soils were left in place due to their location under the existing school building. There are no known human or ecological risks associated with AOC 69W. Groundwater quality will continue to improve and potable use of groundwater is prohibited. The property has been transferred from Army ownership and deed covenants were included to prevent potable use of groundwater and unrestricted use of the property.

The AOC 69W ROD specifies that MCLs are the groundwater monitoring criteria at the site. The MCLs are consistent with Federal MCLs and State of Massachusetts GW-1 standards that are included in the MCP. A portion of AOC 69W is within a Zone II interim wellhead protection area. However, as discussed in **Section 2.1**, the revision to the MCP, which became effective February 2008, allows the adoption of alternative exposure points and monitoring criteria for those sites that are contaminated with oils [i.e., CMR 40.0924(2) and CMR 40.0926(8)]. This MCP revision is applicable to sites that are designated GW-1 solely on the basis of the being within a Zone II or an Aquifer Protection District that overlays or is contiguous with a Zone II. The MCP revision for petroleum release sites recognizes the established CSM for the fate and transport of hydrocarbon compounds in groundwater i.e, that biodegradation and attenuation occur within a short distance of a release, such that the constituents do not generally migrate substantial distances in groundwater. AOC 69W has demonstrated these conditions and the "incomplete" source removal is not affecting or contributing to conditions such that any remnant source strength is causing conditions to persist or worsen. On the contrary, the source area well has steadily declined and is approaching the monitoring criteria and most site wells meet the monitoring criteria.

In support of this and based on the trends discussion in **Section 2.4.2.1**, the monitoring criteria for the EPH C_{11}-C_{22} aromatic and VPH C_9-C_{10} aromatic carbon fractions, particularly at source area well ZWM-99-22X, will likely be achieved within the 30-year ROD timeframe.

The following changes to the LTM program and actions are recommended at AOC 69W:

- Eliminate VPH carbon ranges and target analytes from the LTM program.
- Prepare technical memorandum for AOC 69W presenting site specific information that supports conditions defined within the MCP revision for petroleum release sites, justification for site closure and path forward.

2.5 AREA OF CONTAMINATION 43G

2.5.1 Site Information

2.5.1.1 Contaminant Release

Contaminants at the site were released from the former AAFES gas station and historic gas station. The historic gas station dates back to World War II. Fuel-related compounds were detected, principally benzene, toluene, ethlybenzene, xylenes (BTEX), in site soil and groundwater because of leaking USTs.

2.5.1.2 Contaminants of Concern

The COCs in groundwater at AOC 43G are BTEX, VPH aliphatic and aromatic carbon fractions, nickel, iron, and manganese. The cleanup goals for these COCs are the GW-1 standards as established by the MCP, with the exception of a site-specific cleanup goal of 375 µg/L for manganese, which is specified in the ROD and based on the Devens background value (HLA, 2000b).

2.5.1.3 Selected Remedy

The ROD for AOC 43G was signed in 1996 documenting the selection of intrinsic remediation with LTM as the selected remedy (USACE, 1996). Intrinsic bioremediation is the principal component proposed to prevent COCs that exceed groundwater cleanup levels from potentially migrating off Army property or an area located sufficiently inside the boundary in which compliance will be determined. The ROD stated that the minimum cleanup criteria will meet drinking water standards. Components of the selected remedy included annual reporting to USEPA and the MassDEP, installation of additional groundwater monitoring wells, long-term monitoring, and performing five-year site reviews. Quarterly groundwater sampling was performed between March 1997 and December 1998 in support of an intrinsic remediation assessment. Groundwater sampling results and modeling indicated that intrinsic remediation is a viable remedial option for AOC 43G.

The ROD specifies that if the intrinsic bioremediation assessment results indicate that (1) the groundwater contaminant plume increases in size on Army property, and/or (2) the groundwater contaminant plume remains the same size, but cannot be remediated within 30 years, then a soil vapor extraction (SVE) system will be installed at the existing AOC 43G source area. Furthermore, if at any time during this remedy there is an indication that contaminants are migrating off Army property above drinking water standards (MCLs/MMCL or risk-based concentration [i.e., groundwater cleanup levels]); and/or if the five-year review indicates that the intrinsic remediation alternative is not protective of human health, the Army will implement an additional cleanup action to protect human health and the environment as required under CERCLA.

2.5.2 Site Hydrogeology

According to the RI, groundwater at AOC 43G occurs in overburden till and the meta-siltstone (phyllite) bedrock. The predominant groundwater flow direction at the site is to the east-southeast with an average horizontal gradient of 0.034 feet/foot across the site. In situ hydraulic conductivity estimates yield an average value of 2.0 ft/day for wells in the overburden and 0.07 ft/day for wells screened entirely in the bedrock.

2.5.2.1 Current Extent of Contamination

Results from the 2012 LTM sampling event indicate that benzene was detected in groundwater samples from source area wells at AOC 43G. Source area groundwater monitoring well AAFES-2 had a concentration of benzene (6.60 µg/L) exceeding the GW-1 standard of 5 µg/L (**Table 2.3**). Source area groundwater monitoring well XGM-97-12X had a concentration of benzene (3.03 µg/L) below the GW-1 standard of 5 µg/L. All four source area wells also either non-detect for toluene, ethylbenzene, and total xylene during the fall 2012 LTM event or had detections below the applicable GW-1 standards of 1,000, 700, and 10,000 µg/L, respectively.

As exhibited in the AOC 43G data graphs (**Attachment B**) and Mann-Kendall analyses (**Attachment C**), benzene has undergone a dramatic reduction in concentration from a high for the site of 2,000 µg/L in December 1994 to 6.60 µg/L in October 2012. These results support conclusions of the BIOSCREEN modeling conducted in 1999, which was used to estimate remedial duration and plume migration potential (SWETS and HLA, 1999). The benzene modeling results demonstrated that the contamination was unlikely to migrate off Army property. The benzene criterion at AOC 43G was estimated to be achieved approximately in the years 2007 to 2009, or between 11 to 13 years total following signing of the ROD, which is compliant with the 30-year criteria in the ROD. The BIOSCREEN modeling determined that aerobic degradation was the overriding process at AOC 43G, although the relatively high hydraulic conductivity of the sediments suggests that dilution and plume movement could also account for the dramatic reduction in observed benzene concentrations.

For the fall 2012 LTM event, source area wells AAFES-2 and XGM-97-12X and sentry well XGM-94-04X had concentrations of VPH C_5-C_8 aliphatics and VPH C_9-C_{10} aromatics that exceeded the GW-1 standards of 300 µg/L and 200 µg/L, respectively. All VPH C_9-C_{12} aliphatics results were either non-detect or detections below the GW-1 standard.

As illustrated by data graphs (**Attachment B**) and Mann-Kendall analyses (**Attachment C**), the VPH C_9-C_{10} aromatic hydrocarbon concentrations have declined significantly in four of five AOC 43G wells (**Table 2.3**). By comparison, concentrations in groundwater at sentry well XGM-94-04X (near the source area) have been above the 200 µg/L VPH C_9-C_{10} aromatic hydrocarbon GW-1 standard since fall 2010. The VPH C_5-C_8 aliphatic carbon fraction concentrations have fluctuated throughout the period of LTM sampling with some indication of a declining trend, as detailed in the data graphs (**Attachment B**) and Mann-Kendall analyses (**Attachment C**). Again, by comparison, concentrations in groundwater at sentry well XGM-94-04X have been above the 300 µg/L VPH C_5-C_8 aromatic hydrocarbon GW-1 standard since fall 2010 (**Table 2.3**). With regards to the VPH C_9-C_{12} aliphatic carbon fraction trend, the sharp concentration increase recorded for the 2005 sampling event at wells AAFES-2, XGM-93-02X, and XGM-97-12X has largely declined back to pre-2005 levels (**Table 2.3 and Attachment B**).

Manganese concentrations from the fall 2012 LTM event (Table 2.3) exceeded the site-specific cleanup goal of 375 µg/L at all monitoring wells except AAFES-5, and ranged from 612 µg/L in well XGM-93-02X to 5,560 µg/L in well XGM-94-07X. Groundwater concentrations from AAFES-7 exceeded the site specific cleanup goal of 375 µg/L for the first time during the fall 2012 LTM event. Furthermore, iron was detected above the cleanup goal of 9,100 µg/L in monitoring wells AAFES-2, XGM-93-02X, XGM-94-07X and XGM-97-12X. Naturally occurring manganese in aquifer systems is often associated with iron oxyhydroxides, which can be subsequently mobilized by changes in the in-situ environment to more reducing conditions caused by the biodegradation of fuel compounds. To evaluate this possibility, manganese trends for wells where the cleanup goals were exceeded in the 2012 LTM event were examined (**Attachment B**). As shown in the trend plots, the manganese concentrations are generally in decline or stable, as supported by the Mann-Kendall analyses in **Attachment C**, and this reduction is likely due to the overall decreasing trends in hydrocarbon concentrations observed for the site.

2.5.3 Long-Term Monitoring Program

2.5.3.1 Current Program

As part of the LTM program, eight existing monitoring wells (four source wells and four sentry wells) are sampled for BTEX, VPH, iron, and manganese on an annual basis (October/November). Source wells include AAFES-2, AAFES-6R, XGM-93-02X, and XGM-97-12X. Sentry wells include AAFES-5, XGM-94-04X, XGM-94-07X, and XGM-94-08X. Monitoring well AAFES-6R was installed in January 2006 as a replacement for monitoring well AAFES-6, which had become damaged and was abandoned in January 2006. AAFES-7 was added to the LTM program in 2010 as a downgradient sentry well to determine if dissolved metals, specifically manganese, were migrating off-site.

2.5.3.2 LTM Program Evaluation

The Sovereign team applied the technical approach described in Section 2.1 to determine what optimization actions are appropriate at AOC 43G. The site currently does not pose a risk and is not expected to pose a risk in the future. More specifically, conditions at AOC 43G meet the following criteria:

- Human health and ecological risks are acceptable under current land use conditions;
- The source of contamination has been removed;
- Groundwater quality is improving and will continue to improve; and
- ICs and future land use will eliminate potential future exposure.

The removal actions performed by the Army eliminated the source of petroleum contamination at the site. There are no human or ecological risks associated with AOC 43G, and an analysis of data trends (Appendices B and C) reveals that in most instances the COCs are either stable or decreasing. Groundwater quality will continue to improve and potable use of groundwater is prohibited. In the event of future property transfer, the Army will include deed covenants to prevent potable use of groundwater and unrestricted use of the property.

Until site closure is achieved, the following optimization steps are recommended for the LTM program at AOC 43G:

- Based on results of the MAROs Mann-Kendall analyses of manganese trends discontinue sampling at monitoring wells AAFES-5 (only exceedance was in 1999), AAFES-6R (decreasing), XGM-94-07X (stable) and XGM-94-08X (decreasing).
- Use HydraSleeve™ technology to perform groundwater sampling at AOC 43G.
- Reduce TAL for metals (reduce TAL to report only manganese) and VPH (reduce TAL to report only aliphatics) analyses for "alternate" year annual sampling events (CY2015, CY2017, etc.)
- Non-alternate year (CY2014, CY2016, etc.) annual sampling events will continue with current full TAL for both metals and VPH.
- Prepare technical memorandum for AOC 43G presenting site specific information for reclassification of groundwater from GW-1 to GW-3, justification for site closure and path forward.

2.6 SOUTH POST IMPACT AREA

The following section provides a discussion and evaluation of sites that are included in the current SPIA LTM program, shown in **Figure 1.5**. This includes AOC 26, AOC 27, and the SPM wells. The USEPA Region 1 and MassDEP approved the discontinuation of sampling at AOC 41 in 2007. Consequently, AOC 41 is not discussed in detail within this OER; however, one former AOC 41 monitoring well is sampled as part of the overall SPM monitoring program and will be considered for optimization. Sampling was also discontinued at AOC 25 in 2005, based on recommendations presented in the 2004 LTM report (USACE-NAE, 2005).

2.6.1 Site Information

2.6.1.1 Contaminant Release

AOC 26 and AOC 27 were historically used for firearms and grenade training, as well as open burning/open detonation of explosives. These activities have led to limited impacts in soils and groundwater with metals, explosives, perchlorate and VOCs. The SPIA is currently an active weapons and ordnance discharge area used by the Army, the United States Army Reserve Command (USARC), the National Guard, and local, state, and federal law enforcement agencies for training.

2.6.1.2 Contaminants of Concern

The ROD directed that monitoring wells be sampled for target compound list (TCL) explosives and target analyte list (TAL) metals. Perchlorate was sampled beginning in 2004 and permanently added to the AOC 26 contaminants list in 2006.

2.6.1.3 Selected Remedy

The ROD issued for AOCs 26, 27 and 41 in July 1996 selected "No Action" as the remedy for groundwater (Horne Engineering Services, 1996). The remedy did not include any formal remedial action but did include LTM activities and an Integrated Natural Resources Management Plan (INRMP). The INRMP was written to monitor impacts of the current land use to ecosystems within the SPIA monitoring area and is updated periodically. The groundwater monitoring specified in the ROD to detect potential contaminant migration out of the SPIA monitored areas stated that:

- Monitoring wells will be used to monitor the groundwater from the Explosive Ordinance Discharge (EOD) Range, Zulu Ranges, Hotel Range and AOC 41.
- Monitoring wells will be used to monitor the north, northeast, southeast, and east sides of the SPIA monitored-area and will be sampled for TCL explosives and TAL metals.

The groundwater analytical results at the SPIA are compared to the MCP GW-1 and GW-3 standards for comparison purposes only, as the criteria are not considered "clean-up" standards under a "No Action" ROD.

2.6.1.4 Site Hydrogeology

A bedrock ridge forms a groundwater divide across the northern portion of the SPIA. As a result of this ridge, groundwater from the Zulu and Hotel Ranges and Cranberry Pond in the northeast corner of the SPIA flows north into Slate Rock Brook and Slate Rock Pond. At the same time, groundwater from the EOD Range and most of the remaining portions of the SPIA flows southeast and east to the unnamed brook and New Cranberry Pond or to the north of New Cranberry Pond directly to the Nashua River and its wetland.

Groundwater in the vicinity of the ranges discharges to surface water before it leaves the SPIA. More than 50 percent (%) of the SPIA overlies a medium yield aquifer that is a potential source of drinking water. Measurements of hydraulic head in the groundwater and in streams and ponds within the South Post show that the streams around the SPIA are gaining streams (i.e., groundwater discharges into the streams). Groundwater models developed in conjunction with the RIs indicate that there are several groundwater divides in the area and that most groundwater discharges to surface water before leaving the SPIA. The RI estimates groundwater velocities to range from 0.21 to 18.7 ft/day.

Based on confirmation from 2011 groundwater elevation data, the general groundwater flow path in the Zulu Range (AOC 26) was confirmed as being from south to north/northeast towards a pond/wetland area with an overall flow direction oriented towards the interior of the SPIA and away from the SPM boundary. The hydraulic conductivity (32 ft/day in 26M-92-03X) and thickness of the zone of saturation at the north side of the Zulu Range implies that the aquifer is close to but not exceeding a transmissivity (1,350 ft^2/d), which would classify it as a potentially productive aquifer (310 CMR 40.0006).

Flow at AOC 27 is heading north and west away from Cranberry Pond towards the wetland (north of Old Turnpike Road). The groundwater affected by the site flows north across Old Turnpike Road to a wetland within the northern part of Hotel Range or possibly continuing towards Slate Rock Pond.

2.6.1.5 <u>Current Extent of Contamination</u>

Based on the 2011 LTM groundwater sampling results, contaminant plume migration beyond the SPIA monitored area is not occurring. Sample results from the SPIA SPM wells were predominantly non-detect for monitored compounds; however, arsenic was detected above the GW-1 standard at one SPM well. Although analytical results for some of the sample locations were above their respective GW-1 comparison values, the sample locations are within the SPIA monitored area. Analyte 1,3,5-trinitroperhydro-1,3,5-triazine (RDX) was detected above the revised GW-1 standard of 1 µg/L at three wells and one well point at AOC 26. There were no other RDX exceedances within the SPIA.

At AOC 26, perchlorate was detected above the 2 µg/L GW-1 standard in groundwater collected from well point 26WP-06-01 (19.1 µg/L) and monitoring wells 26M-92-04X (49.2 µg/L) and 26M-97-08X (3.84 µg/L); however, both results are below the 1,000 µg/L GW-3 standard. Perchlorate concentrations in groundwater at well 26M-92-04X have exceeded the GW-1 standard for four consecutive LTM events, with a sharp decrease in concentration between the 2011 and 2012 LTM event. Currently, the trend graph (**Attachment B**) and Mann-Kendall analysis (**Appendix C**) indicate a decreasing/no trend; however, the data are limited (**Table 2.4**) and no definitive trend can be deduced at this time.

Perchlorate was detected below the GW-1 and GW-3 standards in samples collected from well point 26WP-09-02 and wells 26M-10-09X, 26M-92-02X and 26M-92-03X, and not detected in samples from well points 26WP-08-02 and 26WP-09-01. By comparison, groundwater at well point 26WP-06-01 has exhibited a perchlorate exceedance since 2006, and the latest exceedance is the lowest concentration observed since 2007 (**Table 2.4**). To aid in determining perchlorate migration, a new groundwater well, 26M-10-09X, was installed downgradient in October 2010 as a permanent monitoring point to intercept potential off-site migration of perchlorate from AOC 26. In October 2012, well 26M-10-09X had a perchlorate detection of 0.026 µg/L, which is below the 2 μg/L GW-1 standard. This result suggests that the elevated perchlorate concentrations are confined to the central, active portion of the range and are not migrating off-site.

The 2012 results for AOC 26 revealed that all metals were generally detected below background concentrations with the exception of iron and lead for well point 26WP-08-02 (37,000 μg/L and 6 μg/L, respectively). In addition, well point 26WP-08-02 had exceedances of GW-1 standards for arsenic (68 μg/L) and zinc (9,790 μg/L). It should be noted that well points at AOC 26 were installed for monitoring explosives and perchlorate and are not optimal for total metals due to the composition of the galvanized iron pipe material used for the wells. All metals results were below their respective GW-3 standards, where applicable.

As discussed previously, RDX continues to be detected above the recently promulgated 1 μg/L GW-1 standard in AOC 26 monitoring wells 26M-92-03X, 26M-92-04X, 26M-97-08X, and well point 26WP-06-01. These four groundwater monitoring locations also had detected concentrations of octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX), but all concentrations were below the 200 μg/L GW-1 standard. AOC 27 monitoring well 27M-93-06X had a low RDX detection (2.12 μg/L) in 2010 above the GW-1 standard. RDX and HMX results at AOCs 26 and 27 are below the 50,000 μg/L GW-3 standards for both compounds.

The physical properties of the two explosive compounds suggest that they are quite mobile in groundwater. Although their aqueous solubilities are on the low side for explosives, their tendency to sorb is practically negligible, particularly for HMX. Neither compound is at all volatile. These characteristics suggest that HMX and RDX will exist almost completely in the aqueous phase. Based on their physical properties, and the locations of their detection, the following scenario for their fate and transport can be constructed:

- HMX and RDX were most likely introduced into the soils at localized areas within the SPIA. Depending on the process by which RDX is synthesized, HMX is an impurity that may compose up to 10% by weight of RDX;
- HMX and RDX entered the groundwater via infiltration through contaminated soils, as historically they were found consistently in the wells within the ranges;
- Such migration is probably due both to advective flow and dispersion; and
- According to recent studies and a literature review of degradation mechanisms, HMX and RDX have the potential to biodegrade in groundwater, especially under anaerobic geochemical conditions.

According to linear regression of the data plots (**Attachment B**) and the Mann-Kendall analyses (**Attachment C**), RDX concentrations in all wells, where there is sufficient data to establish a trend, have either remained stable since the 2000 LTM event or exhibited a decline. By comparison, long-term trends in HMX have essentially plateaued, with detections remaining below the GW-1 standard.

2.6.2 Long-Term Monitoring Program

2.6.2.1 Current Program

The October 2012 LTM sampling event at SPIA consisted of collecting groundwater samples from 12 monitoring wells, four well points, and one drinking water well. Groundwater samples were collected from four existing AOC 26 monitoring wells (26M-92-02X, 26M-92-03X, 26M-92-04X and 26M-92-08X) and two well points (26WP-06-01 and 26WP-08-02) and analyzed for explosives and metals. Groundwater samples were collected from five existing monitoring wells (26M-92-02X, 26M-92-03X, 26M-92-04X, 26M-92-08X and 26M-10-09X) and four well points (26WP-06-01, 26WP-08-02, 26WP-09-01 and 26WP-09-02) and analyzed for perchlorate. In addition to the samples collected from the AOCs, groundwater samples were collected from seven SPM wells and one drinking water well that are not associated with an AOC. The SPM wells were analyzed for explosives and total metals. SPM well 41M-93-04X samples were analyzed for VOCs and explosives, and the drinking water well was sampled for explosives only.

2.6.2.2 LTM Program Evaluation

Following the technical approach described in **Section 2.1**, the SPIA sites were evaluated to determine whether LTM optimization is warranted. Although contamination at these sites does not pose an unacceptable risk, continued monitoring is recommended due to the potential for additional releases at the active ranges (Zulu and Hotel Ranges). However, there are opportunities to optimize the monitoring program in terms of sampling frequency, sampling locations, and the analyte list. As stated previously, the SPIA groundwater results are compared to MCP GW-1 and GW-3 standards for evaluation purposes but there are no clean-up goals under the “No Action” ROD.

Historical data were reviewed as part of the LTM optimization analysis for AOC 26, AOC 27, and the SPM wells. Analytical sampling results, well locations, construction details, maps, and annual reports were reviewed in order to adequately assemble and evaluate the LTM data collected at these sites over the period from 1997 to 2012. There is sufficient data of reliable quality to perform a qualitative analysis at the three SPIA sites.

The rationale for optimizing the LTM program at AOC 26, AOC 27, and the SPM wells is discussed in the following sections.

AOC 26

Examining the hydrograph (**Attachment B**), Mann-Kendall (**Attachment C**), and/or **Table 2.4** results by constituent, the following observations can be made:

Arsenic

- Consistently trends downward below the 10 µg/L GW-1 standard in the shallow overburden; arsenic has not been detected in the three shallow wells 26M-92-03X, 26M-92-04X, and 26M-97-08X since 1999.
- Concentrations near the bedrock (26M-92-02X) are variable with no apparent upward or downward trend over the past 11 years.

- Arsenic was detected above the 10 µg/L GW-1 standard at well point 26WP-08-02 in 2008 through 2012.
- Arsenic has remained below the 900 µg/L GW-3 standard.

HMX

- Consistently below the 200 µg/L GW-1 standard in the overburden.
- Not detected near bedrock.
- Trends in HMX concentration are relatively stable over the past 11 years.
- HMX has remained below the 50,000 µg/L GW-3 standard.

RDX

- Consistently above the 1 µg/L GW-1 standard in the overburden.
- Not detected near bedrock.
- RMX has remained below the 50,000 µg/L GW-3 standard.

Perchlorate

- Perchlorate is consistently above the 2 µg/L GW-1 standard at 26WP-06-01 based on data collected between 2006 and 2012.
- Variable concentration trend observed at 26WP-06-01 since a maximum concentration was observed in May 2009 (305 µg/L).
- Perchlorate was detected in groundwater from well 26M-92-04X (49.2 µg/L). This was the fourth consecutive detection in exceedance of the GW-1 standard at this well and the most recent detection is a large decrease from the October 2011 sampling event (332 µg/L). This well historically has had periodic detections above the 2 µg/L GW-1 standard. It is located upgradient southeast to 26WP-06-01, within the main footprint of the Zulu 2 range. Groundwater flow from this location is towards the northeast. The non-detections in the other well points, northeast and west of well 26M-92-04X, confirm that the groundwater flow direction confines any potential perchlorate plume to within the SPM area.
- Perchlorate does not exceed the 1,000 µg/L GW-3 standard.

Based on an examination of the trends and the other lines of evidence, the following changes to the current LTM sampling plan are recommended:

- Discontinue metals analyses for well points 26WP-06-01 and 26WP-08-02.
- Add perchlorate analysis for existing LTM sampling program monitoring wells 26M-92-02X, 26M-92-03X, 26M-97-08X and SPM-93-06X.
- Add explosives and metals analyses for existing LTM sampling program monitoring well 26M-10-09X.
- Evaluate extent of perchlorate.

AOC 27

Examining the **Table 2.4** results by constituent, the following observations can be made:

Arsenic

- Detections are transient but below the 10 µg/L GW-1 and 900 µg/L GW-3 standards.

RDX

- Stable trend below the 1 µg/L GW-1 standard in bedrock well 27M-93-05X.
- Consistent downward trend in shallow groundwater (27M-92-01X); above the 1 µg/L GW-1 standard in November 2004 but non-detect for all subsequent events.
- Stable concentrations in mid-depth groundwater (27M-93-06X) at levels that are marginally above the 1 µg/L GW-1 standard when detected.
- RMX does not exceed the 50,000 µg/L GW-3 standard.

HMX

- Consistently well below the 200 µg/L GW-1 standard (maximum value observed is less than 4 µg/L).
- Not detected near bedrock.
- Detected twice at the mid-depth well 27M-93-08X, most recently in 2001.
- Appears to have stabilized at concentrations below 1 µg/L based on the last three sampling events at monitoring well 27M-93-06X.
- HMX does not exceed the 50,000 µg/L GW-3 standard.

Although HMX is well below the GW-1 standard of 200 µg/L and has potential for optimization, there is not a significant cost benefit to reducing the list of explosives to be analyzed, given that eliminating RDX sampling at this time is not recommended.

<u>SPM</u>

Examining the hydrograph (**Attachment B**), Mann-Kendall (**Attachment C**), and/or **Table 2.4** results by constituent, the following observations can be made:

Arsenic

- General downward trends since 2005 for wells SPM-93-06X and SPM-93-10X.
- Flat to slow downward trend at SPM-97-24X and consistently below the 10 µ/L GW-1 standard.
- Arsenic concentrations at SPM-93-12X and SPM-93-16X do not exhibit an upward or downward trend. Arsenic concentrations are below the 10 µg/L GW-1 standard.
- Arsenic does not exceed the 900 µg/L GW-3 standard at any monitored location.

RDX

- RDX has not been detected above the GW-1 or GW-3 standards in any SPM well.
- RDX has not been detected in Hydrant D-1 since 1999 (with the exception of a trace, estimated detection in 2006).

HMX

- HMX has not been detected above the GW-1 or GW-3 standards in any SPM well.

The SPM wells serve as a sentinel network for the SPIA. To ensure that contaminants do not migrate off the SPIA, it is not recommended at this time to reduce sampling or remove sampling locations from the SPM-series well network as long as AOC 26 and AOC 27 are active and there exists the potential for further contamination. Based on current conditions the following changes are recommended for the SPM portion of the SPIA LTM program:

- Remove well 41M-93-04X from the SPM analytical sampling network but retain for 5-year review water level gauging events.
- Monitoring wells located at AOC 41 and gauged prior to five year reviews should be removed from the gauging network and decommissioned. These wells are superfluous to the monitoring network.

2.7 DEVENS CONSOLIDATION LANDFILL

2.7.1 Site Information

The DCL was constructed on the former Devens golf course driving range to accommodate excavated material from seven remedial areas consisting of two SAs, four areas of contamination and one pesticide removal project at three Devens housing areas. The seven sites were:

- SA 12: A half-acre location where construction debris and yard waste were deposited (approximately 8,700 cy);
- SA 13: A 1-acre area used from 1965 to the mid-1990s for yard-waste (approximately 10,000 cy);
- AOC 9: An area used for storing wood, concrete, asphalt, metal, brick, glass, and tree stumps (approximately 121,000 cy);
- AOC 11: A former landfill used from 1975 to 1980 for disposal of wood-frame hospital demolition debris (approximately 35,000 cy);
- AOC 40: Four acres used for construction debris, ash, stumps, and logs (approximately 125,400 cy);
- AOC 41: A one quarter-acre landfill in the SPIA that was used up to the 1950s for disposal of non-explosive material and household debris (approximately 1,500 cy); and
- Grant, Locust, and Cavite Housing Areas: Soils and walling material contaminated with VOCs or pesticides (approximately 2,290 tons of soil and approximately 1,240 tons of concrete).

Construction of the DCL commenced in September 2000 and was completed in November 2002. The Remedial Action Closure Report prepared by Shaw Environmental in September 2003 was accepted, certifying that the DCL was constructed and capped in accordance with the ROD, and met the performance standards and/or response objectives in the ROD. Periodic LTM activities have been performed since the completion of the landfill construction.

2.7.1.1 Selected Remedy

The USEPA approved the ROD for DCL sites in July 1999. It included provisions for either on-site or off-site disposal options. The on-site landfill construction alternative was selected as the best value. Post-closure monitoring is required for a minimum period of 30 years according to Massachusetts Solid Waste Management Regulations (310 CMR 19.142). The ROD included recommendations for cover system monitoring and maintenance consisting of annual site inspections, mowing of vegetation on the landfill cap, and additional cap inspections and/or maintenance as a result of severe weather events. The ROD also required the collection of samples from groundwater monitoring wells in accordance with 310 CMR 19.132 and the performance of five-year reviews to assess the effectiveness of the remedy. Leachate is discharged to the Devens Sewage System by the terms of the authorized industrial wastewater discharge permit No. 017 with MassDevelopment.

Other regulatory requirements include:

- Clean Water Act and National Pollution Discharge Elimination System Permit Program [40 Code of Federal Regulations (CFR) 122, 125];
- Massachusetts Endangered Species Regulations (310 CMR 8.00); and
- Massachusetts Solid Waste Facilities Site Regulations (310 CMR 16.00).

2.7.2 Long-Term Monitoring Program

2.7.2.1 Current Program

The Remedial Action Closure Report describes the operations and maintenance (O&M) activities that are required for the DCL. Current LTM and landfill O&M activities include annual landfill gas vent monitoring, semi-annual groundwater sampling, monthly O&M of the leachate pump station, and semi-annual well gauging and annual landfill cap inspections. Eleven landfill gas vents are monitored annually, four groundwater monitoring wells are sampled semi-annually, seven monitoring wells are gauged semi-annually, and leachate discharge is sampled annually, as part of the current LTM program for the DCL.

The groundwater samples from the DCL monitoring wells continue to show non-detects or detections below the GW-1 and GW-3 standards, as demonstrated in **Table 2.5**. All VPH, EPH, and organochlorine pesticide results have been non-detects or detections below the associated analytical reporting limit since 2004. Metals results have also been below GW-1 and GW-3 limits in the DCL monitoring well groundwater samples since 2003, and the 2004 through 2012 results are consistent with the historical results.

Additionally, MassDevelopment correspondence dated July 29, 2009, discussed the most recent changes to the LTM program that included eliminating the requirement to sample cyanide, aluminum, heptachlor, phenol, and total petroleum hydrocarbons from the new landfill discharge permit. The annual DLC leachate sampling is still to be completed between October

1, and December 31, each year, with the self-monitoring reports due to MassDevelopment by January 5, the following year.

The following analytes are monitored yearly:

1.) Metals include: arsenic, chromium (total), cadmium, copper, lead, nickel, silver, zinc, and mercury;
2.) Total suspended solids (TSS);
3.) Total toxic organics (the sum of VOCs, semi-volatile organic compounds [SVOC], pesticides and PCBs); and
4.) pH.

The revised permit also included the requirement to calibrate the leachate flow meter at least every 12 months and provide a copy of the certificate of calibration to MassDevelopment.

2.7.2.2 LTM Program Evaluation

The HGL/Sovereign team applied the technical approach described in **Section 2.1** to determine whether optimization is appropriate at the DCL. Based on LTM and leachate data, the source containment remedy continues to be effective; the site does not currently pose a risk, and is not expected to pose a risk in the future. Accordingly, reduced monitoring is warranted. In addition to utilizing the USACE and USEPA long-term monitoring evaluation program (USEPA and USACE, 2005), a performance-based evaluation of post-closure care at the DCL was performed to determine the appropriate level of optimization. The evaluation incorporated the module-based approach described in *Evaluating, Optimizing or Ending Post-Closure Care at Municipal Solid Waste Landfills Based on Site-Specific Data Evaluations* (Interstate Technology & Regulatory Council [ITRC], Alternative Landfill Technologies Team, 2006). A separate module was evaluated for each of four post-closure care components that apply to the DCL: leachate management, landfill gas management, groundwater monitoring, and cap monitoring and maintenance. The evaluation of each module included five steps:

1. Satisfy prerequisites;
2. Evaluate change;
3. Implement change;
4. Monitor change; and
5. Module completed.

The performance-based evaluation of the DCL LTM program, coupled with the USACE and USEPA long-term monitoring evaluation program, resulted in the following proposed changes to the DCL LTM program:

- Evaluate the feasibility of modifying the leachate collection and recovery system (LCRS) to allow discharge on-site to groundwater instead of to the MassDevelopment sewer system via a technical memo. If deemed feasible, obtain regulatory approval for the modification per the appropriate state regulatory procedures (310 CMR 19.000 and 314 CMR 5.000). Discharge of leachate to groundwater on site would, per 40 CFR 261.4 (b)

(15) (iv), be subject to federal regulation under sections 307 (b) or 402 of the Clean Water Act. Once approved, perform an engineering redesign of the LCRS to allow for on-site discharge. An ESD would be prepared following the approval of the modification to the LCRS.

- Revise the LTM frequency from semi-annually to annually (fall event) after demonstrating that discharge of leachate to ground surface is not impacting groundwater.

As discussed in **Section 2.7.2.1**, all VPH, EPH, and organochloride pesticide results have been non-detect or detections below the associated reporting limit since 2004, and all metals results have been below GW-1 and GW-3 limits since 2003. Therefore, it is recommended that the current semi-annual LTM frequency be changed to annual LTM, as permitted under 310 CMR 19.132(1)(d).

Leachate has been collected from the DCL LCRS since December 2001 and no exceedances have occurred, with the exception of a TSS exceedance in October 2011. The TSS exceedance in October 2011 was due to a sampling error and a follow-up re-sample in January 2012 determined that TSS was not an issue. Based on over 10 years of leachate sampling data, no harm to human health or the environment would occur if the recovered leachate was discharged on-site instead of the MassDevelopment sewer.

Landfill gas was evaluated based on information included in the 2004 to 2012 Annual Reports. Gas vents located along the highest point on the top crest of the landfill generally had methane levels higher than other areas of the landfill. Although there were high low explosive limit (LEL) readings for some of the higher elevation vents, the Army believed this is not a concern for the following reasons:

- The landfill is fully encapsulated and hence, methane production results from the natural degradation of the organics in the soils and sediments excavated and placed in the landfill during the construction process;
- The majority of the methane appears to be confined within the respective vents of the passive gas collection system; and
- At the present time, an assessment of an active system does not seem to be warranted, as these wells are passively vented directly to the atmosphere and the vents are not located near any potential ignition source.

Based on these observations no change to the landfill gas monitoring frequency is recommended at this time.

Cap monitoring and maintenance has been ongoing since the completion of the DCL, and has consisted of documenting the cap condition via field notes and photographic record. Maintenance has consisted primarily of mowing and herbicide treatments. Based on the annual need to control and maintain vegetation on the DCL cap, no changes are recommended at this time.

2.8 AREAS OF CONTAMINATION 32 AND 43A

2.8.1 Site Information

AOC 32 (DRMO Yard) was an active materials storage facility from 1964 to 1995. It consisted of three fenced areas where various materials were processed and stored, and included former waste oil UST #13. The UST was removed in 1992. Contaminated soils were excavated and disposed off-site. Monitored natural attenuation was the selected remedy for addressing the groundwater contamination.

The AOC 43A POL storage area served as the central distribution point for all gasoline stations at Devens during the 1940s and 1950s, and was subsequently used to store fuels for various purposes. The distribution facility consisted of a main gasoline station, a pump house, four 12,000-gallon USTs, one 10,000-gallon UST, two 12,000-gallon above-ground storage tanks (AST), and two 8,000-gallon ASTs. Gasoline was delivered by rail car and transferred to the storage tanks. The POL storage area consisted of a fenced lot within a developed industrial area of buildings, roads, and grass lots. A wooded area on a rock outcrop bounded the eastern side of the site. Railroad tracks formed the northern boundary. The site investigation indicated that a low level of xylene and an elevated level of petroleum hydrocarbons existed in the subsurface soils. The RI concluded that groundwater contamination required a remedial action evaluation. After the FS was completed, monitored natural attenuation was the selected remedy in the ROD for groundwater. A site plan showing the layout of former AOC 32 and 43A features, including the location of former USTs and ASTs overlain on current features, is provided as **Figure 1.8**.

2.8.1.1 Site Hydrogeology

Interpretive water table elevation maps (provided in the Devens Annual Reports) prepared for AOCs 32 and 43A show the presence of a groundwater divide that bisects the sites. Groundwater on one side of the divide flows to the east and groundwater on the other side of the divide flows to the west. The groundwater gradient east of the divide was determined to be 0.076 ft/ft in the bedrock wells during the latest (spring 2011) monitoring event and 0.036 ft/ft in overburden wells during the same period. The groundwater gradient west of the divide ranged from 0.04 ft/ft in the bedrock wells during the latest monitoring event to 0.028 ft/ft in the overburden wells during the same period. The groundwater maps have remained consistent with little variation in groundwater flow noticed between annual events.

2.8.1.2 Current Extent of Contamination

Below is a summary of the 2011 LTM and performance monitoring sampling events:

- VOCs – Groundwater from monitoring well 32M-01-18XBR had concentrations of 1,3-DCB (120 J µg/L) and 1,4-DCB (69 µg/L) detected above the site-specific cleanup goals of 40 µg/L and 5 µg/L, respectively, during the May 2012 LTM event. In addition, chlorobenzene (280 µg/L) was detected above the 100 µg/L GW-1 standard during the May 2012 LTM event. Groundwater from monitoring well 32M-01-18XBR had concentrations of 1,3-DCB (70 µg/L) and 1,4-DCB (42 µg/L) detected above the site-specific cleanup goals of 40 µg/L and 5 µg/L, respectively, during the October 2012 performance monitoring event. All other VOC results were either non-detects or detections below the respective standard.

- Total Metals – Arsenic was detected in groundwater at a concentration above the 10 µg/L cleanup goal in monitoring well 32M-01-14XOB (80 µg/L); all other arsenic results were either non-detects or detections below the remedial goal of 10 µg/L. Manganese was detected in groundwater above the site-specific cleanup goal of 3,500 µg/L at 32M-01-18XBR during the May 2012 LTM event. All other manganese results were either non-detects or detections below the site-specific cleanup goal of 3,500 µg/L. Manganese concentrations ranged from 3 µg/L in well 32M-01-16XBR to 4,100 µg/L in well 32M-01-18XBR.
- VPH Carbon Range Fractions – Groundwater from monitoring well 32M-01-18XBR had a C_9-C_{10} aromatic carbon concentration of 728 µg/L for the LTM event and 322 µg/L for the performance monitoring event, which exceed the 200 µg/L cleanup goal. All other VPH carbon range fraction results were either non-detects or detections below the respective standard.
- VPH Target Analytes – All VPH target analyte groundwater sample results were non-detects.
- EPH Carbon Range Fractions – All EPH carbon fraction groundwater sample results were non-detects or below cleanup goals.

A linear regression of hydrographs (**Attachment B**) and Mann-Kendall analyses (**Attachment C**) were used to evaluate AOC 32 data trends, determine if the selected remedy of intrinsic remediation (monitored natural attenuation) is progressing, and verify that contaminants are not migrating off-site. Analytes chlorobenzene, 1,2-DCB, 1,3-DCB, 1,4-DCB, arsenic, manganese, and the C_9-C_{12} aliphatic and C_9-C_{10} aromatic carbon fractions for primary source area well 32M-01-18XBR have consistently yielded exceedances above the cleanup standards. Examining the results by constituent, the following observations can be made:

- The chlorobenzene, 1,2-DCB, 1,3-DCB, and 1,4-DCB concentrations show an overall decreasing trend following the spring 2004 LTM event, with a significant decrease in concentrations following the sodium persulfate injections. Moreover, the 2012 LTM data for well 32M-01-18XBR exhibit results below or slightly above the respective cleanup goal.
- The VPH C_9-C_{12} aliphatic and EPH C_9-C_{18} aliphatic carbon concentrations show a decreasing trend following the spring 2004 LTM event, with no exceedances noted since the 2007 events. The VPH C_9-C_{10} aromatic carbon fraction also exhibits a decreasing concentration trend following the spring 2004 LTM, with concentrations hovering slightly above the 200 µg/L cleanup goal since May 2010.
- Metals concentrations have decreased throughout AOC 32 (Tables 2.6a and 2.6b). With the reduction of the hydrocarbon source contaminants and general oxidizing conditions at the site, it is unlikely that dissolved metals will reappear at the former source area. Currently, well 32M-01-14XOB is the only remaining well with a metals (arsenic) exceedance and is located within the overburden on the fringe of the Shepley Hill landfill. The geochemical conditions within groundwater sampled from this overburden

well are mildly oxidizing and not expected to contribute to additional metals dissolution. In addition, the adjacent bedrock well 32M-01-14XBR yielded no exceedances of metals or organic compounds.

2.8.2 Long-Term Monitoring Program

2.8.2.1 Current Program

The current sequence of semi-annual long-term groundwater sampling was initiated in the spring of 2002. Groundwater at AOC 32 is sampled during the spring LTM and fall performance monitoring events. Wells sampled during the spring 2012 LTM event included: 32M-01-13XBR, 32M-01-14XOB, 32M-01-14XBR, 32M-01-15XBR, 32M-01-16XBR, 32M-01-17XBR, 32M-01-18XBR and 32Z-99-02X. The fall 2012 sampling event (non-LTM) included wells 32M-01-13XBR, 32M-01-15XBR, 32M-01-16XBR, 32M-01-17XBR, and 32M-01-18XBR. No AOC 43A wells are sampled due to an absence of contaminant exceedances in the 43M series wells since 2002; however, depth to water measurements are collected from six AOC 43A wells during the LTM sampling and an additional nineteen AOC 32 wells to determine groundwater flow patterns across the site. Site reviews are conducted every five years to insure that the remedy continues to provide adequate protection of human health and the environment. The purpose of the LTM program is to monitor the potential for off-site migration of contaminants and verify that elevated contaminant concentrations are decreasing over time.

2.8.2.2 LTM Program Evaluation

Following the technical approach outlined in **Section 2.1**, the Sovereign team reviewed historical reports and LTM data to determine whether continued monitoring under the current program, LTM optimization, or site closure is appropriate at AOCs 32 and 43A. Based on this evaluation, it was determined that current conditions warrant an optimized groundwater monitoring approach at AOCs 32 and 43A.

Although ICs currently restrict groundwater usage and eliminate risk associated with contaminated groundwater, contaminant concentrations are present within a monitoring well located at the former source area. Several contaminant concentrations at AOC 32 are above currently established GW-1 based cleanup goals; however; the source of groundwater contamination has been removed, enhanced remediation through the injection of sodium persulfate was performed at the source area, and contaminant concentrations continue to decline through natural processes. The site currently does not pose a risk and is not expected to pose a risk in the future. More specifically, conditions at AOCs 32 and 43A meet the following criteria:

- Human health and ecological risks are acceptable under current land use conditions;
- The source of contamination has been removed;
- Groundwater quality will continue to improve and will meet cleanup goals well within the 30-year timeframe specified in the ROD;
- The migration of ROD COCs to the Zone II boundary (located approximately 2,000 feet to the east) at concentrations above cleanup goals is not likely due to diminishing contaminant concentrations; and

- Existing land use and deed restrictions minimize potential future risks.
- Groundwater flow across the site is well established and has not changed noticeably since the initiation of the LTM program.

The ROD for AOCs 32 and 43A specifies that MCLs are the groundwater cleanup goals at the site. The MCLs are consistent with Federal MCLs and State of Massachusetts GW-1 standards that are included in the MCP. From a regulatory perspective, the goals specified in the ROD must be achieved before site closure is approved. As presented in a letter prepared by the Army and submitted to the MassDEP and USEPA Region 1 in October 2007, the GW-3 groundwater standards are believed to be more relevant to AOCs 32 and 43A, and as discussed above, this site is not within a current or potential drinking water source area, there is no current or future risk associated with groundwater at the site, and the source of contamination has been removed.

The MassDEP had agreed to reevaluate their GUVD to assess whether GW-3 reclassification is applicable to AOCs 32 and 43A. A draft GUVD was subsequently submitted by the Army to MassDEP in December 2010 for their review and approval. The December 2010 draft GUVD included four sites, of which one was AOCs 32 and 43A. MassDEP reviewed the draft GUVD in early 2011 and suggested that cleanup goals for the four sites, including AOCs 32 and 43A, could be reconsidered using a site-by-site approach, rather than attempting to revise the approved GUVD. The site-by-site approach would allow cleanup goals to be setup based on an analysis of site-specific information (e.g., aquifer protection districts, current and future ownership, and future uses) instead of the broad regional view of groundwater resources in the approved GUVD. Per MassDEP, a site-by-site approach would allow for the decision makers to jointly compile and consider the relevant site-specific data needed to properly classify groundwater under the MCP, ensure cleanup goals conform to the Devens reuse plan, and, if appropriate, document changes in a site-specific CERCLA document (e.g., ESD).

Based on the site conditions and established COC trends, the following optimization steps are recommended to the LTM program at AOCs 32 and 43A:

- Discontinue the fall performance monitoring event;
- Reduce the number of monitoring wells sampled during the primary spring event to the four wells sampled for performance monitoring, with the exception of substituting 32M-01-14XOB in place of 32M-01-15XBR. The other three sampled wells are 32M-01-13XBR, 32M-01-17XBR, and 32M-01-18XBR;
- Reduce site-wide groundwater gauging from annually to every 5 years prior to five-year reviews;
- Discontinue non-LTM program monitoring well gauging after the 2015 five year review and decommission all non-LTM program wells west of the groundwater divide;
- Remove EPH carbon ranges COC list;
- Use HydraSleeve™ technology to collect groundwater samples; and

- Prepare technical memorandum for AOCs 32 and 43A presenting site specific information for reclassification of groundwater from GW-1 to GW-3, justification for site closure and path forward.

2.9 SUDBURY ANNEX

2.9.1 Site Information

AOC A7, within the Sudbury Annex, is the site of a former dumping ground. Army research and development laboratory, Natick Labs, reportedly dumped and buried laboratory wastes on-site between the late 1950s and mid-1970s. Drums and other chemical containers, including quart- to gallon-size metal and glass containers, were reportedly disposed of at AOC A7. Other debris from the base was also reportedly dumped and buried on-site, and burning of flammable wastes was performed as a volume reduction method.

Portions of the Annex groundwater, including groundwater associated with AOC A7, were found to contain elevated levels of VOCs, pesticides and metals above Massachusetts drinking water standards. The contamination is currently contained under a landfill cap and the groundwater is monitored to verify that contaminants from the landfill are not above acceptable levels.

2.9.1.1 Selected Remedy

The ROD for the Source Control of the Operable Unit at AOC A7 was signed in September 1995 and the ROD for Management of Migration was signed in September 1997. The selected source control remedy included:

- removal and off-site disposal of chemical waste debris in the laboratory dump area;
- construction of a RCRA Subtitle C landfill cap to contain the remaining site contaminants;
- O&M;
- ICs and land use restrictions to limit future use of land at AOC A7;
- long-term groundwater monitoring; and
- five-year reviews to assess whether the remedy remains protective of human health and the environment.

Sudbury Annex was removed from the NPL in January 2002. At that time, 2,205 acres were transferred to the U.S. Fish and Wildlife Service, 4.1 acres were transferred to the U.S. Air Force, and 71.4 acres were transferred to the Federal Emergency Response Agency.

In June 2002, all known monitoring wells at the former annex were decommissioned except for those at AOC A7, and at this time the four wells at AOC P58 were also decommissioned.

2.9.2 Long-Term Monitoring Program

2.9.2.1 Current Program

The environmental restoration programs at each of the sites are mature. RI, FS, and RODs have been completed and LTMM has been performed for 15 years. In accordance with the RODs, LTMM and maintenance activities consisting of environmental monitoring and LUC inspections are routinely conducted.

The current program is being conducted in accordance with the 2009 Sudbury LTMMP. The optimization within the 2009 Sudbury LTMMP consisted of the following changes to the AOC A7 LTMM program:

- Discontinued sampling of groundwater from wells OHM-A7-11 and OHM-A7-46 but retained these wells for depth to water measurements;
- Reduced the frequency for collection of depth to water data to an annual frequency, to be performed in conjunction with the fall sampling event;
- Reduced the landfill gas vent monitoring and landfill cap inspections from a semi-annual frequency to an annual frequency; and
- Reduced the frequency of LUC inspections at AOCs P31 and P58 from semi-annual to annual.

2.9.2.2 LTMM Program Evaluation

The HGL/Sovereign team applied the technical approach described in **Section 2.**1 to determine whether optimization is appropriate at Sudbury (A7). Based on a review of the historical data, continued monitoring is recommended for the site. The source containment remedy continues to be effective; the site does not currently pose a risk, and is not expected to pose a risk in the future. Accordingly, reduced monitoring is warranted. In addition to utilizing the USACE and USEPA long-term monitoring evaluation program (USEPA and USACE, 2005), a performance-based evaluation of post-closure care at Sudbury was performed to determine the appropriate level of optimization. This evaluation was conducted for Sudbury previously in the 2009 LTMMP (HGL, 2009). The evaluation incorporated the module-based approach described in *Evaluating, Optimizing or Ending Post-Closure Care at Municipal Solid Waste Landfills Based on Site-Specific Data Evaluations* (ITRC, Alternative Landfill Technologies Team, 2006). A separate module was evaluated for each of three post-closure care components that apply to Sudbury: landfill gas management, groundwater monitoring, and cap monitoring and maintenance. The evaluation of each module included five steps:

1. Satisfy prerequisites;
2. Evaluate change;
3. Implement change;
4. Monitor change; and
5. Module completed.

The Army and USEPA additionally agreed upon criteria to reduce sampling frequency and analyses performed. Monitoring wells not classified as "compliance points" per 310 CMR 19.132 (2), with no exceedances of GW-1 standards over the last 5 years, would be eliminated from the LTM program starting after the next five-year review. Compliance point monitoring wells with no exceedances of GW-1 standards over the last 5 years would have a reduction in sampling frequency from annual to biennial following the next five year review. Compliance point monitoring wells currently exhibiting GW-1 standard exceedances would continue to be sampled annually but would be candidates for biennial sampling, after the next five year review, if current downward trends continue. Metals analyses would continue to be sampled for until removed from the LTM program, based on no exceedances since 2004, by a recommendation included in the next five year review document. Unnecessary monitoring wells would be removed and needed compliance point monitoring locations would be retained for sampling per 310 CMR 19.132 (2). The performance-based evaluation of the Sudbury LTM program, coupled with the USACE and USEPA long-term monitoring evaluation program, resulted in the following proposed changes to the Sudbury LTM program:

- Remove metals analyses from the fall 2016 LTM program via a recommendation in the next five-year review document.
- Remove well OHM-A7-51 from the fall 2016 LTM sampling program via a recommendation in the next five year review document, based on the last groundwater analytical exceedance documented in October 2003 (PCE) and a compliance point, per 310 CMR 19.132 (2), that is located hydraulically downgradient (SUD-A07-065).
- Remove well OHM-A7-09 from the LTM sampling program based on no historical groundwater analytical exceedances and a compliance point, per 310 CMR 19.132 (2), is located hydraulically downgradient (SUDWP-A07-01).
- Continue sampling upgradient monitoring well SUD-A07-14 on an annual basis and revise sampling frequency to biennial, based on no groundwater analytical exceedances, after the next five-year report (CY2016).
- Continue sampling OHM-A7-08 and SUD-A07-065 on an annual basis until the next five-year review report (CY2016) and revise sampling frequency to biennial if a downward trend is maintained.
- Continue sampling new well point SUDWP-A07-01 on an annual basis until a trend can be established to allow for the adjustment of the sampling frequency.
- Reduce the landfill gas vent monitoring from an annual frequency to every 5 years prior to the five-year review report;
- Utilize global positioning system (GPS) coordinates and a GPS unit to locate surface water gauges during the annual sampling event.

The Sovereign team evaluated analytical data collected through 2012 for three wells (OHM-A7-08, OHM-A7-51, and JO-AO7-M63/SUD-AO7-M65, **Figure 1.10**) that have exhibited historical exceedances of groundwater standards. Per the data in **Table 2.7**, trend graphs in **Attachment B**, and Mann-Kendall analyses in **Attachment C**, all pesticide and VOC concentrations exhibit a declining trend, with the 2012 data yielding results either below or slightly above the associated GW-1 standards. Finally, although several metals have been detected at varying concentrations, all metal and mercury results have remained below the corresponding GW-1 and GW-3 standards. The 301 CMR 132(1)(h) allows analyte removal from the sampling program and the ITRC confirmation sampling will be conducted until PCC is complete.

Landfill gas monitoring was evaluated based on information included in the 1998 to 2012 Sudbury Annual LTM Reports. Monitoring results for methane, carbon dioxide, and LEL were primarily non-detect from 1998 to 2012. Gas vent monitoring was reduced from semi-annual to annual via the previous performance evaluation, and further reduction in gas vent monitoring frequency is recommended to every 5 years.

Cap monitoring and maintenance has been ongoing since the completion of the Sudbury landfill. Cap monitoring consists of documenting the cap condition via field notes and photographic record, and maintenance consists primarily of mowing and herbicide treatments. Based on the annual need to control and maintain vegetation on the Sudbury cap no changes are recommended at this time.

2.10 CONCLUSIONS

The evaluation of the LTM sites involved reviewing historical reports, analyzing data collected as part of the LTM program, and considering previous input from the USEPA and MassDEP. This information was used to determine whether LTM optimization is appropriate for each of the sites, or whether the current LTM requirements are needed to ensure adequate protection of human health and the environment. Several criteria including current risk, potential future risk, persistence of contaminant source, and contaminant plume stability were used to identify sites where site closure should be pursued or LTM optimization is appropriate.

After reviewing the LTM program at each of the sites, the Army recommends pursuing LTM optimization at AOC 57, AOC 69W, AOC 43G, SPIA, the DCL, Sudbury, and AOCs 32 and 43A. At each of these sites, the source of contamination has been either completely or substantially removed, contamination in groundwater is largely stable or declining, and current and future risk is minimal. Additional investigation work may be required in the future at AOC 69W to delineate the downgradient edge of the manganese exceedance and the increase in perchlorate concentrations at AOC 26 (SPIA).

The following recommendations are provided based on an evaluation of site conditions and analytical data trends, and involve optimization steps that can be pursued at the particular site independent of site closure:

AOC 57:

- Change the groundwater monitoring frequency at Area 3 from annual to every 5 years to coincide with the five-year reviews.
- Use HydraSleeve™ technology to perform groundwater sampling at Area 3.
- Reduce surface water sampling to every 5 years at Area 3 to coincide with the five-year reviews.
- Discontinue sampling of surface water and groundwater from all wells at Area 2.
- Decommission sumps at Area 2.

- Eliminate VOCs from the groundwater and surface water COC list for Area 3.
- Prepare technical memorandum for AOC 57 presenting site specific information that supports justification for site closure and path forward.

AOC 69W:

- Eliminate VPH carbon ranges and target analytes from the LTM program.
- Install an additional sentry wellpoint downgradient of the existing wellpoint 69WP-08-01 to characterize manganese concentrations in groundwater.
- Prepare technical memorandum for AOC 69W presenting site specific information that supports conditions defined within the MCP revision for petroleum release sites, justification for site closure, and path forward.

AOC 43G:

- Based on results of the MAROs Mann-Kendall analyses of manganese concentration trends discontinue sampling at monitoring wells AAFES-5 (only exceedance was in 1999), AAFES-6R (decreasing), XGM-94-07X (stable) and XGM-94-08X (decreasing).
- Use HydraSleeve™ technology to perform groundwater sampling at AOC 43G.
- Reduce TAL for metals (reduce TAL to report only manganese) and VPH (reduce TAL to report only aliphatics) analyses for "alternate" year annual sampling events (CY2015, CY2017, etc.)
- Non-alternate year (CY2014, CY2016, etc.) annual sampling events will continue with current full TAL for both metals and VPH.
- Prepare technical memorandum for AOC 43G presenting site specific information for reclassification of groundwater from GW-1 to GW-3, justification for site closure, and path forward.

SPIA:

- Discontinue metals analyses for well points 26WP-06-01 and 26WP-08-02.
- Evaluate the extent of perchlorate at AOC 26.
- Add perchlorate analysis for existing LTM sampling program monitoring wells 26M-92-02X, 26M-92-03X, 26M-97-08X and SPM-93-06X.
- Add explosives and metals analyses for existing LTM sampling program monitoring well 26M-10-09X.
- Remove well 41M-93-04X from the SPM analytical sample network.
- Discontinue all 5-year review water level monitoring at AOC 41 monitoring wells with the exception of 41M-93-04X.

DCL:

- Evaluate the feasibility of direct discharge to groundwater. If deemed feasible, modify the LCRS to allow discharge on-site instead of to the MassDevelopment sewer system.

- Revise the LTM frequency from semi-annually to annually (fall event) after demonstrating that discharge of leachate to ground surface is not impacting groundwater.

AOCs 32 and 43A:

- Discontinue the fall performance monitoring event.
- Reduce the number of monitoring wells sampled during the primary spring event to the four wells sampled for performance monitoring, with the exception of substituting 32M-01-14XOB in place of 32M-01-15XBR. The other three sampled wells are 32M-01-13XBR, 32M-01-17XBR, and 32M-01-18XBR.
- Reduce site-wide groundwater gauging from annually to every 5 years prior to five-year reviews.
- Discontinue non-LTM program monitoring well gauging after the 2015 five year review and decommission all non-LTM program wells west of the groundwater divide.
- Remove the EPH carbon ranges from the COC list.
- Use HydraSleeve™ technology to collect groundwater samples.
- Prepare technical memorandum for AOCs 32 and 43A presenting site specific information for reclassification of groundwater from GW-1 to GW-3, justification for site closure, and path forward.

Sudbury:

- Remove metals analyses from fall 2016 LTM program via a recommendation in the next five-year review report.
- Remove well OHM-A7-51 from the fall 2016 LTM sampling program via a recommendation in the next five year report document, based on the last groundwater analytical exceedance documented in October 2003 (PCE) and a compliance point, per 310 CMR 19.132 (2), that is located hydraulically downgradient (SUD-A07-065).
- Remove well OHM-A7-09 from the LTM sampling program based on no historical groundwater analytical exceedances and a compliance point, per 310 CMR 19.132 (b), is located hydraulically downgradient (SUDWP-A07-01).
- Continue sampling upgradient monitoring well SUD-A07-14 on an annual basis and revise sampling frequency to biennial, based on no groundwater analytical exceedances, after the next five-year report (CY2016).
- Continue sampling OHM-A7-08 and SUD-A07-065 on an annual basis until the next five-year review (2016) and revise sampling frequency to biennial if a downward trend is maintained.
- Continue sampling new well point SUDWP-A07-01 on an annual basis until a trend can be established to allow for the adjustment of the sampling frequency. Recommend reducing the landfill gas vent monitoring from an annual frequency to every 5 years prior to the five-year review report.

- Recommend utilization of GPS coordinates and a GPS unit to locate surface water gauges during annual sampling event.

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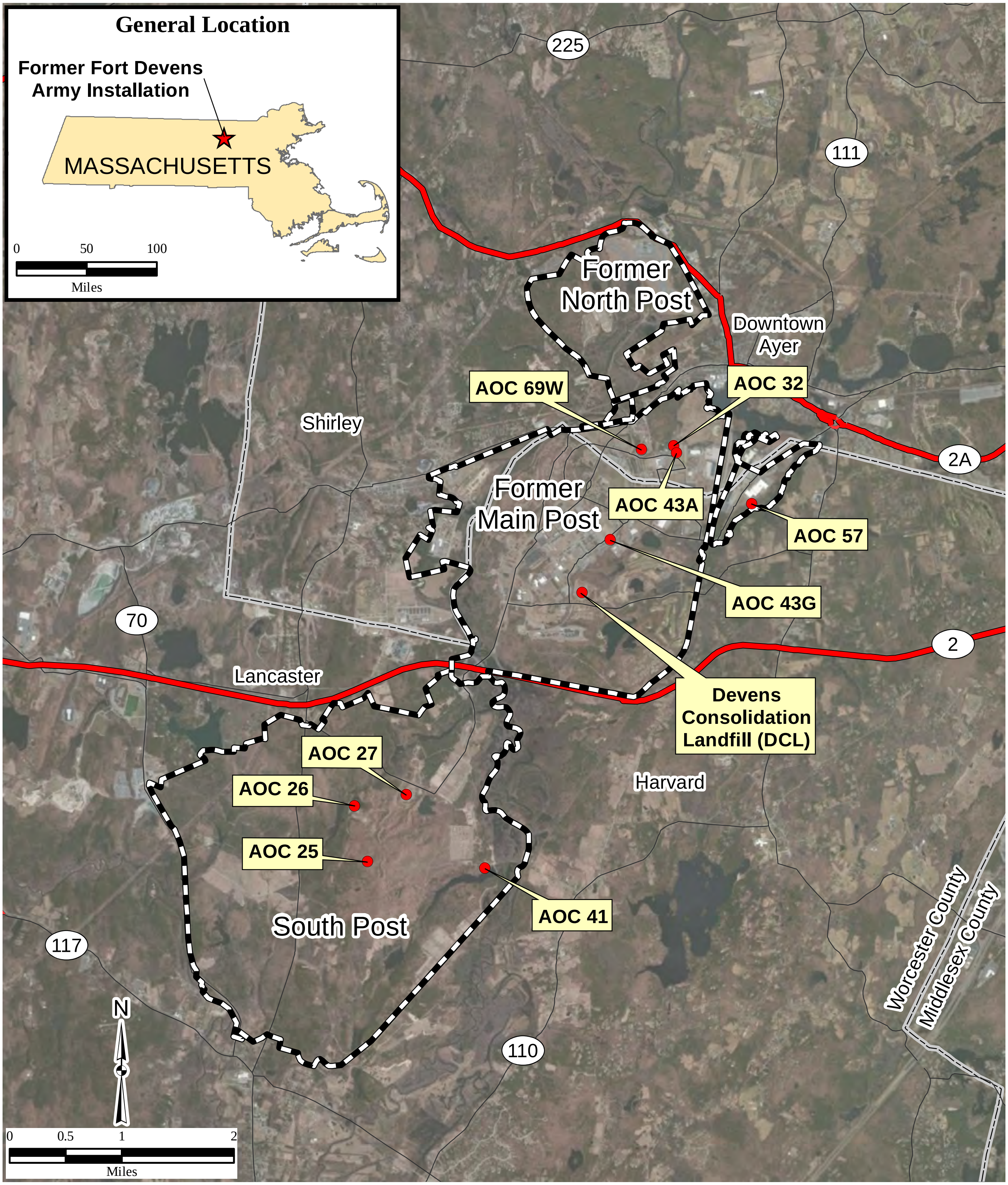
FIGURES



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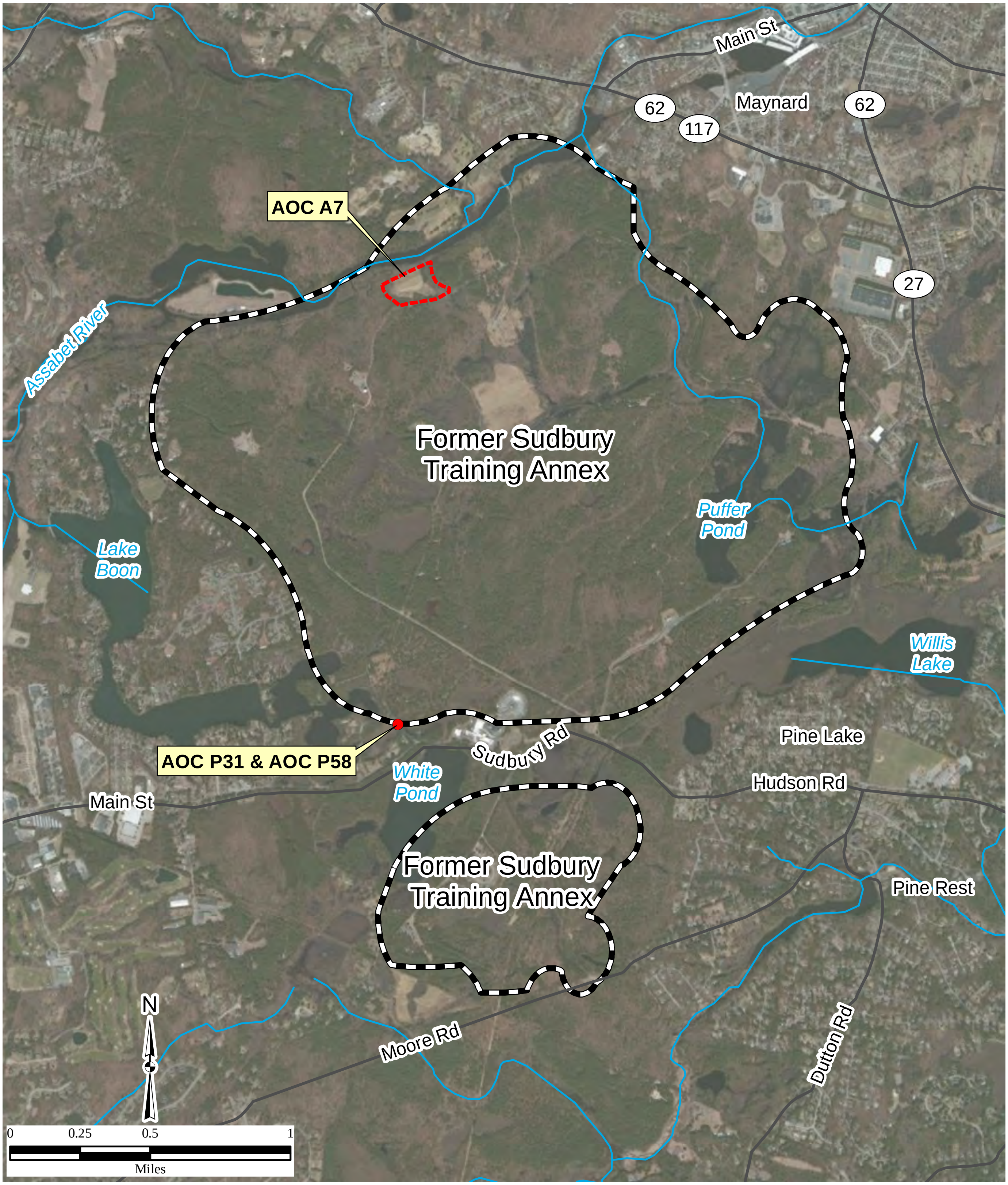
Source: HGL ESRI, USACE, www.mass.gov,
ESRI Online Bing Maps Aerial

Legend

●	Area of Contamination (AOC)
—	Major Road
🟥	Highway
- - -	County Line
▭	Former Fort Devens

Figure 1.1a
Site Location
Former Fort Devens
Army Installation



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Source: HGL, ESRI,
ESRI Online Bing Maps Aerial

Legend

● Area of Contamination (AOC)

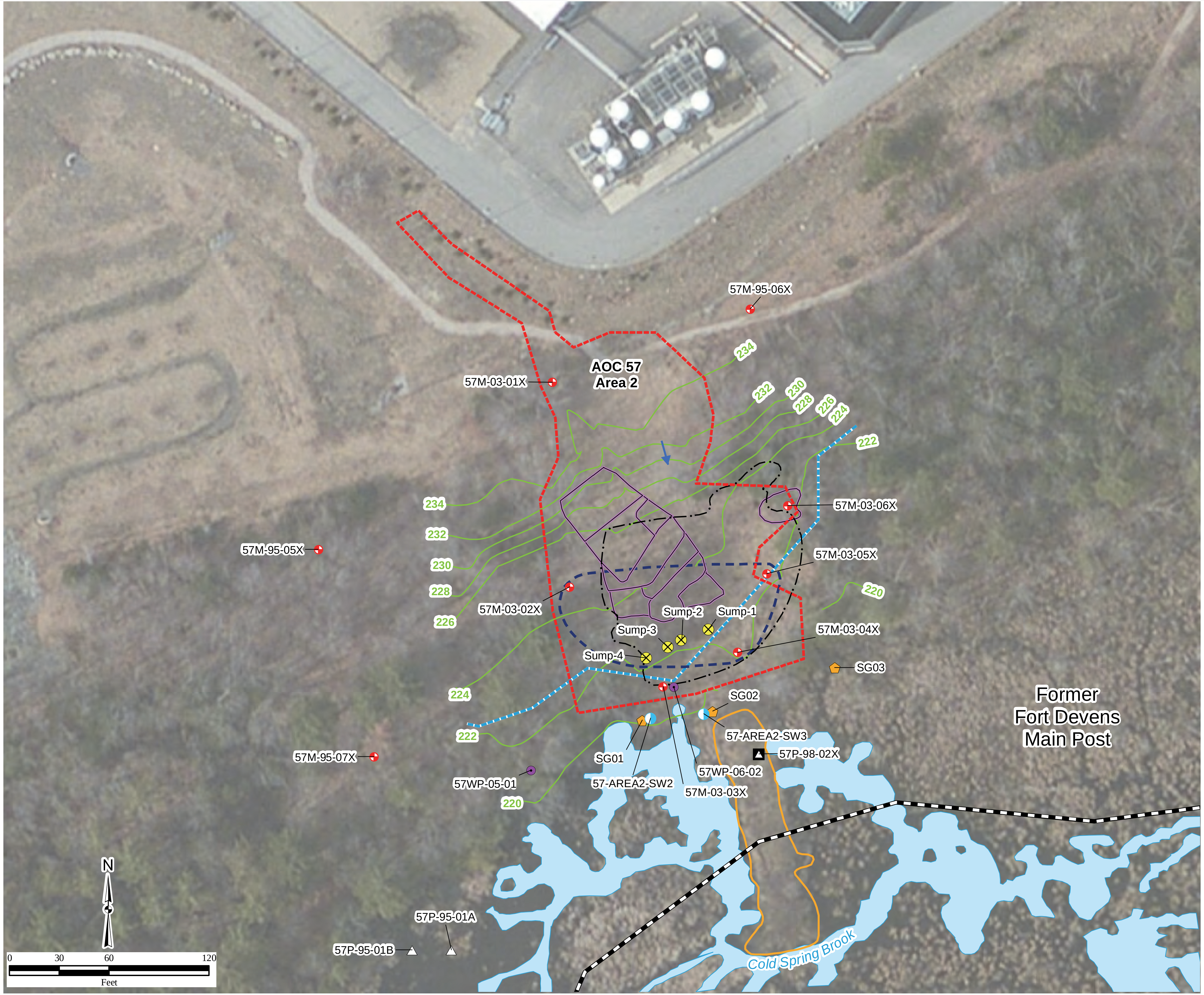
- - - Area of Contamination Perimeter

— Major Road

— Surface Water Course

▨ Former Sudbury Training Annex

Figure 1.1b
Site Location
Sudbury Annex



Optimization Evaluation for LTMM
Former Fort Devens Army Installation and Sudbury Annex

Figure 1.2a
Site Layout
Area of Contamination 57–Area 2

Legend

●	Monitoring Well
●	Well Point
△	Piezometer–Abandoned
▲	Piezometer–Presumed Destroyed
⬟	Staff Gauge
◑	Surface Water Sample Location
⊗	Decommissioned Sump
57M-03-06X	Well/Piezometer/Sump/Sample Location Identification
—	Final Excavation Limit (2003)
–·–·–	Conti Excavation Limit (2002)
—222—	Topographic Contour (ft amsl) (contour interval=2 ft)
▬ ▬	Former Fort Devens Boundary
- - - -	Flagged Wetland Limits
→	Groundwater Flow Direction
▭	Approximate Historical Extent of Groundwater Contamination in Exceedance of Cleanup Goals (based on Fall 2003 to Spring 2011 analytical data)
▭	Containment Dam
▭	Area of Contamination (AOC)
▭	Surface Water

Notes:
Topographic contours from www.mass.gov, dated 2003.

ft amsl=feet above mean sea level
LTM=long-term monitoring

\\gst-srv-01\HGLGIS\Ft_Devens\Devens_and_Sudbury\Optimization_Eval_2012\(1-02a)Layout_AOC57_Area2.mxd
5/27/2014 TB
Source: HGL, USACE, www.mass.gov,
ESRI Online Bing Maps Aerial

Figure 1.2b
Site Layout
Area of Contamination 57–Area 3

Legend

●	LTM Sample Well
●	LTM Well–Gauge Only
●	LTM Well Point–Gauge Only
▲	LTM Piezometer
◐	Surface Water Sample Location
⊕	Monitoring Well–Abandoned (2012)
⊞	Monitoring Well–Destroyed
57M-96-12X	Well/Piezometer/Sample Location Identification
—226—	Topographic Contour (ft amsl) (contour interval=10 ft)
→	Groundwater Flow Direction
▭	Approximate Historical Extent of Groundwater Contamination in Exceedance of Cleanup Goals (based on Fall 2003 to Spring 2011 analytical data)
▭	Area of Contamination (AOC)/ 1999 Excavation Area
▭	Alternate III-2a Estimated Soil Excavation Area (approximate location)
🟦	Surface Water

Notes:
Well 57M-96-09X buried by construction.
Topographic contours from www.mass.gov, dated 2003.

ft amsl=feet above mean sea level
LTM=long-term monitoring

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5/27/2014 TB
Source: HGL, USACE, www.mass.gov,
ESRI Online Bing Maps Aerial

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HydroGeoLogic, Inc

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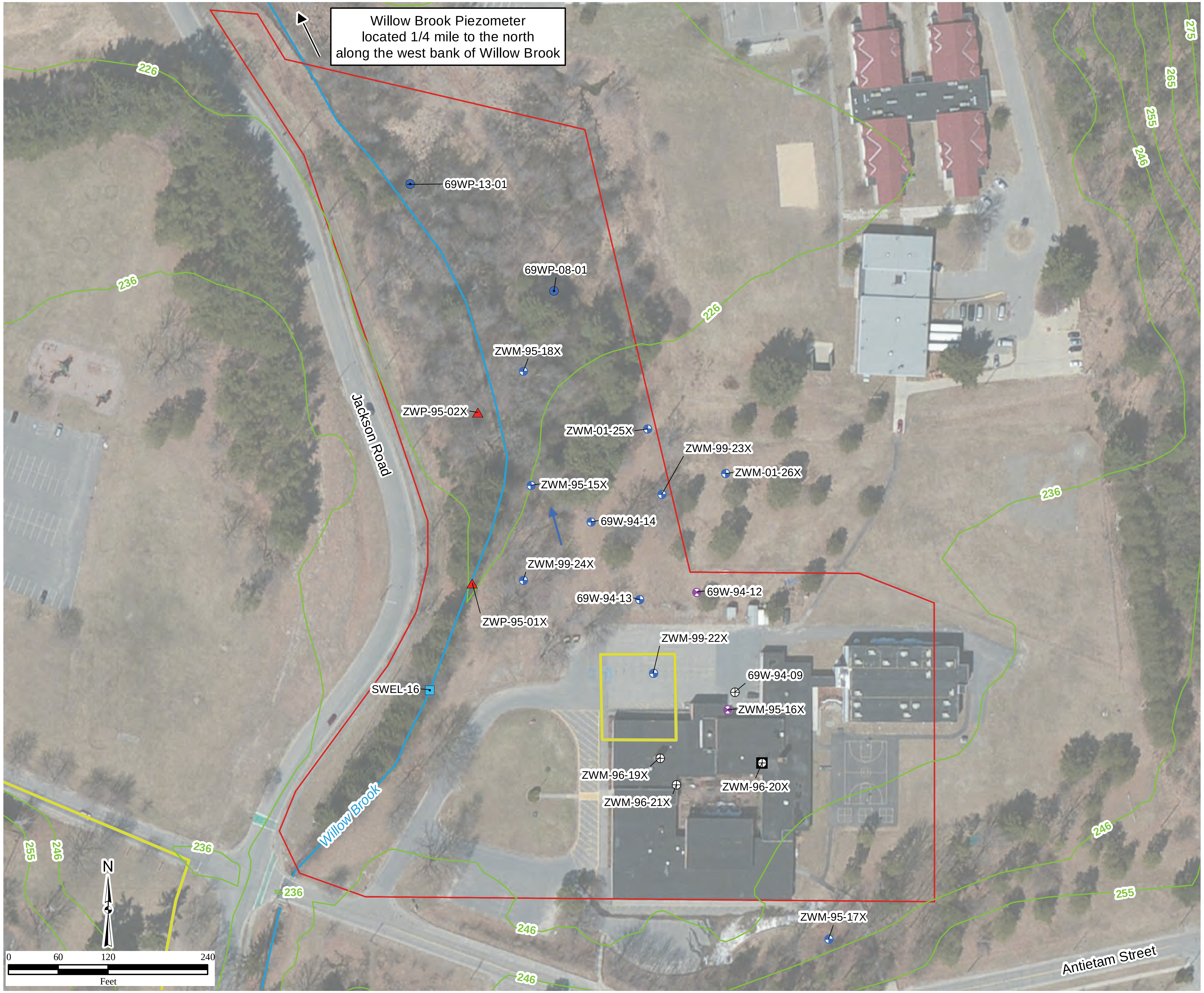
Former Fort Devens Army Installation and Sudbury Annex

Figure 1.3
Site Layout
Area of Contamination 69W



Legend

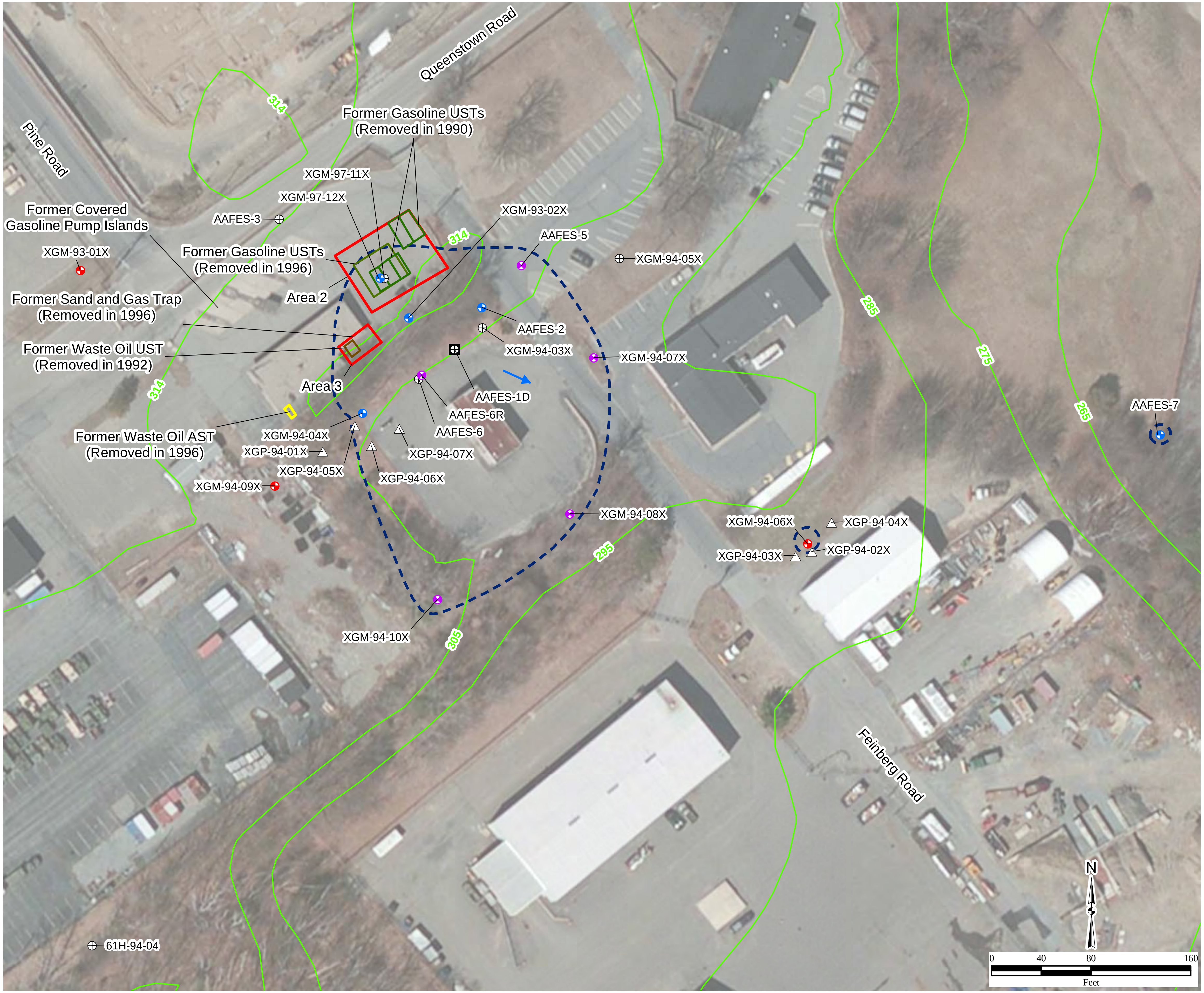
- ● LTM Sample Well
- ● LTM Sample Well Point
- ● LTM Well–Gauge Only
- ▲ LTM Piezometer
- ⊕ Monitoring Well–Abandoned (2012)
- ⊞ Monitoring Well–Presumed Destroyed
- ■ Surface Water Elevation Location
- ZWM-95-16X Well/Piezometer/Surface Water Elevation Location Identification
- → Groundwater Flow Direction (October 2012)
- — Parcel Boundary
- —226— Topographic Contour (ft amsl)
- — Surface Water Course
- ☐ Excavated Soils Management Area

Notes:
Topographic contours from www.mass.gov, dated 2003.

ft amsl=feet above mean sea level
LTM=long-term monitoring

\\gst-srv-01\HGLGIS\Ft_Devens\Devens_and_Sudbury\Optimization_Eval_2012\(1-03)Layout_AOC69W.mxd
5/27/2014 TB
Source: HGL, USACE, www.mass.gov,
ArcGIS Online Bing Maps Aerial

Sovereign Consulting Inc.
HGL HydroGeoLogic, Inc.



Optimization Evaluation for LTMM
Former Fort Devens Army Installation and Sudbury Annex

Figure 1.4
Site Layout
Area of Contamination 43G

Legend

- ● LTM Sample Well
- ● LTM Well–Gauge Only
- △ Piezometer–Abandoned
- ● Monitoring Well
- ⊕ Abandoned Monitoring Well
- ⊞ Monitoring Well–Presumed Destroyed
- XGM-94-07X Well/Piezometer Identification
- → Groundwater Flow Direction
- —265— Topographic Contour (ft amsl)
- ⬚ Approximate Historical Extent of Groundwater Contamination in Exceedance of Cleanup Goals (based on 1999 to 2011 analytical data)
- 🟩 Former Gasoline UST(s)
- 🟫 Former Waste Oil UST
- 🟨 Former Waste Oil AST
- 🟥 Former UST Area

Notes:
Topographic contours from www.mass.gov, dated 2003.

AST=above ground storage tank
ft amsl=feet above mean sea level
LTM=long-term monitoring
UST=underground storage tank

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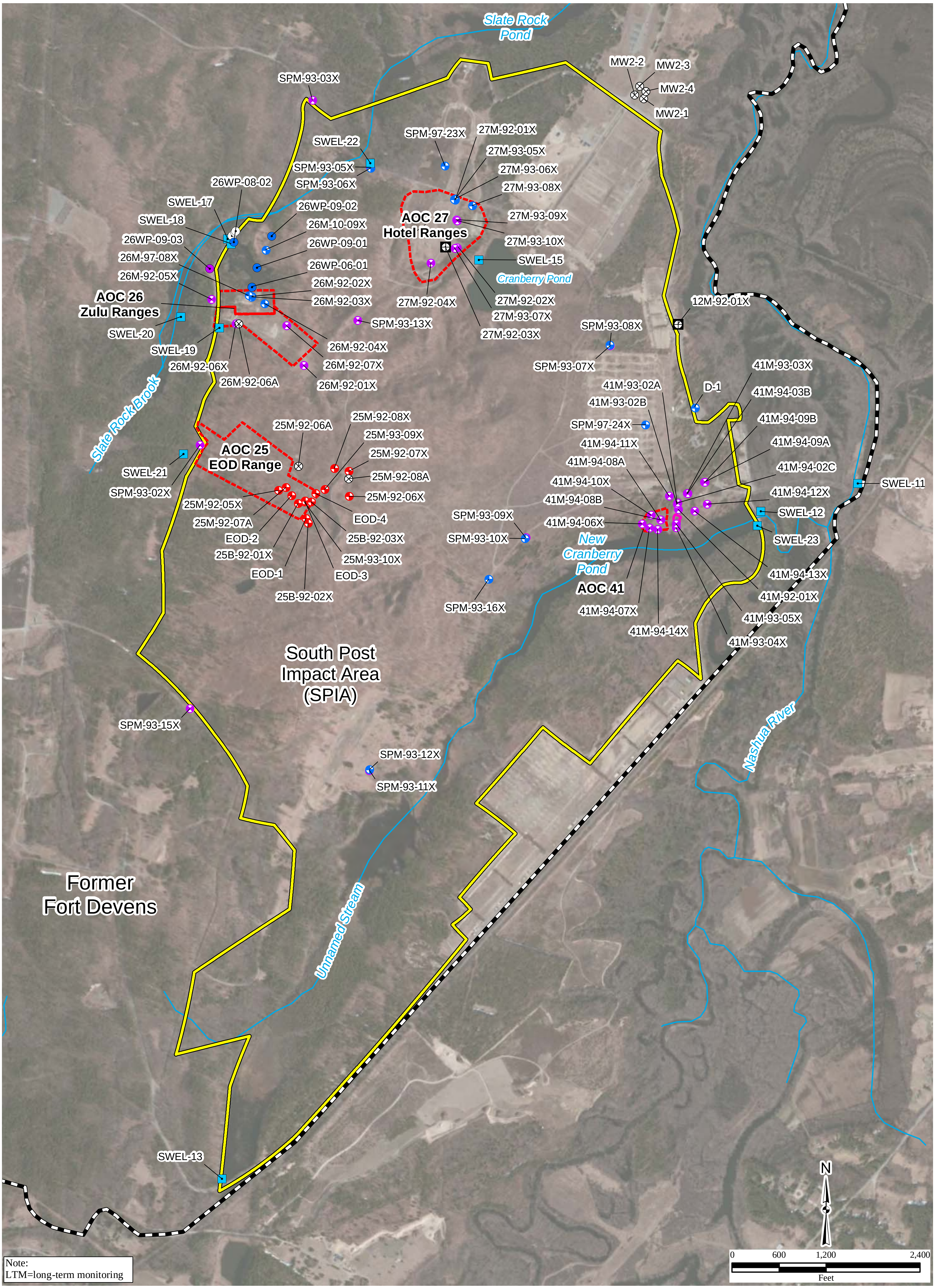
5/27/2014 TB
Source: HGL, USACE, www.mass.gov,
ESRI Online Bing Maps Aerial



Note:
LTM=long-term monitoring

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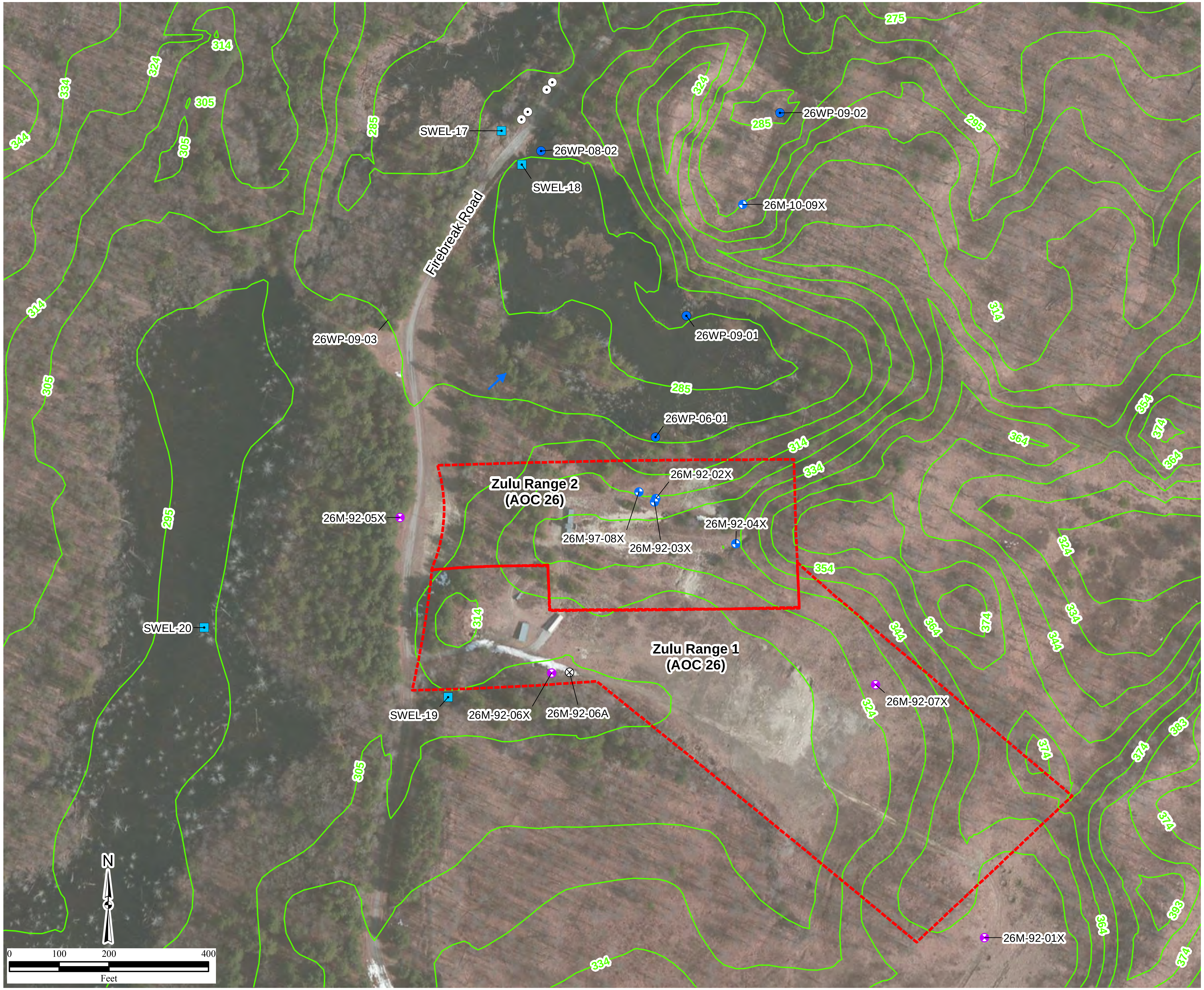
Optimization_Eval_2012\(1-05)Layout_SPIA.mxd
5/27/2014 PD
Source: HGL, USACE,
ESRI Online Bing Maps Aerial

Legend

●	LTM Sample Well	⊞	Monitoring Well–Possibly Destroyed
●	LTM Well–Periodic Gauge Only	SWEL-12	Well/Elevation Location Identification
●	LTM Sample Well Point	—	Surface Water Course
▣	Surface Water Elevation Location	▬	Former Fort Devens Boundary
●	Monitoring Well	☐	Landfill Debris
⊗	Abandoned Monitoring Well	☐	Area of Contamination (AOC)
⊙	Abandoned Well Point Installation Location – Shallow Refusal	☐	South Post Impact Area (SPIA)
●	Well Point-Periodic Gauge Only		

Figure 1.5
Site Layout
South Post
Impact Area

Figure 1.6
Site Layout
South Post Impact Area
Area of Contamination 26
Zulu Ranges 1 and 2



Legend

●	LTM Sample Well
●	LTM Sample Well Point
●	LTM Well–Periodic Gauge Only
⊗	Abandoned Monitoring Well
⊙	Abandoned Well Point Installation Location–Shallow Refusal
▪	Surface Water Elevation Location
26M-92-03X	Well/Elevation Point Identification
→	Groundwater Flow Direction
—334—	Topographic Contour (ft amsl)
▭	Area of Contamination (AOC)

Notes:
Topographic contours from www.mass.gov, dated 2003.

ft amsl=feet above mean sea level
LTM=long-term monitoring

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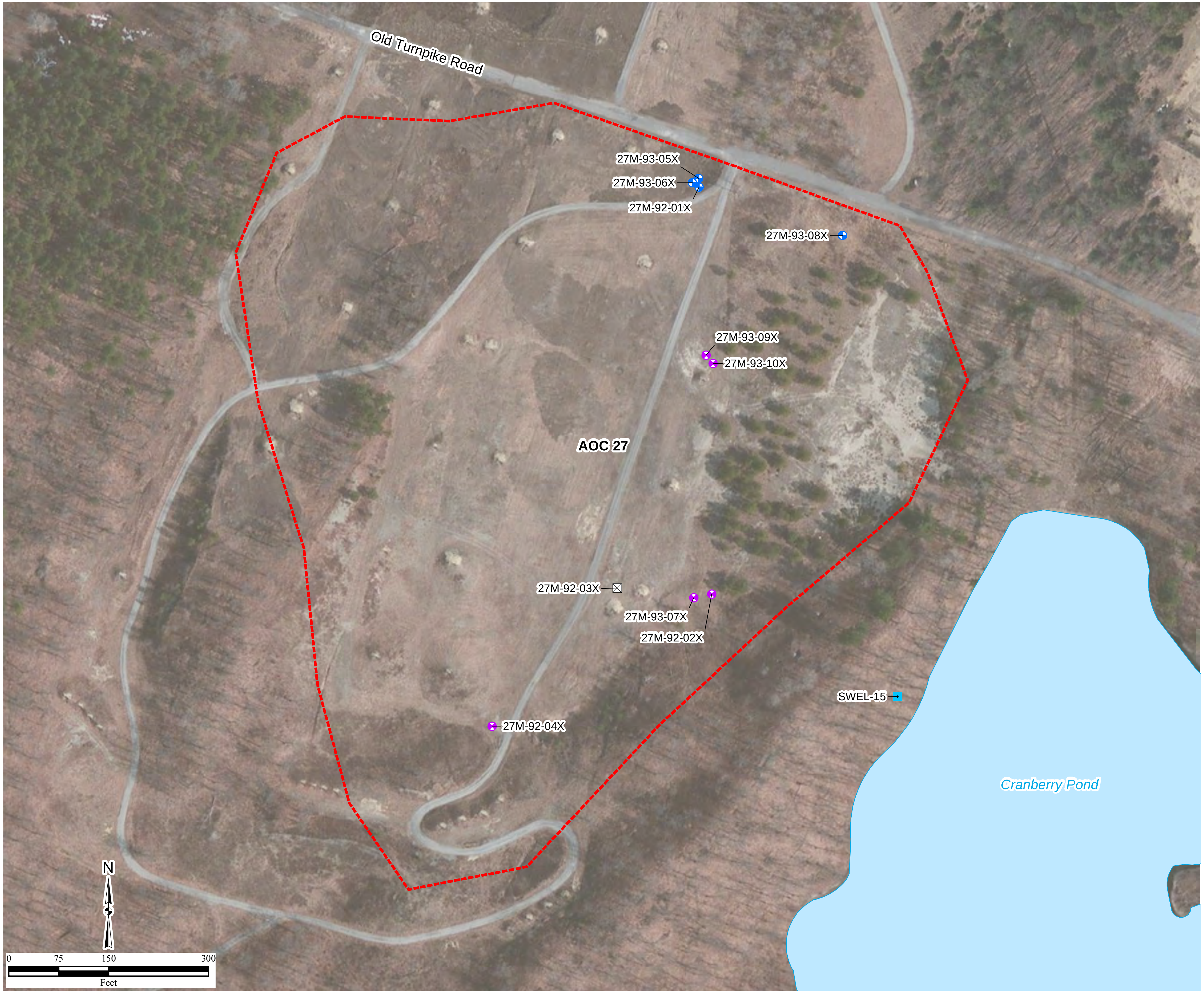
(1-06)Layout_AOC26.mxd
3/27/2013 PD
Source: HGL, USACE, www.mass.gov
ESRI Online Bing Maps Aerial

Sovereign and HGL—Optimization Evaluation for LTMM
Former Fort Devens Army Installation and Sudbury Annex

Figure 1.7
Site Layout
South Post Impact Area
Area of Contamination 27
Hotel Range



Legend

●	LTM Sample Well
●	LTM Well–Gauge Only
▪	Surface Water Elevation Location
☒	Monitoring Well–Destroyed
27M-93-10X	Well/Gauging Location Identification
⬚	Area of Contamination (AOC)
▭	Surface Water

Note:
LTM=long-term monitoring

\\Gst-srv-01\HGLGIS\Ft_Devens\Devens_and_Sudbury\Optimization_Eval_2012\(1-07)Layout_AOC27.mxd
4/5/2012 PD
Source: HGL, USACE, www.mass.gov,
ESRI Online Bing Maps Aerial

Sovereign Consulting Inc.

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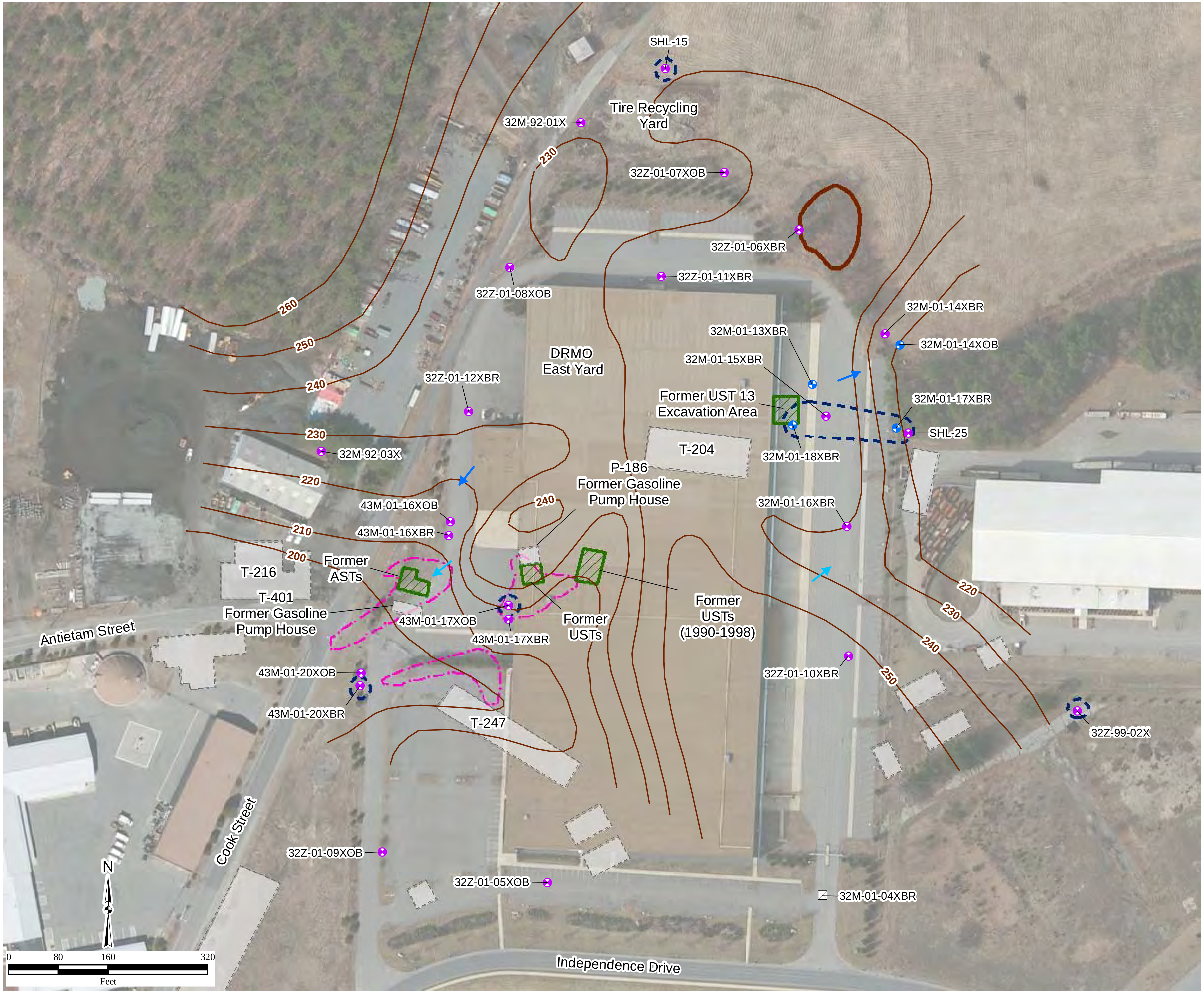

Figure 1.8
Site Layout
Areas of Contamination 32 and 43A

Legend

●	LTM Sample Well
●	LTM Well–Gauge Only
☒	Monitoring Well–Paved Over
32M-92-01X	Well Identification
→	Overburden Groundwater Flow Direction
→	Bedrock Groundwater Flow Direction
—240—	Post-Construction Bedrock Contour (ft amsl, contour interval=10 ft)
▨	Former Storage Tank(s)
▭	Former Building
T-247	Former Building Number
▭	Approximate Historical Extent of Groundwater Contamination in Exceedance of Cleanup Goals (based on April 2002 to October 2011 analytical data)
▭	TPHC Soil Contamination
▭	Remaining Bedrock Outcrop

Notes:
Source of post-construction bedrock:
Draft 2004 Annual Report, Area of Contamination 32 and 43A, Long Term Groundwater Monitoring, Devens, Massachusetts, USACE, 2005.

AST=above ground storage tank
DRMO=Defense Reutilization and Marketing Office
ft amsl=feet above mean sea level
LTM=long-term monitoring
TPHC=total petroleum hydrocarbons
UST=underground storage tank

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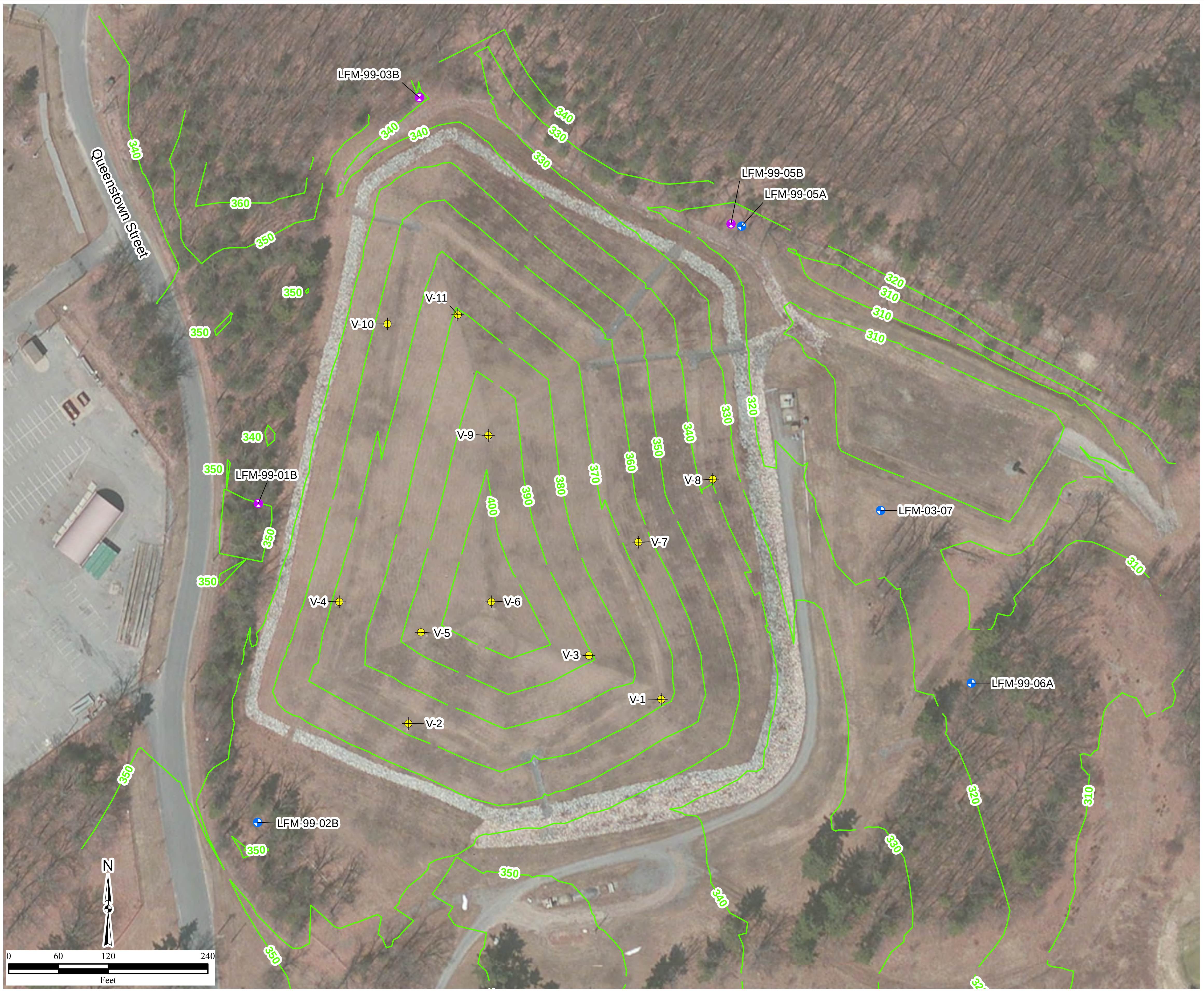
5/27/2014 TB
Source: HGL, USACE, MACTEC, CSM,
ESRI Online Bing Maps Aerial



Sovereign and HGL—Optimization Evaluation for LTMM
Former Fort Devens Army Installation and Sudbury Annex

Figure 1.9
Site Layout
Devens Consolidation Landfill

Legend

●	LTM Sample Well
●	LTM Well–Gauge Only
⊕	Gas Vent
LFM-99-01B	Well/Vent Identification
—380—	Topographic Contour (ft amsl) (contour interval=10 ft)

Notes:
Gas vent locations were approximated based upon the locations displayed in Figure 2 of Devens Consolidation Landfill 2004 Annual Report.
Topographic contours from www.mass.gov, dated 2003.

ft amsl=feet above mean sea level
LTM=long-term monitoring

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4/5/2012 PD
Source: HGL, USACE, MACTEC, www.mass.gov,
ESRI Online Bing Maps Aerial

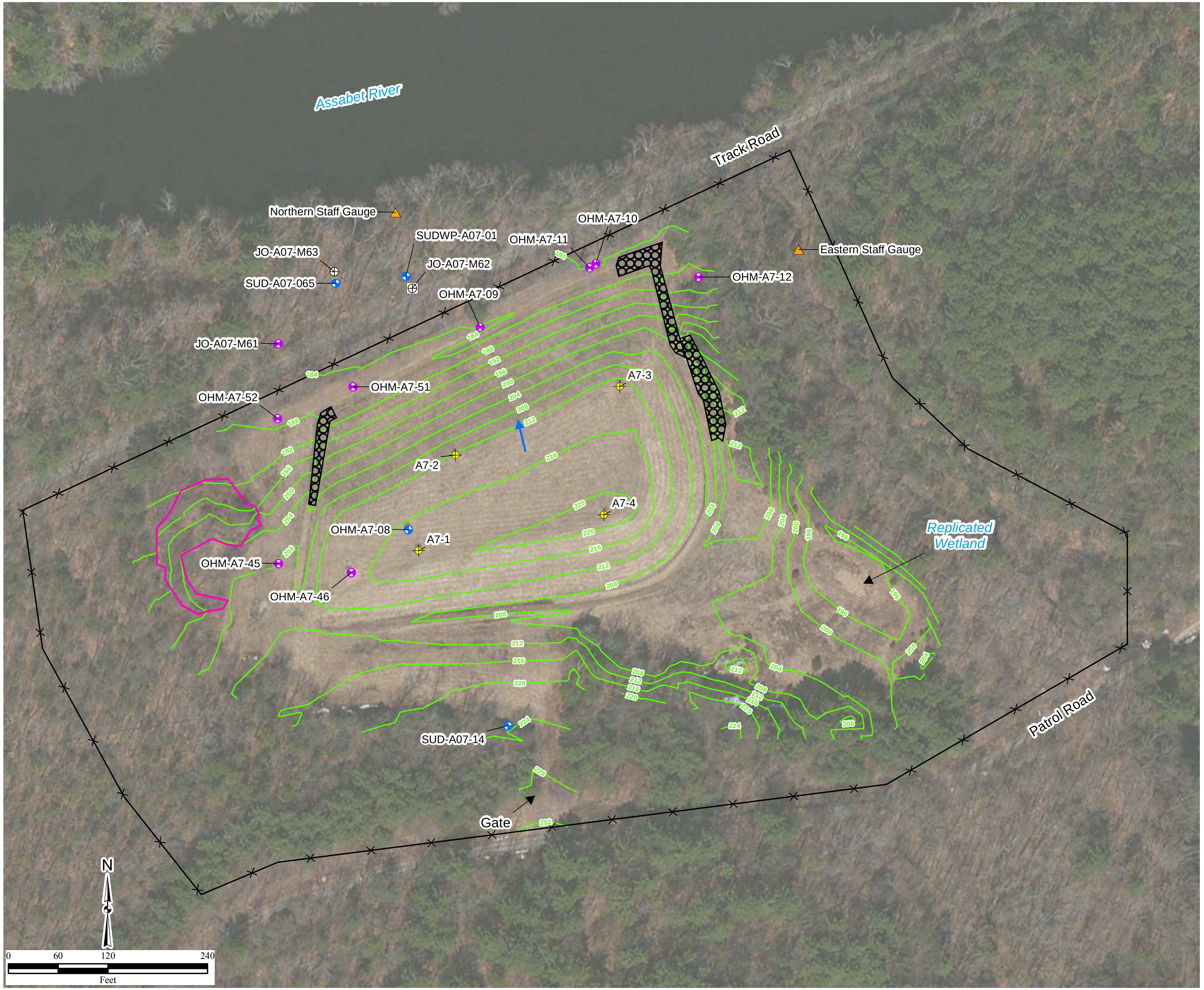

Figure 1.10
Site Layout
Area of Contamination A7
Former Sudbury Training Annex

Legend

●	LTM Sample Well
●	LTM Well–Gauge Only
⊞	Damaged LTM Sample Well
▲	Staff Gauge
⊕	Abandoned Monitoring Well
✛	Gas Vent
OHM-A7-08	Well/Gauge/Vent Identification
→	Groundwater Flow Direction
—220—	Topographic Contour (ft amsl) (contour interval=4 ft)
×—	Fence
▭	Stump Pile Area
▩	Toe Drain

Note:
LTM=Long Term Monitoring

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4/25/2014 PD
Source: HGL, USACE, www.mass.gov,
ESRI Online Bing Maps Aerial

TABLES

Key for Tables

General Terms

AOC	Area of Contamination
COD	chemical oxygen demand
CMR	Code of Massachusetts Regulations
EPH	extractable petroleum hydrocarbons
MCP	Massachusetts Contingency Plan
μg/L	Micrograms per liter
mg/L	Milligrams per liter
mV	Millivolts
NA	Not analyzed/available
NC	Not collected
ND	Not detected
NS	No standard established
NTU	Nephelometric turbidity units
ORP	Oxidation-reduction potential
SHE	Standard Hydrogen Electrode

Result Indicators (Laboratory Results Only)

Bold Text	Indicates a detected result above a background level.
Bold Text	Indicates a detected result above the associated site cleanup goal or GW-1 Standard.
Bold Text	Indicates a detected result above USEPA Water Quality Criteria.
Bold Text	Indicates a detected result above GW-3 Standard.

Data Qualifiers

J	Estimated detection
U	Not detected (at associated reporting limit)
UJ	Not detected; reporting limit is an estimate
R	Rejected due to serious deficiencies in associated QC. The presence or absence of the analyte cannot be verified.
EJ	Detected result reported at a concentration above the calibrated range of the instrument and is considered an estimate.

Table 2.1
Exceedances Over Time
AOC 57
2003 to 2012

Well Number	Fall 2003	Spring 2004	Fall 2004	Spring 2005	Fall 2005	Spring 2006	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Spring 2009	Spring 2010	Spring 2011	Spring 2012
GROUNDWATER														
Arsenic - 10 µg/L Cleanup Goal														
57M-03-02X (AREA 2)	(4.2)	(6.4)	(8.9)	ND	(8.8)	14	13	(6)	(8)	13	10	18	(7)	(8)
57M-03-04X (AREA 2)	41	30	50	47	167	(3.7)	(6)	(3)	ND	ND	ND	(7)	13	ND
57M-03-05X (AREA 2)	22	21	19	ND	18.6	15	11	(5)	(9)	11	12	27	(7)	11
SUMP-1 (AREA 2)	NC	55	(7.8)	ND	36.1	25	(9.0)	(4.1)	(7)	NC	NC	NC	NC	NC
SUMP-2 (AREA 2)	NC	28	24	ND	36.2	38	17	(3.2)	28	NC	NC	NC	NC	NC
SUMP-3 (AREA 2)	NC	22	25	ND	16.8	21	20	(4.7)	14	NC	NC	NC	NC	NC
SUMP-4 (AREA 2)	NC	21	62	ND	24.8	23	37	ND	62	NC	NC	NC	NC	NC
57M-95-03X (AREA 3)	36	44	230	25	13.6	(7)	49	(4.8)	51	23	21	23	58	36
57M-96-11X (AREA 3)	270	240	120	161	215	163	171	166	193	160	163	148	190	192
Trichloroethene - 5 µg/L Cleanup Goal														
57M-03-02X (AREA 2)	(3.9)	(4.3)	5.3	5.3	6.1	5.3	(3.3)	(4.7)	(3.2)	6.2	(4.0)	(1.2)	(4.5)	(4.9)
Tetrachloroethene - 5 µg/L Cleanup Goal														
57M-03-02X (AREA 2)	(4.1)	(2.3)	(2.7)	(3.9)	6.0	(2.3)	(0.84)	5.8	(1.5)	(3.7)	(0.43 J)	ND	(1.4)	(0.98)
C_{11}-C_{22} Aromatics - 200 µg/L Cleanup Goal														
SUMP-2 (AREA 2)	NC	ND	ND	ND	251	ND	ND	ND	ND	NC	NC	NC	NC	NC
1,4-Dichlorobenzene - 5 µg/L Cleanup Goal														
57M-95-03X (AREA 3)	(1.4)	(2.2)	13	(0.5)	(0.8)	(1.4)	(4.5)	(1.4)	13	(0.9)	(2.4 J)	(1.4 J)	5.1	(2.4 J)
57M-96-11X (AREA 3)	(3.4)	(3.8)	(2.4)	(3.3)	(1.4)	(3.7)	(2.4)	(4.4)	(1.6)	5.1	7.5	(2.1 J)	(2.3 J)	(0.92 J)
SURFACE WATER														
Arsenic - 150 µg/L Water Quality Criteria														
57-AREA 2-SW-3 (AREA 2)	(14)	(8.1)	(46)	(96)	(39.9)	(7)	(46)	(63)	(11)	(6)	(2.6J)	(4.8J)	(5)	(2.0 J)
Iron - 1,000 µg/L Water Quality Criteria														
57-AREA 2-SW-2 (AREA 2)	NC	NC	NC	NC	NC	1,100	(480)	3,900	1,200	2,600	(770)	1,400	(360 J)	(200)
57-AREA 2-SW-3 (AREA 2)	NC	NC	NC	NC	NC	(740)	8,300	4,500	1,100	1,500	7600	(150)	(150)	(170)
57-AREA 3-SW-1 (AREA 3)	NC	NC	NC	NC	NC	(600)	4,500	(520)	7,100	6,800	2500	(240)	20,000	8,300
Lead - 2.5 µg/L Water Quality Criteria														
57-AREA 2-SW-2 (AREA 2)	ND	ND	ND	ND	ND	(1.8)	(1.9)	12	ND	NC	NC	NC	NC	NC
57-AREA 2-SW-3 (AREA 2)	2.6	ND	ND	5.2	3.3	2.8	ND	12	ND	NC	NC	NC	NC	NC
57-AREA 3-SW-1 (AREA 3)	34	ND	(0.81)	3.4	ND	(2.3)	ND	(1.8)	14	NC	NC	NC	NC	NC

Notes:

Number in parentheses denotes that the concentration is below the cleanup goal.

The unadjusted result was used beginning with the Spring 2006 sampling event.

All general terms, laboratory indicators and data qualifiers are defined on the Key for Tables found at the beginning of this section.

Table 2.2
Exceedances Over Time
AOC 69W
2000 to 2012

Well Number	Spring 2000	Fall 2000	Spring 2001	Fall 2001	Spring 2002	Fall 2002	Spring 2003	Fall 2003	Spring 2004	Fall 2004	Spring 2005	Fall 2005	Spring 2006	Fall 2007	Fall 2008	Fall 2009	Fall 2010	Fall 2011	Fall 2012
C_{11}-C_{22} Aromatics[1] - 200 µg/l Monitoring Criteria[2]																			
69W-94-13	690	1,400	720	790	1,900	290	ND	(160)	ND	(110)	ND	ND	209	311	(152)	225	339	242	379
ZWM-95-15X	ND	ND	ND	ND	1,400	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	ND
ZWM-99-22X	2,500	1,400	2,100	370	620	210	380	330	270	400	320	280	627	(166)	356	276	209	327	308
ZWM-99-23X	(170)	520	200	(140)	(140)	ND	ND	ND	ND	ND	ND	ND	(174)	(107)	(80)	ND	ND	ND	ND
C_9-C_{10} Aromatics - 200 µg/l Monitoring Criteria[2]																			
69W-94-13	(120)	270	(160)	320	(150)	200	(62)	(140)	(130)	230	(110)	(140)	(84)	(144)	(81)	(105)	(142)	(66.7)	(63.0 J)
ZWM-99-22X	620	(150)	550	(83)	(88)	(150)	840	450	650	600	460	460	330	(113)	217	(120)	(76.4)	(114)	(55.5 J)
ZWM-99-23X	(46)	(62)	(40)	(34)	ND	ND	(53)	(59)	ND	ND	(100)	ND	ND	ND	(28)	(35.2)	ND	ND	ND
Arsenic, dissolved - 10 µg/l Monitoring Criteria[2]																			
69W-94-13	54	110	85	150	52	130	35	69	27	88	56	60	69	142	73	86	127	120	115
ZWM-95-15X	ND	(7.9)	ND	22	36	40	ND	16	(7.7)	30	ND	ND	ND	16	ND	ND	13	41	23
ZWM-99-22X	150	130	230	140	86	140	150	160	140	140	120	120	159	244	223	408	343	367	299
ZWM-99-23X	23	70	67	55	15	ND	27	ND	44	61	46	47	56	56	52	62	15	60	29
ZWM-99-25X	N/A	N/A	N/A	(4.1 J)	ND	ND	(2.3 J)	ND	ND	(3.4 J)	ND	ND	(3 J)	-5	(2.3 J)	(2 J)	ND	13	19
Manganese, dissolved - 375 µg/l Monitoring Criteria[2]																			
69WP-08-01	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	(174)	(89)	(78)	2,190	904
69W-94-13	2,300	1,700	1,500	1,600	2,100	2,400	2,800	4,100	2,500	1,300	3,000	1,600	2,600	1,120	1,940	2,110	1,360	1,840	1,400
ZWM-95-15X	(28)	1,300	(25)	(100)	1,500	2,200	1,600	970	4,600	980	850	(130)	860	1,230	438	502	1,120	1,010	1,580
ZWM-99-22X	2,000	1,800	2,300	2,400	2,000	1,500	2,700	2,300	3,100	1,900	3,400	3,200	3,700	3,120	3,790	2,660	1,750	2,160	1,120
ZWM-99-23X	4,200	3,600	5,800	1,500	550	1,700	5,300	4,300	2,500	2,300	5,200	2,500	2,700	1,320	2,500	3,080	523	1,720	500
ZWM-01-25X	N/A	N/A	N/A	(280)	(61)	1,000	(89)	(230)	(140)	(300)	(140)	490	1,400	3,210	1,320	5,830	1,490	2,820	2,540

Notes:

The number in parentheses denotes that the concentration is below the cleanup goal.

[1] The unadjusted result was used beginning with the Spring 2006 sampling event.

[2] The monitoring criteria is based on the lower value between the site-specific cleanup goal and the MCP GW-1 Standard (310 CMR 40 Subpart P).

All general terms, laboratory indicators and data qualifiers are defined on the Key for Tables found at the beginning of this section.

Table 2.3
Exceedances Over Time
AOC 43G
1999 to 2012

Well Number	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Benzene - 5 µg/L Cleanup Goal														
AAFES-2	62	36	43	26	9	6.6	6.1	(1.3)	ND^2	ND^2	(3.93 J)	ND	ND	6.60 J
XGM-93-02X	81	32	12	140	24	39	29	18.5	8.8	(2.6)	(0.997 J)	ND	ND	ND
XGM-97-12X	270	550	700	780	290	260	35.6	129	22.8	13.7 J	27.4J	ND	13.8	(3.03 J)
Toluene - 1,000 µg/L Cleanup Goal														
XGM-97-12X	(390)	1,100	(870)	1,000	(610)	(460)	(53.4)	(239)	(15.9)	(11.4 J)	(5.3 J)	ND	ND	ND
C_5-C_8 Aliphatics^1 - 300 µg/L VPH Boundary Standards														
AAFES-2	ND	1,400*	ND	1,200	1,200	ND	2,070	1,430	1,400	ND^2	ND	859	1,270	1560 J
AAFES-6	(370)	420*	(290)	ND	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
AAFES-6R**	NC	NC	NC	NC	NC	NC	NC	(305)	ND^2	ND	ND	(114)	ND	(215)
XGM-93-02X	ND	570*	(270)	790	410	ND	788	519	ND	ND^2	ND	(124)	ND	ND
XGM-94-04X	ND	420*	(140)	ND	ND	ND	ND	ND	ND	ND	ND	533	765	497 J
XGM-97-12X	970	1,300	1,100	1,100	1,100	ND	2,370	1,740	1,230	ND^2	4,050	644	367	507 J
C_9-C_{12} Aliphatics^1 - 700 µg/L VPH Boundary Standards														
AAFES-2	ND	(81)	ND	(200)	ND	(57)	5,220	987	1,000	1,020	950	768	1,080	(542 J)
XGM-93-02X	ND	(39)	ND	(58)	(33)	(34)	1,570	-268	(94)	(182)	(55.5)	ND	(85.1)	ND
XGM-97-12X	(96)	ND	ND	(130)	ND	(90)	7,310	1,340	1,080	2,210	1,450	922	(535)	(275 J)
C_9-C_{10} Aromatics - 200 µg/L VPH Boundary Standards														
AAFES-2	9,400	7,200	5,300	13,000	6,600	6,700	3,130	3,710	2,420	2,120	2,660	1,870	1,050	1,090 J
XGM-93-02X	510	2,300	1,100	3,600	1,600	3,700	918	766	228	325	(110)	(73.4)	ND	ND
XGM-94-04X	200	570	(170)	(28)	ND	ND	ND	ND	ND	ND	ND	243	469	300 J
XGM-97-12X	4,500	5,500	5,400	7,500	8,700	7,400	3,810	4,010	4,220	5,260	4,110	2,470 J	463	367 J
Iron, total - 9,100 µg/L Cleanup Goal														
AAFES-2	24,000	20,000	27,000	26,000	14,000	20,000	21,900	12,000	20,000	18,000	16,000	14,000	22,000	18,000
AAFES-6	11,000	9,200	13,000	9,400	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
AAFES-6R**	NC	NC	NC	NC	NC	NC	NC	11,000	11,000	(6,500)	(4,300)	(3,300)	(1,100)	(6,900)
XGM-93-02X	30,000	18,000	11,000	24,000	15,000	28,000	11,500	13,000	(5,800)	11,000	(8,500)	11,000	12,000	(6,000)
XGM-94-07X	(3,500)	(2,900)	(5,800)	(2,300)	(1,000)	(300)	(1,610)	(1,400)	(4,500)	9,300	(8,800)	12,000	13,000	23,000
XGM-94-08X	(4,800)	13,000	(4,500)	(4,600)	(3,200)	(2,500)	(4,520)	(6,100)	(4,600)	(2,200)	(1,300)	(1,000)	(750)	(2,300)
XGM-97-12X	32,000	26,000	33,000	46,000	33,000	32,000	20,100	18,000	22,000	25,000	25,000	16,000	27,000	20,000
Manganese, total^3 - 375 µg/L Cleanup Goal														
AAFES-2	4,600	3,900	4,800	3,700	3,100	4,000	3,590	2,700	3,790	3,600	3,320	2,490	3,700	3,100
AAFES-5	710	180*	(190)	(27)	(21)	(89)	(118)	(50)	(34)	ND	ND	(244)	(36)	(206)
AAFES-6	2,900	9,200	3,400	3,000	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
AAFES-6R**	NC	NC	NC	NC	NC	NC	NC	2,900	3,090	3,630	907	1,670	1,830	3,220
AAFES-7	NC	NC	NC	NC	NC	NC	NC	NC	NC	(106)/ND	(81)	(79)	(5 J)	706
XGM-93-02X	3,900	2,500	1,900	2,500	1,900	2,600	1,450	2,000	1,800	1,420	1,630	737	3,020	612
XGM-94-04X	2,900	2,200	3,400	2,000	1,400	1,400	1,580	1,100	559	(68)	2,730	6,490	2,140	2,580
XGM-94-07X	5,700	3,700	6,100	4,500	3,600	1,000	6,120	5,100	4,120	5,100	4,990	3,870	6,060	5,560
XGM-94-08X	4,500	4,600	4,900	3,600	3,600	3,800	7,260	4,200	3,380	3,100	2,150	2,070	2,780	4,620
XGM-94-10X	830	2,000	2,600	(31)	(120)	960	960	330	NC	NC	NC	NC	NC	NC
XGM-97-12X	6,300	4,100	4,200	3,900	4,100	3,000	437	1,800	2,070	3,060	2,390	2,110	3,540	1,640

Notes: All general terms, laboratory indicators and data qualifiers are defined on the Key for Tables found at the beginning of this section.

Number in parentheses denotes that concentration is below cleanup goal or VPH Boundary Standard.

* = Analyte detected 5 times of the amount detected in the equipment blank sample.

**=AAFES 6R was installed in January 2006 to replace abandoned well AAFES-6.

[1] Adjusted result used beginning with 2006 sample event.

[2] Detection limit was above the cleanup goal or VPH Boundary Standard.

[3] USEPA approved revised cleanup goal effective October 2008.

Table 2.4
Exceedances Over Time - South Post Impact Area
1992 to 2012

Well Number	1992	1993	1993	1993	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	May 2009	Nov 2009	Feb 2010	July 2010	Oct 2010	Oct 2011	Nov 2012
Area of Contamination 26																											
RDX - 1 μg/L GW-1 Standard																											
26M-92-03X	75	83.4	58	NC	NC	NC	NC	NC	23	8.9	97	12	62	260	6.7	18	17	7.79	12.9	12.5	NC	17.3	NC	NC	16.3	10.7	9.75
26M-92-04X	270	390	198	NC	NC	NC	NC	NC	NC	227.4	240	260	200	180	210	260	210	196	184	165	NC	170	NC	NC	170	157	181
26M-97-08X	NC	NC	NC	NC	NC	NC	NC	NC	29	28.5	46	30	57	63	37	45	41	45.1	44	32.8	NC	26.7	NC	NC	27.6	25.8	43.2
26WP-06-01	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	190	NC	137	162 J	98.1	126	116	65.2
Perchlorate - 2 μg/L GW-1 Standard																											
26WP-06-01	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	3.1	5.6	133	305	114	93.7	64.1	89.2	68.3	19.1
26M-92-04X	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	3.1	NC	2.3	(1.8)	(1.7)	(1.5)	2.98	NC	NC	47.5	332	49.2
26M-97-08X	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	3.84
Arsenic, total - 10 μg/L GW-1 Standard; 10.5 μg/L Background Level																											
26M-92-04X	100	[7.46]	[6.61]	NC	NC	NC	NC	NC	NC	ND	(1.5)	ND	ND	ND	ND	ND	ND	ND	ND	ND	NC	ND	NC	NC	ND	ND	ND
26WP-08-02	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	128	NC	46	NC	NC	64	62	68
Lead - 15 μg/L GW-1 Standard; 4.25 μg/L Backgroud Level																											
26M-92-04X	27	(6.4)	ND	NC	NC	NC	NC	NC	NC	ND	ND	ND	ND	ND	ND	[1.7]	ND	ND	ND	ND	NC	ND	NC	NC	ND	ND	ND
26WP-08-02	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	20	NC	ND	NC	NC	(6.0 J)	ND	(6.0 J)
Area of Contamination 27																											
RDX -1 μg/L GW-1 Standard																											
27M-92-01X	12.1	12.3	NC	NC	NC	NC	NC	NC	4.6	2.8	3.0	2.6	3.0	1.8	ND	1.3	ND	ND	NC	ND	NC	NC	NC	NC	ND	NC	ND
27M-93-06X	NC	1.56	1.77	NC	NC	NC	NC	NC	2.2	2.2	1.3	(0.96)	(0.91)	(0.95)	(0.75)	(0.91)	1.50	3.4	NC	1.8	NC	NC	NC	NC	2.12 J	NC	ND
Arsenic, total - 10 μg/L GW-1 Standard; 10.5 μg/L Background Level																											
27M-92-01X	25.3	25.9	NC	NC	NC	NC	NC	NC	ND	ND	ND	(6.5)	(4.5)	ND	ND	ND	ND	(3.0)	NC	ND	NC	NC	NC	NC	ND	NC	ND
27M-93-05X	NC	[4.96]	[5.22]	10.8	(6.64)	NC	NC	NC	ND	ND	[3.3]	[6.6]	[4.1]	ND	ND	ND	ND	(7.0)	NC	ND	NC	NC	NC	NC	(7.0)	NC	(4 J)
Lead - 15 μg/L GW-1 Standard; 4.25 μg/L Backgroud Level																											
27M-92-01X	17.4	15.3	NC	NC	NC	NC	NC	NC	ND	ND	[1.6]	[2.2]	[2.2]	[2.2]	ND	[2.3]	ND	ND	NC	[2.3]	NC	NC	NC	NC	(3.5 J)	NC	(4 J)
1,3-Dintrobenzene - No Groundwater Standard																											
27M-93-05X	NC	NC	NC	0.288	1.3	NC	NC	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NC	ND	NC	NC	NC	NC	ND	NC	ND
27M-93-06X	NC	NC	NC	NC	1.09	NC	NC	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NC	ND	NC	NC	NC	NC	ND	NC	ND
27M-93-08X	NC	NC	NC	(1.82)	1.03	NC	NC	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NC	ND	NC	NC	NC	NC	ND	NC	ND
Area of Contamination 41																											
Vinyl Chloride - 2 μg/L GW-1 Standard																											
41M-93-04X	NC	NC	NC	NC	NC	NC	NC	NC	ND	ND	3.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	NC	NC	NC	NC	ND	ND	ND
TCE - 5 μg/L GW-1 Standard																											
41M-93-04X	NC	NC	NC	NC	NC	1.3	<0.5	NC	<0.5	1 J	<1.0	<1.0	0.24 J	<1.0	<5.0	<1.0	<1.0	9.1	ND	ND	NC	NC	NC	NC	ND	(0.21 J)	ND
South Post Monitoring Wells																											
Arsenic, total - 10 μg/L GW-1 Standard; 10.5 μg/L Background Level																											
SPM-93-06X	NC	33.6	21.7	33.3	19.8	NC	NC	NC	ND	ND	[8.1]	15.4	[7.4]	[9.8]	11.7	10.9	35.2	24	31	27	NC	11	NC	NC	13	13	ND
SPM-93-10X	NC	ND	ND	ND	ND	NC	NC	NC	ND	ND	[6.4]	[5.6]	[5.8]	[3.7]	[7.8]	[5.2]	13.2	[7.0]	(5.0)	(7.0)	NC	ND	NC	NC	(6.0)	10	(4.7 J)
1,3-Dintrobenzene - No Groundwater Standard																											
SPM-93-08X	NC	NC	NC	ND	3.84	NC	NC	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NC	ND	NC	NC	ND	ND	ND
SPM-93-10X	NC	NC	NC	3.25	ND	NC	NC	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NC	ND	NC	NC	ND	ND	ND
SPM-93-16X	NC	NC	NC	4.37	2.06	NC	NC	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NC	ND	NC	NC	ND	ND	ND
Antimony, total - 6 μg/L GW-1 Standard; 3.03 μg/L Background Level																											
SPM-93-06X	NC	ND	ND	ND	ND	NC	NC	NC	ND	ND	ND	ND	(2.2)	ND	ND	ND	ND	ND	7.8	ND	NC	ND	NC	NC	ND	ND	(0.16 J)
SPM-93-16X	ND	ND	ND	ND	ND	NC	NC	NC	ND	ND	ND	ND	ND	ND	ND	ND	13.8	ND	ND	ND	NC	8.5 J	NC	NC	ND	ND	ND

Notes:

Number in parentheses denotes that concentration is below GW-1 standard.

Number in brackets denotes that concentration is below background level.

* = Analyte detected 5 times of the amount detected in the equipment blank sample.

All general terms, laboratory indicators and data qualifiers are defined on the Key for Tables found at the beginning of this section.

Table 2.5
Exceedances Over Time
Devens Consolidation Landfill
2003 to 2012

Well Number	June 2003	November 2003	May 2004	October 2004	May 2005	May 2006	May 2007	June 2008	October 2008	May 2009	October 2009	May 2010	October 2010	July 2011	October 2011	May 2012	October 2012
Arsenic - 10 µg/L GW-1 Standard																	
LFM-99-07	(7.9)	29 J	ND	(1.7 J)	ND	ND	(2.3 J)	ND	ND	ND	NA	(3.3 J)	(2.5 J)	ND	(4 J)	ND	NA
Lead - 15 µg/L GW-1 Standard																	
LFM-99-07	(13)	17 J	ND	ND	ND	ND	ND	ND	ND	(1.9 J)	NA	ND	ND	ND	(3 J)	ND	NA

Notes:

The number in parentheses denotes that the concentration is below the GW-1 standard.

All general terms, laboratory indicators and data qualifiers are defined on the Key for Tables found at the beginning of this section.

Table 2.6a
Exceedances Over Time
AOC 32 and 43A
2002 to 2012

Well	April 2002	October 2002	June 2003	December 2003	May 2004	October 2004	June 2005	October 2005	June 2006	October 2006	May 2007	October 2007	June 2008	October 2008
	AOC 32 WELLS - EXCEEDANCES													
32M-01-18XBR (Source well)	VOCs and Manganese	VOCs and Manganese	VOCs and Manganese	VOCs and Manganese	VOCs, VPH, Manganese and Arsenic	VOCs, VPH, Manganese	VOCs, VPH, Manganese and Arsenic	VOCs, VPH, Manganese	VOCs, VPH, Manganese and Arsenic	VOCs, VPH, Manganese and Arsenic	VOCs, VPH, EPH, Manganese and Arsenic	VOCs, VPH and Manganese	VOCs, VPH, Manganese and Arsenic	VOCs, VPH, Manganese and Arsenic
32M-01-14XBR (Sentry well)	No Exceedances	Arsenic and Lead	Arsenic	No Exceedances	Arsenic	Arsenic	No Exceedances	Arsenic and Lead	No Exceedances	No Exceedances	No Exceedances	No Exceedances	No Exceedances	Not Sampled
32M-01-14XOB (Sentry well)	No Exceedances	No Exceedances	Manganese and Arsenic	Manganese and Arsenic	No Exceedances	Arsenic	Manganese and Arsenic	Arsenic and Lead	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Manganese and Arsenic
32M-01-15XBR	No Exceedances	No Exceedances	Manganese and Arsenic	Manganese and Arsenic	No Exceedances	No Exceedances	No Exceedances	No Exceedances	No Exceedances	1,4-DCB	No Exceedances	1,4-DCB	1,4-DCB	1,4-DCB
32M-01-17XBR	No Exceedances	No Exceedances	Manganese and Arsenic	Manganese and Arsenic	No Exceedances	No Exceedances	No Exceedances	No Exceedances	No Exceedances	1,4-DCB	No Exceedances	No Exceedances	No Exceedances	No Exceedances
32Z-99-02X (Distant sentry well)	Not Sampled	Arsenic and Lead	No Exceedances	No Exceedances	No Exceedances	No Exceedances	No Exceedances	Not Sampled	No Exceedances	No Exceedances	No Exceedances	No Exceedances	No Exceedances	Not Sampled
SHL-15	Arsenic and Manganese	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	No Exceedances	No Exceedances	Arsenic	Not Sampled	Not Sampled	Not Sampled	Not Sampled
	AOC 43A WELLS - EXCEEDANCES													
43M-01-17XOB (Source well)	VOCs and Arsenic	Arsenic	No Exceedances	Arsenic	Arsenic	No Exceedances	No Exceedances	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled
43M-01-20XBR (Sentry well)	Manganese	Manganese	No Exceedances	Not Sampled	No Exceedances	No Exceedances	No Exceedances	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled

Notes:

1,4-DCB = 1,4-Dichlorobenzene

All general terms, laboratory indicators and data qualifiers are defined on the Key for Tables found at the beginning of this section.

Table 2.6a
Exceedances Over Time
AOC 32 and 43A
2002 to 2012

Well	March 2009	May 2009	November 2009	May 2010	October 2010	June 2011	October 2011	May 2012	October 2012
	AOC 32 WELLS - EXCEEDANCES								
32M-01-18XBR (Source well)	VOCs, VPH, and Manganese	VOCs, VPH, Manganese and Arsenic	VOCs, VPH, Manganese and Arsenic	VOCs, VPH, and Arsenic	VOCs, VPH, and Manganese	VOCs and VPH	VOCs and VPH	VOCs, VPH, and Manganese	VOCs and VPH
32M-01-14XBR (Sentry well)	Not Sampled	No Exceedances	Not Sampled	No Exceedances	Not Sampled	No Exceedances	Not Sampled	No Exceedances	Not Sampled
32M-01-14XOB (Sentry well)	Not Sampled	Manganese and Arsenic	Not Sampled	Arsenic	Not Sampled	Arsenic	Not Sampled	Arsenic	Not Sampled
32M-01-15XBR	No Exceedances	No Exceedances	No Exceedances	No Exceedances	No Exceedances	No Exceedances	No Exceedances	No Exceedances	No Exceedances
32M-01-17XBR	No Exceedances	No Exceedances	1,4-DCB	1,4-DCB	No Exceedances	No Exceedances	No Exceedances	No Exceedances	No Exceedances
32Z-99-02X (Distant sentry well)	Not Sampled	No Exceedances	Not Sampled	No Exceedances	Not Sampled	No Exceedances	Not Sampled	No Exceedances	Not Sampled
SHL-15	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled
	AOC 43A WELLS - EXCEEDANCES								
43M-01-17XOB (Source well)	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled
43M-01-20XBR (Sentry well)	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled

Notes:

1,4-DCB = 1,4-Dichlorobenzene

All general terms, laboratory indicators and data qualifiers are defined on the Key for Tables found at the beginning of this section.

Table 2.6b
Summary of Cleanup Goal Exceedances
AOC 32 and 43A
32M-01-18XBR

Parameter	Units	Cleanup Goal	April 2002	October 2002	June 2003	December 2003	May 2004	October 2004	June 2005	October 2005	June 2006	October 2006	May 2007	October 2007	June 2008	October 2008	March 2009	May 2009	November 2009
Trichloroethene	μg/L	5	19	ND	ND	(3.4 QA)	5.2 QA	(3.4 QA)	ND	(0.6)	ND	ND	(4.2)	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	μg/L	600	5,900	2,500	3,800	3,900	6,200	4,200	4,500	1,450	5,900	2,800	6,100	690	2,700	4,100	(330)	1,700	730
1,3-Dichlorobenzene	μg/L	40	660	300	460	430	730	530	590	209	750	360	850	120	450	580	62	270	150
1,4-Dichlorobenzene	μg/L	5	450	200	310	280	470	320	370	120	490	210	550	67	270	390	41	180	100
Bromodichloromethane	μg/L	3	NC	NC	NC	ND	ND	ND	ND	ND	19	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	μg/L	5	NC	NC	NC	ND	ND	ND	ND	ND	39	ND	ND	ND	ND	ND	ND	ND	ND
VPH C_9-C_{12} Aliphatics (Adjusted)	μg/L	700	5,000	ND	(350)	(511)	5,100 QA	4,480	(470)	(686)	ND	ND	(2.5)	ND	ND	ND	(2,725)	(132 J)	(250)
VPH C_9-C_{10} Aromatics	μg/L	200	9,100	2,900	1,700	2,600	11,000	4,400	260	1,150	5,850	4,120	6,050	952	3,230	3,660	292 J	1,890	837
EPH C_9-C_{18} Alphatics	μg/L	700	920	(240)	(620)	940	2,300	1,100	1,400	(228)	1,340	785	854	(158)	(430)	(455)	(101 J)	(470)	(246)
Arsenic, Total	μg/L	10	ND	ND	(3.5)	(8.8)	10.4	(6.2)	24.4	ND	30	15	51	(3.1)	38	34	174	51	18
Arsenic, Dissolved	μg/L	10	ND	ND	(3.0)	NC	10.1	(6.3)	NC	NC	33	NC	NC	NC	NC	NC	NC	NC	NC
Manganese, Total	μg/L	3,500	7,730	9,260	14,100	11,000	17,400	13,400	16,700	11,600	18,000	16,000	18,200	10,200	14,800	18,900	(2,170)	29,400	6,970
Manganese, Dissolved	μg/L	3,500	7,500	8,960	14,200	13,900	18,100	12,500	NC	NC	19,000	NC	NC	NC	NC	NC	NC	NC	NC
Field Paramters - ORP[1]	mV	NS	120.37	216.33	111.90	45.1	NC	17.6	24.7	33.8	-2.0	14.9	-30.9	1.5	-40.1	60.9	431.7	437.7	120.7
Field Paramters - Turbidity	NTU	NS	NC	NC	NC	0.91	NC	1.63	0.51	0.50	0.10	0.65	1.9	0.40	0	3	17.7	17.7	2.4

Notes:

The number in parenthesis denotes that the concentration is below the cleanup goal.

QA= Result is reported from the QA lab analysis. The primary lab result has an elevated reporting limit due to the dilution of the sample or the primary lab result was outside the calibration range.

The water quality data was not available for the May 2004 sampling event.

Historic documents were searched but the necessary information was not available.

[1] The ORP value was not corrected to SHE.

All general terms, laboratory indicators and data qualifiers are defined on the Key for Tables found at the beginning of this section.

Table 2.6b
Summary of Cleanup Goal Exceedances
AOC 32 and 43A
32M-01-18XBR

Parameter	Units	Cleanup Goal	May 2010	October 2010	June 2011	October 2011	May 2012	October 2012
Trichloroethene	µg/L	5	ND	ND	ND	ND	(0.60)	ND
1,2-Dichlorobenzene	µg/L	600	(300)	(570)	(340)	(260)	610 J	(340)
1,3-Dichlorobenzene	µg/L	40	59	100	86	64	120 J	70
1,4-Dichlorobenzene	µg/L	5	26	62	50	37	69	42
Bromodichloromethane	µg/L	3	ND	ND	ND	ND	ND	ND
Chloroform	µg/L	5	ND	ND	ND	ND	ND	ND
VPH C_9-C_{12} Aliphatics (Adjusted)	µg/L	700	ND	ND	(104)	(108)	(486)	ND
VPH C_9-C_{10} Aromatics	µg/L	200	300	541	444	272	728	322
EPH C_9-C_{18} Alphatics	µg/L	700	ND	ND	ND	ND	(175)	ND
Arsenic, Total	µg/L	10	18	(3.5 J)	(3 J)	(5)	(5)	(4 J)
Arsenic, Dissolved	µg/L	10	NC	NC	NC	NC	NC	NC
Manganese, Total	µg/L	3,500	(2,360)	4,510	(2,300)	(1,150)	4,100	1,540
Manganese, Dissolved	µg/L	3,500	NC	NC	NC	NC	NC	NC
Field Paramters - ORP[1]	mV	NS	-177.8	137.2	408.1	158.8	163.4	223.8
Field Paramters - Turbidity	NTU	NS	244.0	3.07	2.68	3.53	2.22	1.26

Notes:

The number in parenthesis denotes that the concentration is below the cleanup goal.

QA= Result is reported from the QA lab analysis. The primary lab result has an elevated reporting limit due to the dilution of the sample or the primary lab result was outside the calibration range.

The water quality data was not available for the May 2004 sampling event.

Historic documents were searched but the necessary information was not available.

[1] The ORP value was not corrected to SHE.

All general terms, laboratory indicators and data qualifiers are defined on the Key for Tables found at the beginning of this section.

Table 2.7
Exceedances of GW-1 Standards Over Time
Sudbury Landfill-AOC A7
1996 to 2012

Well Number	July 1996	October 1996	April 1997	October 1997	April 1998	October 1998	April 1999	October 1999	April 2000	October 2000	May 2001	October 2001	April 2002	October 2002	April 2003	October 2003	April 2004	October 2004	June 2005	September 2005	November 2006	October 2007	October 2008	November 2009	June 2011	October 2011	October 2012
1,1,2,2-Tetrachloroethane - 2 µg/L GW-1 Standard ***; 50,000 µg/L GW-3 Standard***																											
OHM-A7-51	66	85	34	29	11	9	6.5	19	7.7	4.9	(1)	6.0	(1)	6.1	4.8	2.4	2.7	4.4	2	(1.4)	(1.9)	2.4	2	(0.94)	(1.2)	(0.58)	(1.77)
JO-A07-M63/ SUD-A07-065[1]	13	21	24	26	20	31	23	22	12	20	12	14	20	13	5.1	3.8	4.8	1.8	2.0	4.10	3.60	4.20	3.60	2.30	3.30	2.10	3.14
Tetrachloroethene - 5 µg/L GW-1 Standard ***; 30,000 µg/L GW-3 Standard***																											
OHM-A7-08	12	27	120	120	92	130	94	92	43	71E	40	59	14	33	24	23J	21	13	8.7	25.4	16.4J	6.2J	8.1	11	5.6	6.2	8.18
OHM-A7-51	82	65	26	20	7.3	8.4	7.9	13	8.3	6.8	(2.1)	6.5	6.3	7.8	6.4	5.8J	(4.6J)	4	3.1	(3.8)	(3.8)	(3.1J)	(4.5)	(2.6)	(4)	(2.9)	(3.56)
JO-A07-M63/ SUD-A07-065[1]	14	14	28	21	28	32	30	24	17	25	40	16	23	14	(1.9)	(3.0)	(2.9)	(0.62)	(1.5)	11.6	8.9	11.9	13	12	15	9.9	13.2
Trichloroethene - 5µg/L GW-1 Standard ***; 5,000 µg/L GW-3 Standard***																											
JO-A07-M63/ SUD-A07-065[1]	10	15	24	25	(1)	36	36	30	21	37	17	29	40	33	5.9	11	17	9.3	(3.8)	25.4	7.1	9.3	(4.6)	(4.4)	(4.7)	(1.3)	6.77
gamma-BHC (Lindane) - 0.2 µg/L GW-1 Standard; 4 µg/L GW-3 Standard																											
OHM-A7-08	0.538	2.8	17	(0.052)	16	13	12	6.7	9.6	5.1J	7	4.3Q	1.4	2.6	2.6	2.0	1.4	0.82J	1.1	1.84	1.91	0.58	0.52J	0.522	0.332	0.45	0.529
SUD-A07-065	NS	NS	NS	0.31	ND	0.38	0.32	0.33	0.066	ND	0.25	0.31	0.25	0.24	(0.12)	(0.041J)	ND	(0.10)	(0.059)	(0.17)	(0.18)	0.34	0.22	(0.097)	(0.077)	(0.079)	0.243
JO-A07-M62	NS	ND	ND	ND	ND	ND	ND	ND	ND	0.84	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD - 0.2 µg/L GW-1 Standard; 50 µg/L GW-3 Standard																											
OHM-A7-08	NS	NS	NS	0.35	5	5.6	0.3	5	0.28	2	(0.1)	0.25	(0.13)	2	0.21	0.4	0.29	(0.11)	0.21	(0.12)	(0.1)	(0.16)	(0.04)	(0.05)	(0.053)	(0.043)	(0.049 J)
Arsenic - 10 µg/L GW-1 Standard; 900 µg/L GW-3 Standard																											
OHM-A7-08	NS	NS	ND	ND	ND	ND	ND	ND	(7.9)	13	10	15	(8.7)	24	(1.8)	21	14	15.8	(0.94J)	ND	ND	(4.7)	ND	ND	ND	ND	ND
JO-A07-M63/ SUD-A07-065[1]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	(5.9)	(6.2)	(1.5 J)	(1.1 J)	(0.99)	(4.1)	(0.17 J)	(3.9)	ND	ND	ND	ND	ND	ND	ND
JO-A07-M62	NS	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	(1.2 J)	ND	(0.88 J)	ND	ND	ND	NS	ND	ND	(2.7 J)	ND	ND	ND	NS
Lead- 15 µg/L GW-1 Standard; 10 µg/L GW-3 Standard																											
OHM-A7-08	NS	NS	485	290	17	(10)	(11.7)	(10)	(11)	(5.8)	(10)	(4.4)	(5.2)	(7.9)	(0.9)	(14)	(9.5)	(9.3)	ND	ND	ND	(7.3)	ND	ND	ND	(5 J)	ND
JO-A07-M63/ SUD-A07-065[1]	ND	ND	ND	ND	ND	ND	ND	ND	(1.9 J)	ND	ND	ND	ND	(2)	(1.4)	(0.46 J)	(2.7)	(3.4)	ND	ND	ND	ND	ND	ND	ND	ND	ND
JO-A07-M62	NS	NS	27.4	ND	(3.1)	ND	ND	ND	ND	ND	ND	ND	ND	(3)	(0.15 J)	(0.082 J)	(0.14)	ND	ND	NS	ND	ND	ND	ND	ND	ND	NS

Notes:

The number in parentheses denotes that the concentration is below the **GW-1 Standard**.

[1] JO-A07-M63/SUD-A07-065 ('07 and beyond)

All general terms, laboratory indicators and data qualifiers are defined on the Key for Tables found at the beginning of this section.

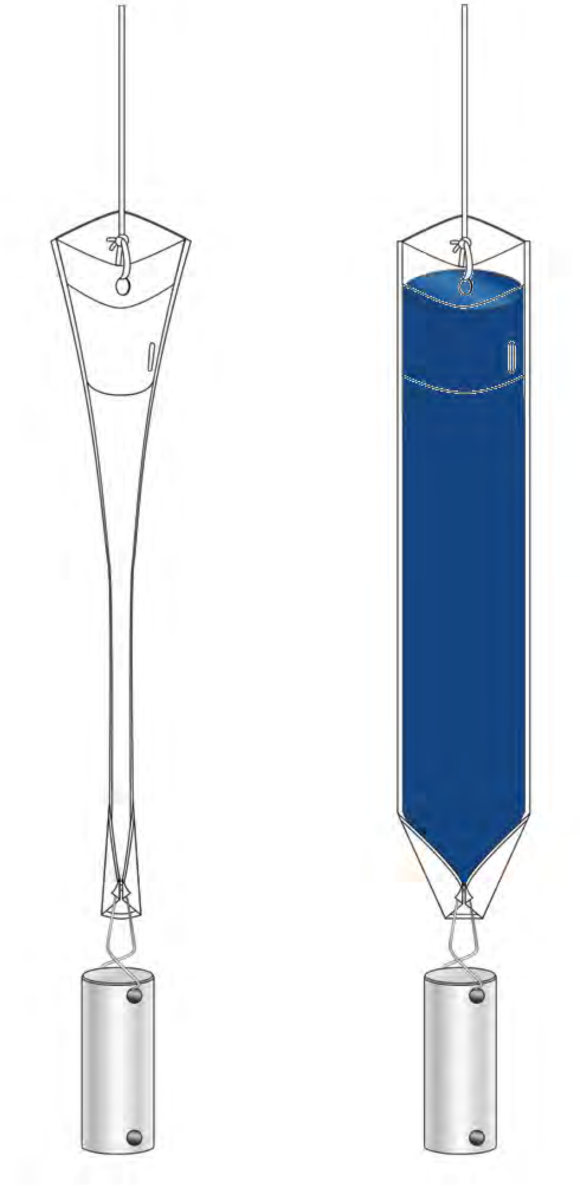
ATTACHMENT A

HYDRASLEEVE™
STANDARD OPERATING PROCEDURE:
SAMPLING GROUND WATER WITH A HYDRASLEEVE™

HYDRASleeve™

Simple by Design US Patent No. 6,481,300; No. 6,837,120 others pending

Standard Operating Procedure:
Sampling Ground Water with a HydraSleeve



This Guide should be used in addition to field manuals appropriate to sampling device (i.e., HydraSleeve or Super Sleeve).

Find the appropriate field manual on the HydraSleeve website at http://www.hydrasleeve.com.

For more information about the HydraSleeve, or if you have questions, contact:
GeoInsight, 2007 Glass Road, Las Cruces, NM 88005, 1-800-996-2225,
info@hydrasleeve.com.

Table of Contents

Introduction

The HydraSleeve is classified as a no-purge (passive) grab sampling device, meaning that it is used to collect ground-water samples directly from the screened interval of a well without having to purge the well prior to sample collection. When it is used as described in this Standard Operating Procedure (SOP), the HydraSleeve causes no drawdown in the well (until the sample is withdrawn from the water column) and only minimal disturbance of the water column, because it has a very thin cross section and it displaces very little water (<100 ml) during deployment in the well. The HydraSleeve collects a sample from within the screen only, and it excludes water from any other part of the water column in the well through the use of a self-sealing check valve at the top of the sampler. It is a single-use (disposable) sampler that is not intended for reuse, so there are no decontamination requirements for the sampler itself.

The use of no-purge sampling as a means of collecting representative ground-water samples depends on the natural movement of ground water (under ambient hydraulic head) from the formation adjacent to the well screen through the screen. Robin and Gillham (1987) demonstrated the existence of a dynamic equilibrium between the water in a formation and the water in a well screen installed in that formation, which results in formation-quality water being available in the well screen for sampling at all times. No-purge sampling devices like the HydraSleeve collect this formation-quality water as the sample, under undisturbed (non-pumping) natural flow conditions. Samples collected in this manner generally provide more conservative (i.e., higher concentration) values than samples collected using well-volume purging, and values equivalent to samples collected using low-flow purging and sampling (Parsons, 2005).

Applications of the HydraSleeve

The HydraSleeve can be used to collect representative samples of ground water for all analytes (volatile organic compounds [VOCs], semi-volatile organic compounds [SVOCs], common metals, trace metals, major cations and anions, dissolved gases, total dissolved solids, radionuclides, pesticides, PCBs, explosive compounds, and all other analytical parameters). Designs are available to collect samples from wells from 1” inside diameter and larger. The HydraSleeve can collect samples from wells of any yield, but it is especially well-suited to collecting samples from low-yield wells, where other sampling methods can’t be used reliably because their use results in dewatering of the well screen and alteration of sample chemistry (McAlary and Barker, 1987).

The HydraSleeve can collect samples from wells of any depth, and it can be used for single-event sampling or long-term ground-water monitoring programs. Because of its thin cross section and flexible construction, it can be used in narrow, constricted or damaged wells where rigid sampling devices may not fit. Using multiple HydraSleeves deployed in series along a single suspension line or tether, it is also possible to conduct in-well vertical profiling in wells in which contaminant concentrations are thought to be stratified.

As with all groundwater sampling devices, HydraSleeves should not be used to collect groundwater samples from wells in which separate (non-aqueous) phase hydrocarbons (i.e., gasoline, diesel fuel or jet fuel) are present because of the possibility of incorporating some of the separate-phase hydrocarbon into the sample.

Description of the HydraSleeve

The HydraSleeve (Figure 1) consists of the following basic components:

- A suspension line or tether (A.), attached to the spring clip or directly to the top of the sleeve to deploy the device into and recover the device from the well. Tethers with depth indicators marked in 1-foot intervals are available from the manufacturer.
- A long, flexible, 4-mil thick lay-flat polyethylene sample sleeve (C.) sealed at the bottom (this is the sample chamber), which comes in different sizes, as discussed below with a self-sealing reed-type flexible polyethylene check valve built into the top of the sleeve (B.) to prevent water from entering or exiting the sampler except during sample acquisition.
- A reusable stainless-steel weight with clip (D.), which is attached to the bottom of the sleeve to carry it down the well to its intended depth in the water column. Bottom weights available from the manufacturer are 0.75” OD and are available in three sizes: 5 oz. (2.5” long); 8 oz. (4” long); and 16 oz. (8” long). In lieu of a bottom weight, an optional top weight may be attached to the top of the HydraSleeve to carry it to depth and to compress it at the bottom of the well (not shown in Figure 1);
- A discharge tube that is used to puncture the HydraSleeve after it is recovered from the well so the sample can be decanted into sample bottles (not shown).
- Just above the self-sealing check valve at the top of the sleeve are two holes which provide attachment points for the spring clip and/or suspension line or tether. At the bottom of the sample sleeve are two holes which provide attachment points for the weight clip and weight.

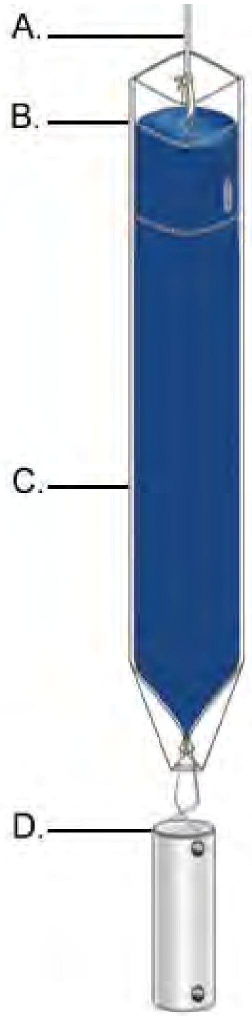


Figure 1. HydraSleeve components.

> **Note:** The sample sleeve and the discharge tube are designed for one-time use and are disposable. The spring clip, weight and weight clip may be reused after thorough cleaning. Suspension cord is generally disposed after one use although, if it is dedicated to the well, it may be reused at the discretion of the sampling personnel.

Selecting the HydraSleeve Size to Meet Site-Specific Sampling Objectives

It is important to understand that each HydraSleeve is able to collect a finite volume of sample because, after the HydraSleeve is deployed, you only get one chance to collect an undisturbed sample. Thus, the volume of sample required to meet your site-specific sampling and analytical requirements will dictate the size of HydraSleeve you need to meet these requirements.

The volume of sample collected by the HydraSleeve varies with the diameter and length of the HydraSleeve. Dimensions and volumes of available HydraSleeve models are detailed in Table 1.

Table 1. Dimensions and volumes of HydraSleeve models.

Diameter	Volume	Length	Lay-Flat Width	Filled Dia.
2-Inch HydraSleeves				
Standard 625-ml HydraSleeve	625 ml	< 30”	2.5”	1.4”
Standard 1-Liter HydraSleeve	1 Liter	38”	3”	1.9”
1-Liter HydraSleeve SS	1 Liter	36”	3”	1.9”
2-Liter HydraSleeve SS	2 Liters	60”	3”	1.9”
4-Inch HydraSleeves				
Standard 1.6-Liter HydraSleeve	1.6 Liters	30”	3.8”	2.3”
Custom 2-Liter HydraSleeve	2 Liters	36”	4”	2.7”

HydraSleeves can be custom-fabricated by the manufacturer in varying diameters and lengths to meet specific volume requirements. HydraSleeves can also be deployed in series (i.e., multiple HydraSleeves attached to one tether) to collect additional sample to meet specific volume requirements, as described below.

If you have questions regarding the availability of sufficient volume of sample to satisfy laboratory requirements for analysis, it is recommended that you contact the laboratory to discuss the minimum volumes needed for each suite of analytes. Laboratories often require only 10% to 25% of the volume they specify to complete analysis for specific suites of analytes, so they can often work with much smaller sample volumes that can easily be supplied by a HydraSleeve.

HydraSleeve Deployment

Information Required Before Deploying a HydraSleeve

Before installing a HydraSleeve in any well, you will need to know the following:

- The inside diameter of the well
- The length of the well screen
- The water level in the well
- The position of the well screen in the well
- The total depth of the well

The inside diameter of the well is used to determine the appropriate HydraSleeve diameter for use in the well. The other information is used to determine the proper placement of the HydraSleeve in the well to collect a representative sample from the screen (see HydraSleeve Placement, below), and to determine the appropriate length of tether to attach to the HydraSleeve to deploy it at the appropriate position in the well.

Most of this information (with the exception of the water level) should be available from the well log; if not, it will have to be collected by some other means. The inside diameter of the well can be measured at the top of the well casing, and the total depth of the well can be measured by sounding the bottom of the well with a weighted tape. The position and length of the well screen may have to be determined using a down-hole camera if a well log is not available. The water level in the well can be measured using any commonly available water-level gauge.

HydraSleeve Placement

The HydraSleeve is designed to collect a sample directly from the well screen, and it fills by pulling it up through the screen a distance equivalent to 1 to 1.5 times its length. This upward motion causes the top check valve to open, which allows the device to fill. To optimize sample recovery, it is recommended that the HydraSleeve be placed in the well so that the bottom weight rests on the bottom of the well and the top of the HydraSleeve is as close to the bottom of the well screen as possible. This should allow the sampler to fill before the top of the device reaches the top of the screen as it is pulled up through the water column, and ensure that only water from the screen is collected as the sample. In short-screen wells, or wells with a short water column, it may be necessary to use a top-weight on the HydraSleeve to compress it in the bottom of the well so that, when it is recovered, it has room to fill before it reaches the top of the screen.

Example

2" ID PVC well, 50' total depth, 10' screen at the bottom of the well, with water level above the screen (the entire screen contains water).

Correct Placement (figure 2): Using a standard HydraSleeve for a 2" well (2.6" flat width/1.5" filled OD x 30" long, 650 ml volume), deploy the sampler so the weight (an 8 oz., 4"-long weight with a 2"-long clip) rests at the bottom of the well. The top of the sleeve is thus set at about 36" above the bottom of the well. When the sampler is recovered, it will be pulled upward approximately 30" to 45" before it is filled; therefore, it is full (and the top check valve closes) at approximately 66" (5 ½ feet) to 81" (6 ¾ feet) above the bottom of the well, which is well before the sampler reaches the top of the screen. In this example, only water from the screen is collected as a sample.

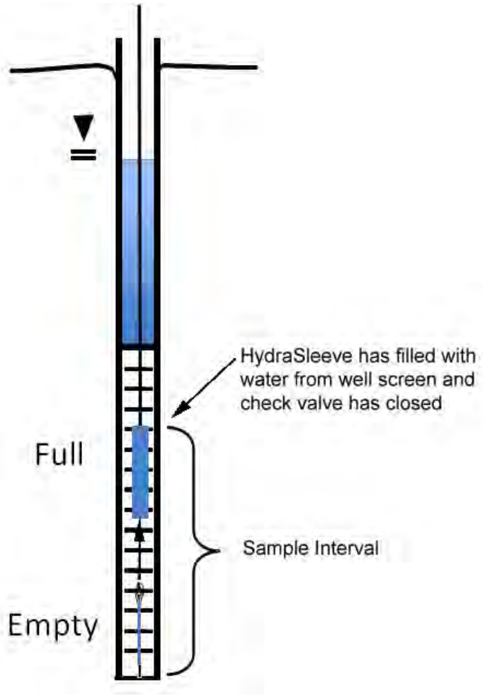


Figure 2. Correct placement of HydraSleeve.

Incorrect Placement (figure 3): If the well screen in this example was only 5' long, and the HydraSleeve was placed as above, it would not fill before the top of the device reached the top of the well screen, so the sample would include water from above the screen, which may not have the same chemistry.

The solution? Deploy the HydraSleeve with a top weight, so that it is collapsed to within 6" to 9" of the bottom of the well. When the HydraSleeve is recovered, it will fill within 39" (3 ¼ feet) to 54" (4 ½ feet) above the bottom of the well, or just before the sampler reaches the top of the screen, so it collects only water from the screen as the sample.

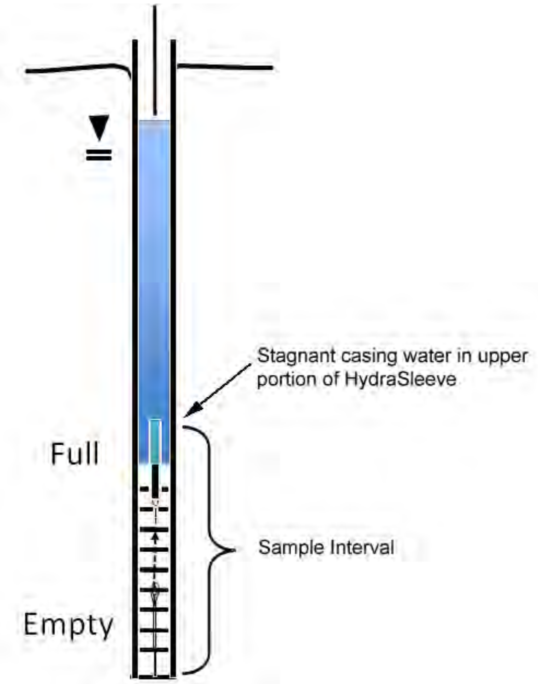


Figure 3. Incorrect placement of HydraSleeve.

This example illustrates one of many types of HydraSleeve placements. More complex placements are discussed in a later section.

Procedures for Sampling with the HydraSleeve

Collecting a ground-water sample with a HydraSleeve is a simple one-person operation.

Note: Before deploying the HydraSleeve in the well, collect the depth-to-water measurement that you will use to determine the preferred position of the HydraSleeve in the well. This measurement may also be used with measurements from other wells to create a ground-water contour map. If necessary, also measure the depth to the bottom of the well to verify actual well depth to confirm your decision on placement of the HydraSleeve in the water column.

Measure the correct amount of tether needed to suspend the HydraSleeve in the well so that the weight will rest on the bottom of the well (or at your preferred position in the well). Make sure to account for the need to leave a few feet of tether at the top of the well to allow recovery of the sleeve

Note: Always wear sterile gloves when handling and discharging the HydraSleeve.

I. Assembling the HydraSleeve

1. Remove the HydraSleeve from its packaging, unfold it, and hold it by its top.
2. Crimp the top of the HydraSleeve by folding the hard polyethylene reinforcing strips at the holes.
3. Attach the spring clip to the holes to ensure that the top will remain open until the sampler is retrieved.
4. Attach the tether to the spring clip by tying a knot in the tether.

Note: Alternatively, attach the tether to one (NOT both) of the holes at the top of the Hydrasleeve by tying a knot in the tether.

5. Fold the flaps with the two holes at the bottom of the HydraSleeve together and slide the weight clip through the holes.
6. Attach a weight to the bottom of the weight clip to ensure that the HydraSleeve will descend to the bottom of the well.

II. Deploying the HydraSleeve

1. Using the tether, carefully lower the HydraSleeve to the bottom of the well, or to your preferred depth in the water column

   During installation, hydrostatic pressure in the water column will keep the self-sealing check valve at the top of the HydraSleeve closed, and ensure that it retains its flat, empty profile for an indefinite period prior to recovery.

Note: Make sure that it is not pulled upward at any time during its descent. If the HydraSleeve is pulled upward at a rate greater than 0.5'/second at any time prior to recovery, the top check valve will open and water will enter the HydraSleeve prematurely.

2. Secure the tether at the top of the well by placing the well cap on the top of the well casing and over the tether.

Note: Alternatively, you can tie the tether to a hook on the bottom of the well cap (you will need to leave a few inches of slack in the line to avoid pulling the sampler up as the cap is removed at the next sampling event).

III. Equilibrating the Well

The equilibration time is the time it takes for conditions in the water column (primarily flow dynamics and contaminant distribution) to restabilize after vertical mixing occurs (caused by installation of a sampling device in the well).

- Situation: The HydraSleeve is deployed for the first time or for only one time in a well

  The HydraSleeve is very thin in cross section and displaces very little water (<100 ml) during deployment so, unlike most other sampling devices, it does not disturb the water column to the point at which long equilibration times are necessary to ensure recovery of a representative sample.

  In most cases, the HydraSleeve can be recovered immediately (with no equilibration time) or within a few hours. In regulatory jurisdictions that impose specific requirements for equilibration times prior to recovery of no-purge sampling devices, these requirements should be followed.

- Situation: The HydraSleeve is being deployed for recovery during a future sampling event

  In periodic (i.e., quarterly or semi-annual) sampling programs, the sampler for the current sampling event can be recovered and a new sampler (for the next sampling event) deployed immediately thereafter, so the new sampler remains in the well until the next sampling event.

Thus, a long equilibration time is ensured and, at the next sampling event, the sampler can be recovered immediately. This means that separate mobilizations, to deploy and then to recover the sampler, are not required. HydraSleeves can be left in a well for an indefinite period of time without concern.

IV. HydraSleeve Recovery and Sample Collection

1. Hold on to the tether while removing the well cap.

2. Secure the tether at the top of the well while maintaining tension on the tether (but without pulling the tether upwards)

3. Measure the water level in the well.

4. In one smooth motion, pull the tether up between 30” to 45” (36” to 54” for the longer HydraSleeve) at a rate of about 1’ per second (or faster).

   The motion will open the top check valve and allow the HydraSleeve to fill (it should fill in about 1 to 1.5 times the length of the HydraSleeve). This is analogous to coring the water column in the well from the bottom up.

   When the HydraSleeve is full, the top check valve will close. You should begin to feel the weight of the HydraSleeve on the tether and it will begin to displace water. The closed check valve prevents loss of sample and entry of water from zones above the well screen as the HydraSleeve is recovered.

5. Continue pulling the tether upward until the HydraSleeve is at the top of the well.

6. Decant and discard the small volume of water trapped in the Hydrasleeve above the check valve by turning the sleeve over.

V. Sample Collection

Note: Sample collection should be done immediately after the HydraSleeve has been brought to the surface to preserve sample integrity.

1. Remove the discharge tube from its sleeve.

2. Hold the HydraSleeve at the check valve.

3. Puncture the HydraSleeve just below the check valve with the pointed end of the discharge tube

4. Discharge water from the HydraSleeve into your sample containers.

Control the discharge from the HydraSleeve by either raising the bottom of the sleeve, by squeezing it like a tube of toothpaste, or both.

5. Continue filling sample containers until all are full.

Measurement of Field Indicator Parameters

Field indicator parameter measurement is generally done during well purging and sampling to confirm when parameters are stable and sampling can begin. Because no-purge sampling does not require purging, field indicator parameter measurement is not necessary for the purpose of confirming when purging is complete.

If field indicator parameter measurement is required to meet a specific non-purging regulatory requirement, it can be done by taking measurements from water within a HydraSleeve that is not used for collecting a sample to submit for laboratory analysis (i.e., a second HydraSleeve installed in conjunction with the primary sample collection HydraSleeve [see Multiple Sampler Deployment below]).

Alternate Deployment Strategies

Deployment in Wells with Limited Water Columns

For wells in which only a limited water column exists to be sampled, the HydraSleeve can be deployed with an optional top weight instead of a bottom weight, which collapses the HydraSleeve to a very short (approximately 6” to 9”) length, and allows the HydraSleeve to fill in a water column only 36” to 45” in height.

Multiple Sampler Deployment

Multiple sampler deployment in a single well screen can accomplish two purposes:

- It can collect additional sample volume to satisfy site or laboratory-specific sample volume requirements.
- It can accommodate the need for collecting field indicator parameter measurements.
- It can be used to collect samples from multiple intervals in the screen to allow identification of possible contaminant stratification.

It is possible to use up to 3 standard 30” HydraSleeves deployed in series along a single tether to collect samples from a 10’ long well screen without collecting water from the interval above the screen.

The samplers must be attached to the tether at both the top and bottom of the sleeve. Attach the tether at the top with a stainless-steel clip (available from the manufacturer). Attach the tether at the bottom using a cable tie. The samplers must be attached as follows (figure 4):

- The first (attached to the tether as described above, with the weight at the bottom) at the bottom of the screen
- The second attached immediately above the first
- The third (attached the same as the second) immediately above the second

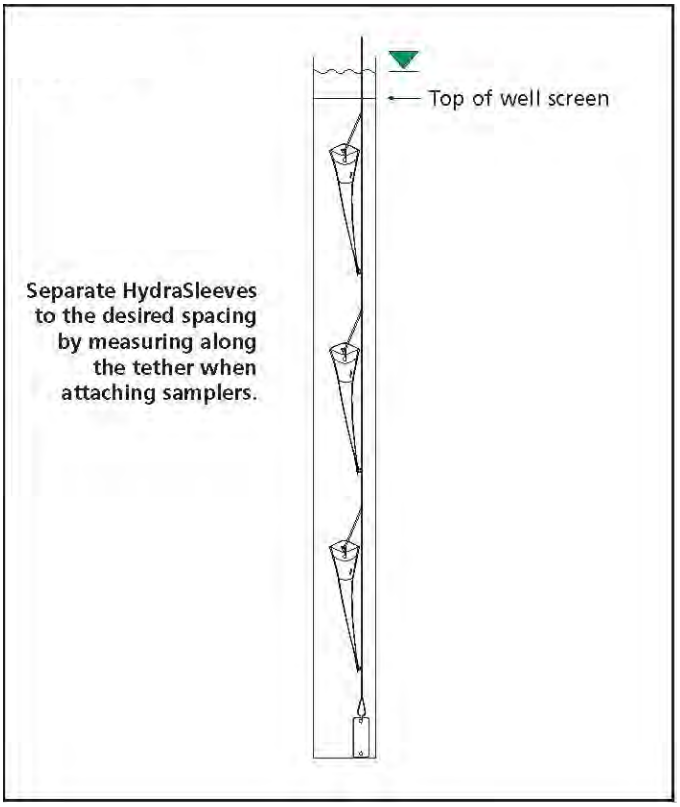


Figure 4. Multiple HydraSleeve deployment.

Alternately, the first sampler can be attached to the tether as described above, a second attached to the bottom of the first using a short length of tether (in place of the weight), and the third attached to the bottom of the second in the same manner, with the weight attached to the bottom of the third sampler (figure 5).

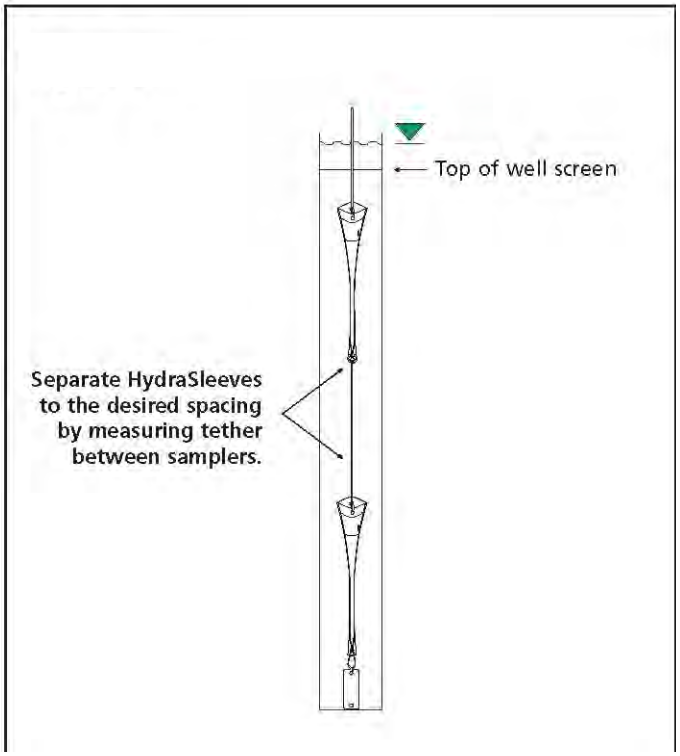


Figure 5. Alternative method for deploying multiple HydraSleeves.

In either case, when attaching multiple HydraSleeves in series, more weight may be required to hold the samplers in place in the well than would be required with a single sampler. Recovery of multiple samplers and collection of samples is done in the same manner as for single sampler deployments.

Post-Sampling Activities

The recovered HydraSleeve and the sample discharge tubing should be disposed as per the solid waste management plan for the site. To prepare for the next sampling event, a new HydraSleeve can be deployed in the well (as described previously) and left in the well until the next sampling event, at which time it can be recovered.

The weight and weight clip can be reused on this sampler after they have been thoroughly cleaned as per the site equipment decontamination plan. The tether may be dedicated to the well and reused or discarded at the discretion of sampling personnel.

References

McAlary, T. A. and J. F. Barker, 1987, Volatilization Losses of Organics During Ground-Water Sampling From Low-Permeability Materials, Ground-Water Monitoring Review, Vol. 7, No. 4, pp. 63-68

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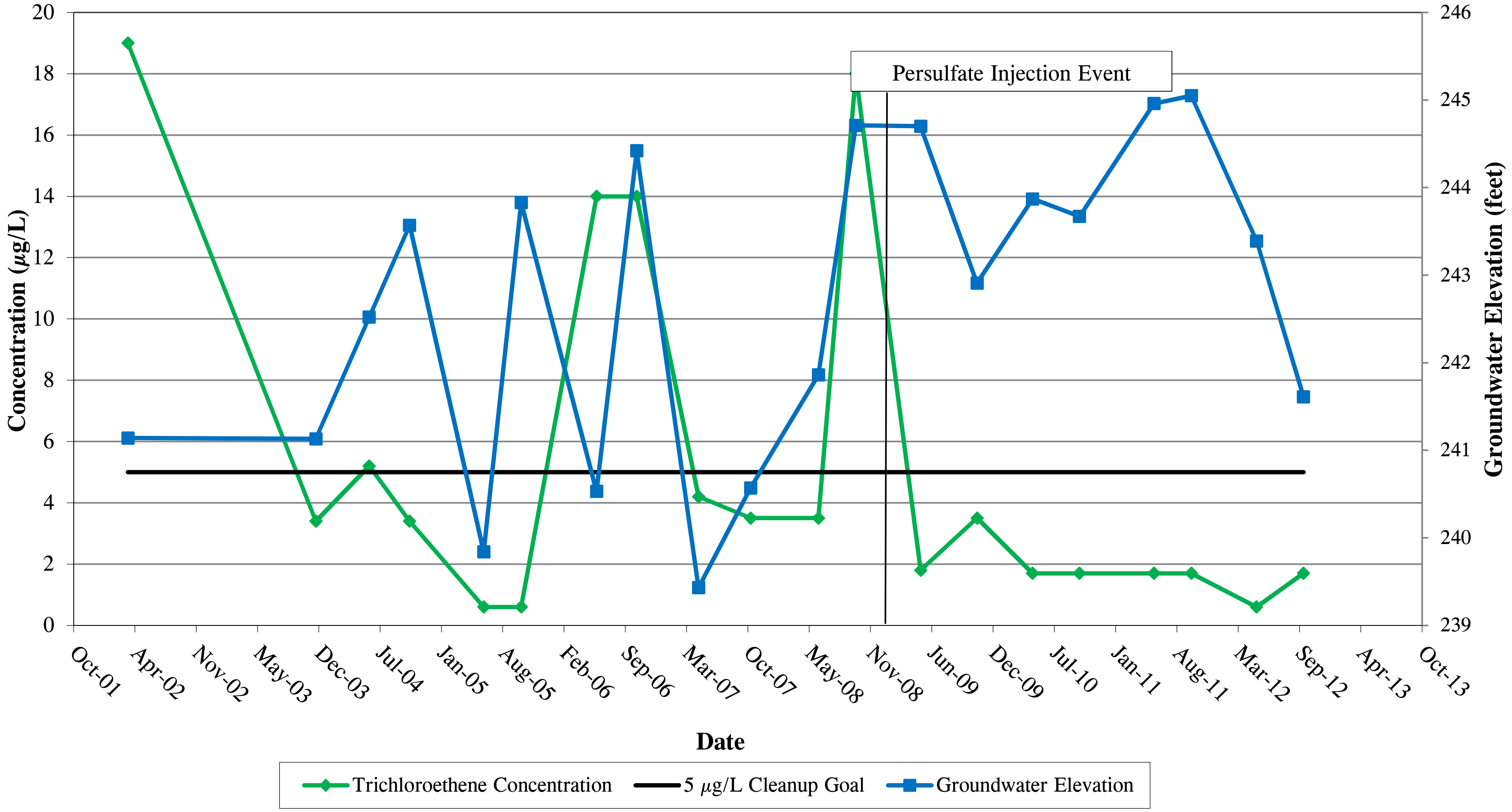
Robin, M. J. L. and R. W. Gillham, 1987, Field Evaluation of Well Purging Procedures, Ground-Water Monitoring Review, Vol. 7, No. 4, pp. 85-93

ATTACHMENT B

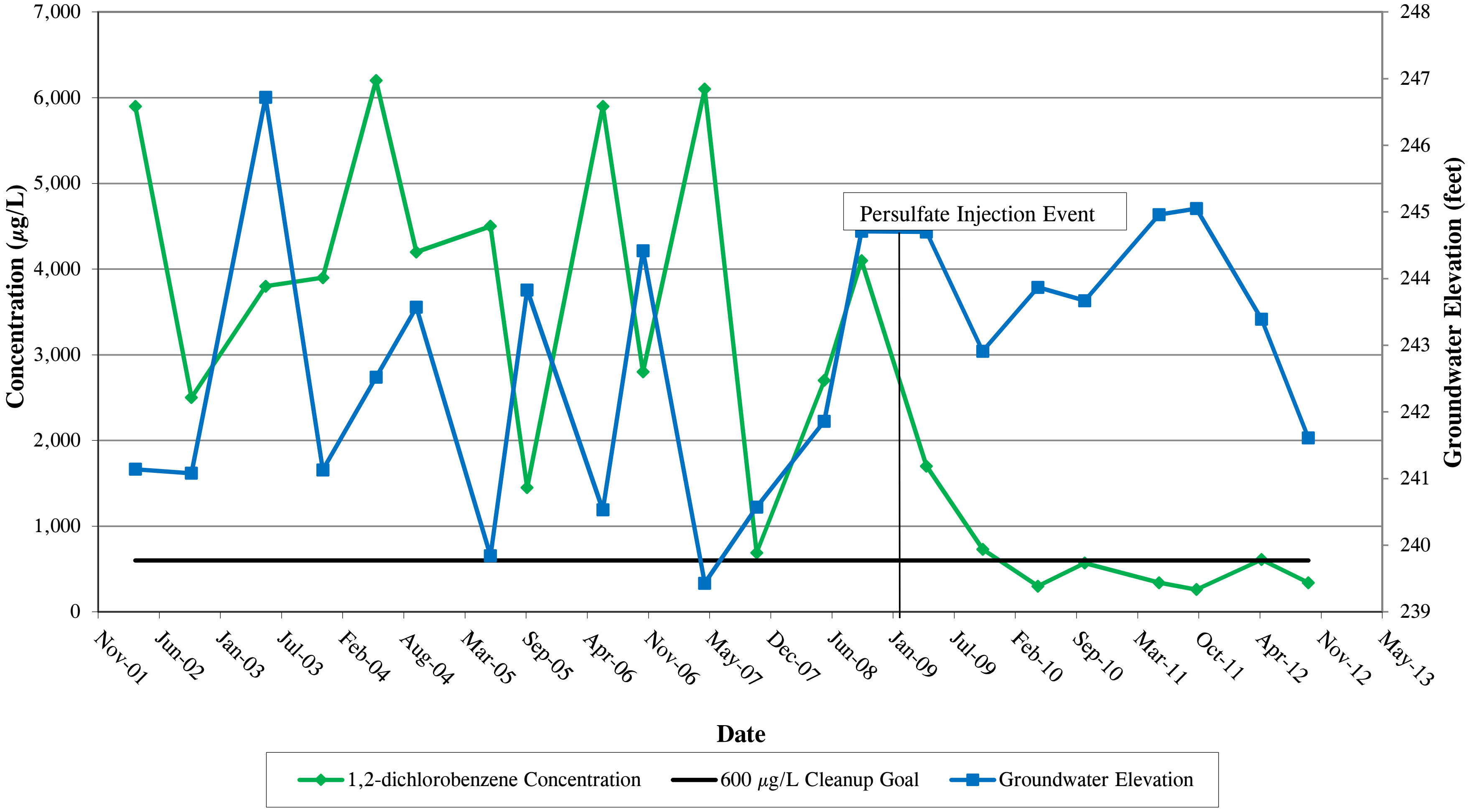
HYDROGRAPHS
OF GROUNDWATER ELEVATION DATA
AND ANALYTE CONCENTRATIONS
VERSUS TIME/LONG-TERM TREND GRAPHS

AOCs 32 and 43A

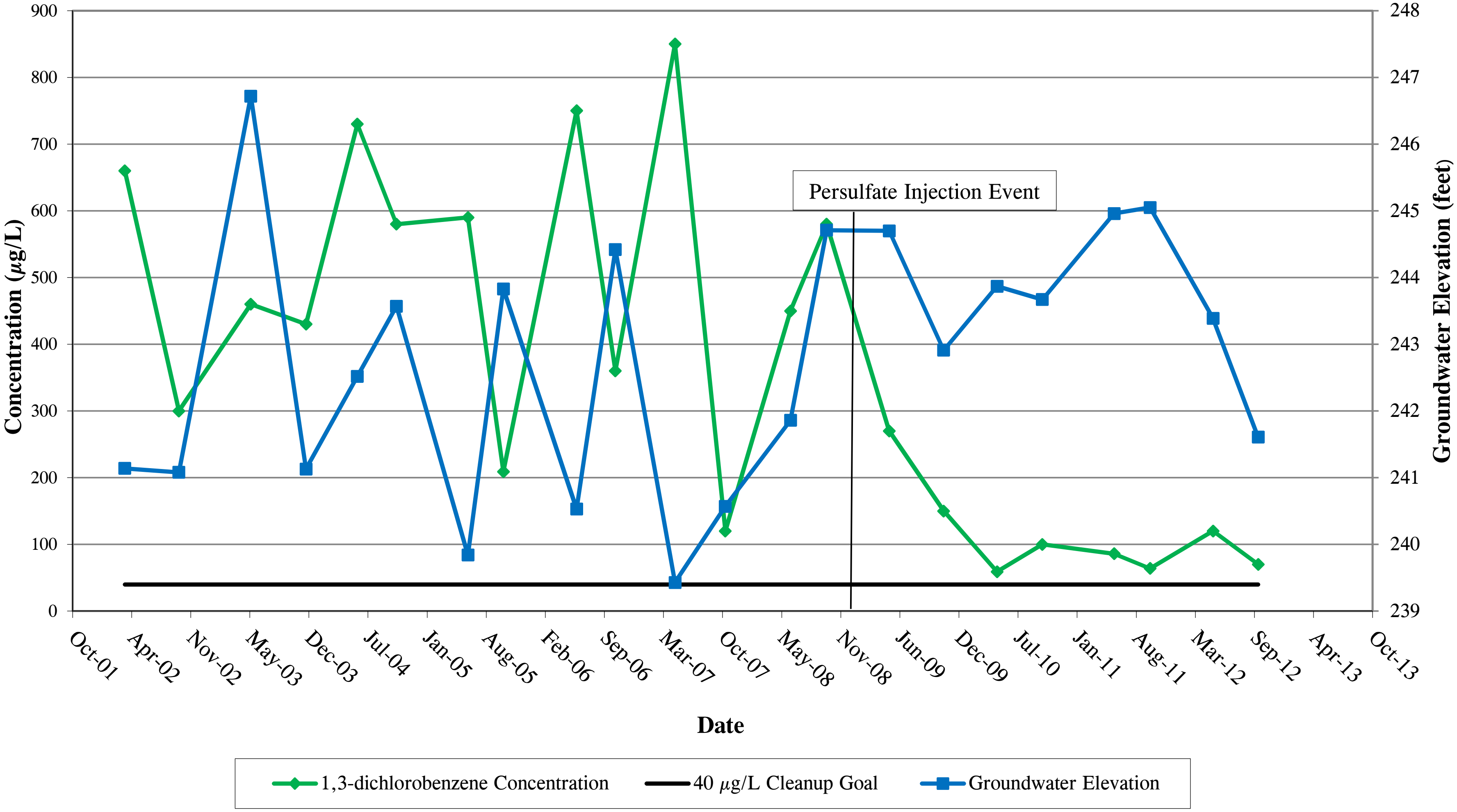
Groundwater Elevation and Analyte Concentrations
Trichloroethene
Areas of Contamination 32 and 43A
Well 32M-01-18XBR



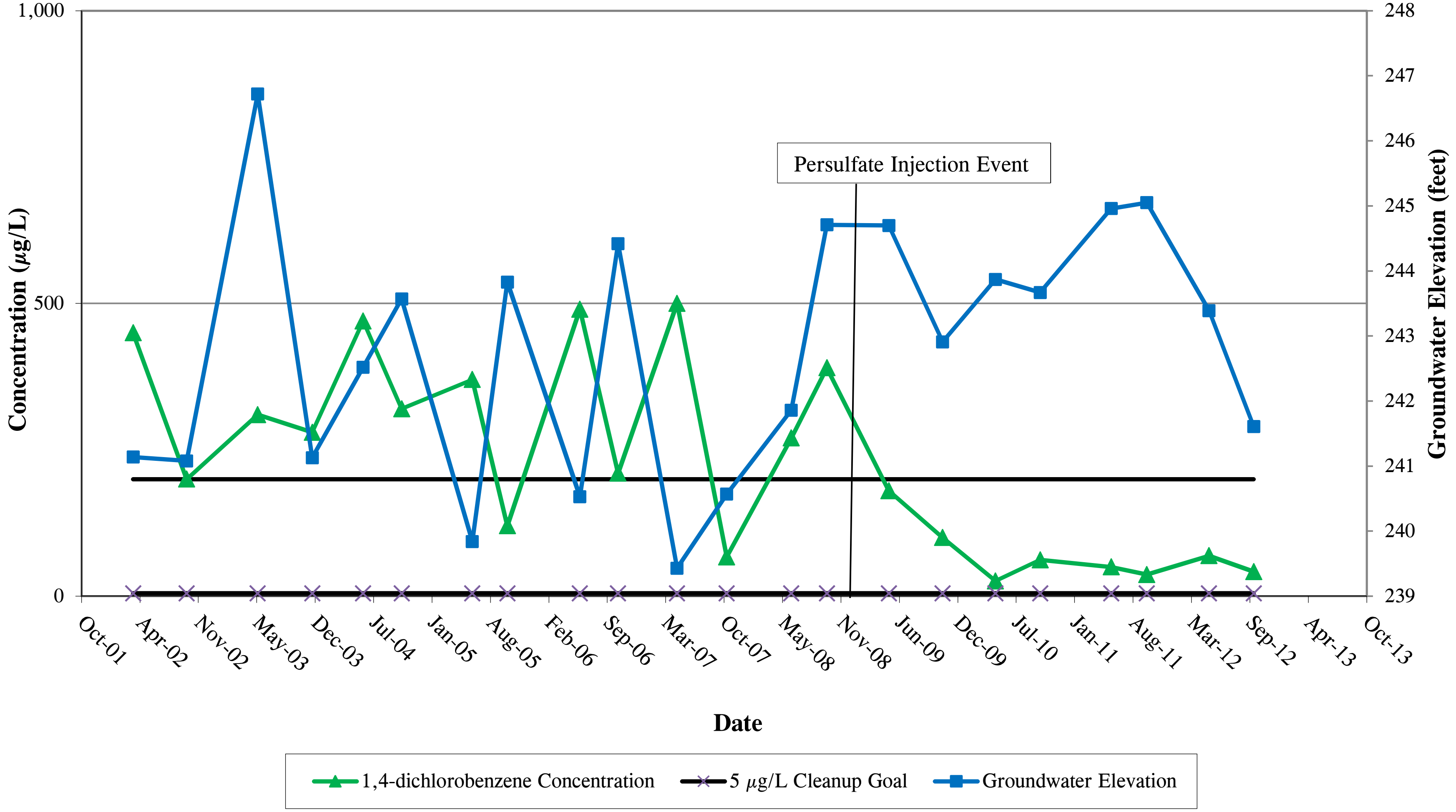
Groundwater Elevation and Analyte Concentrations
1,2-Dichlorobenzene
Areas of Contamination 32 and 43A
Well 32M-01-18XBR



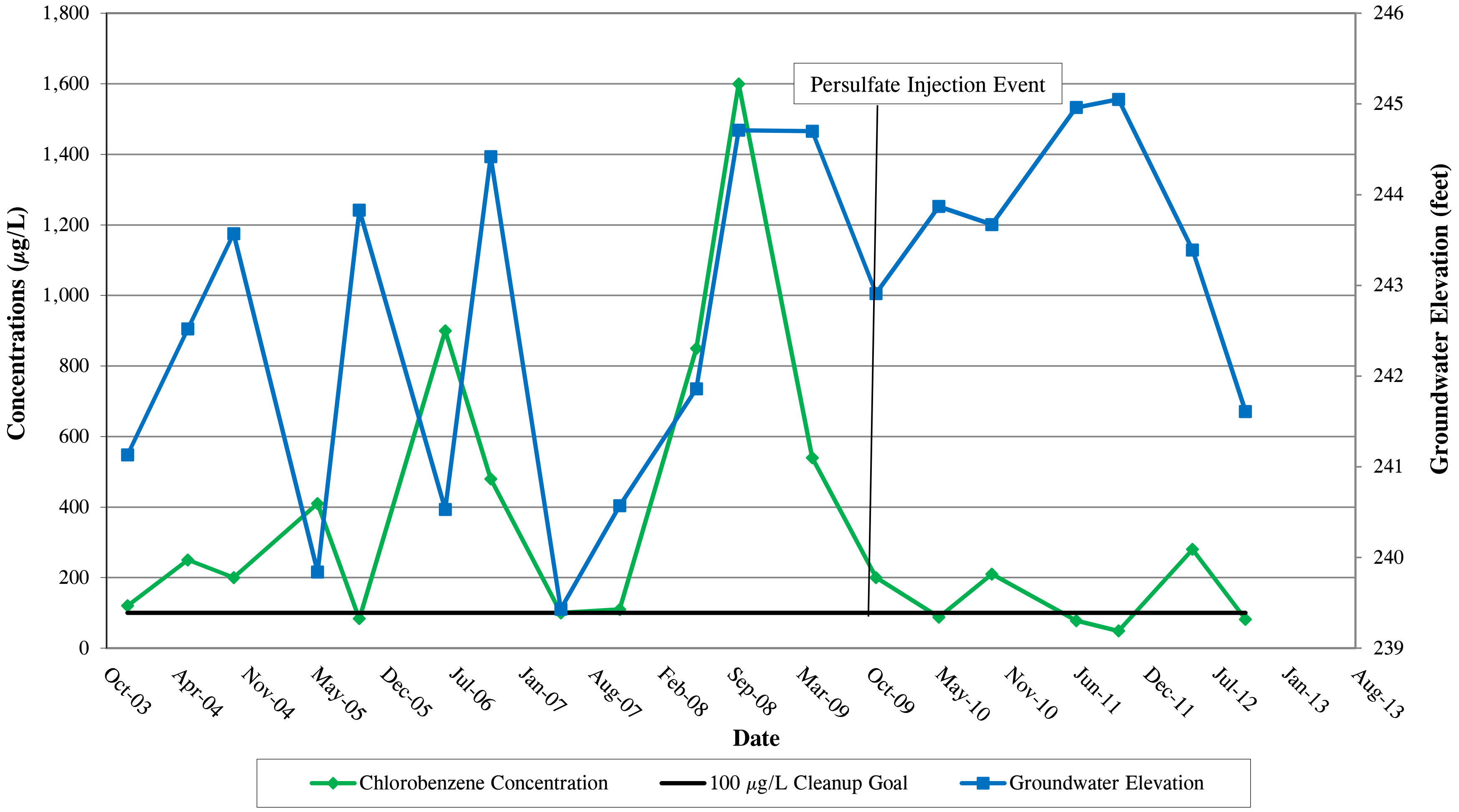
Groundwater Elevation and Analyte Concentrations
1,3-Dichlorobenzene
Areas of Contamination 32 and 43A
Well 32M-01-18XBR



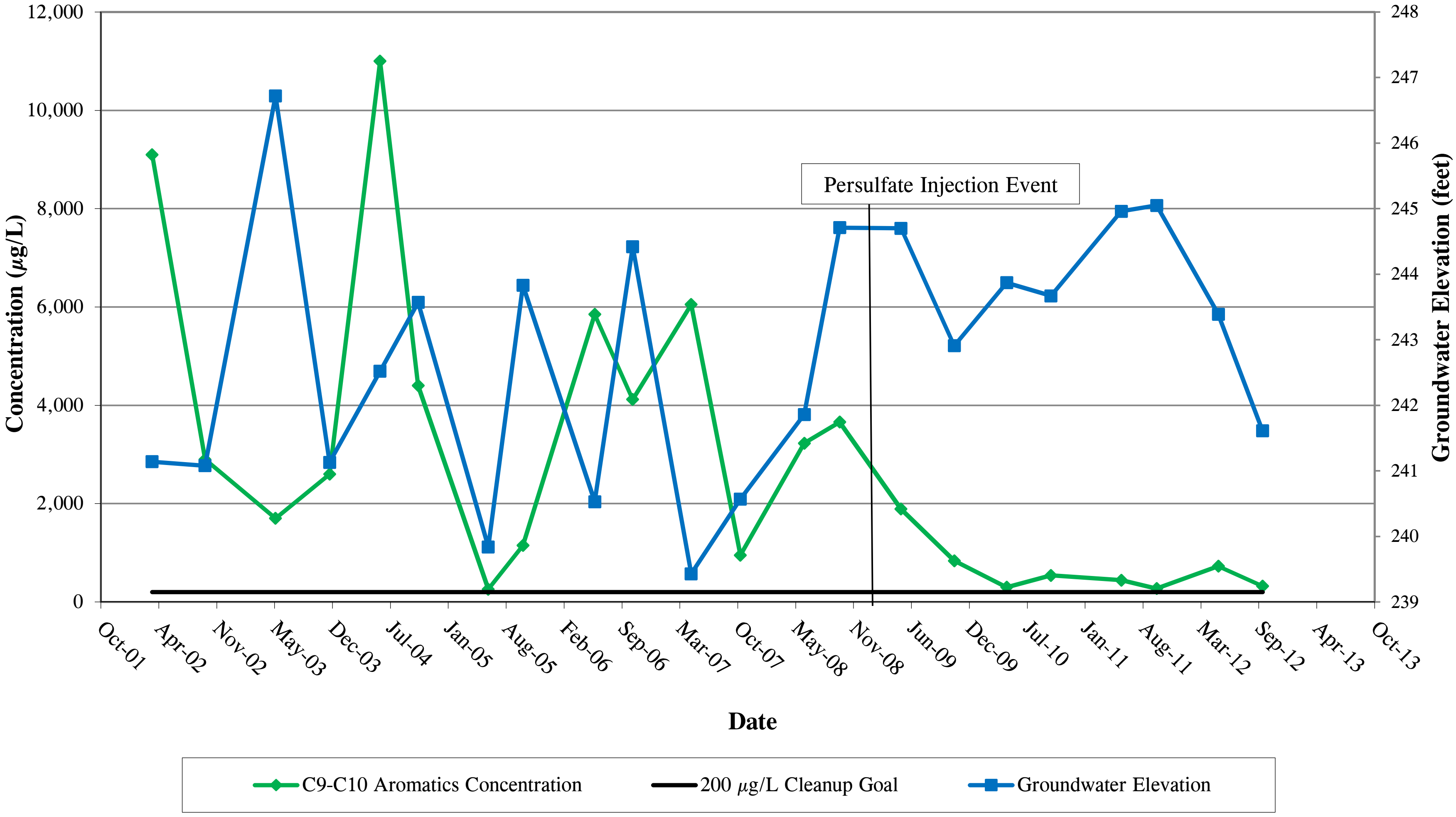
Groundwater Elevation and Analyte Concentrations
1,4-Dichlorobenzene
Area of Contamination 32 and 43A
Well 32M-01-18XBR



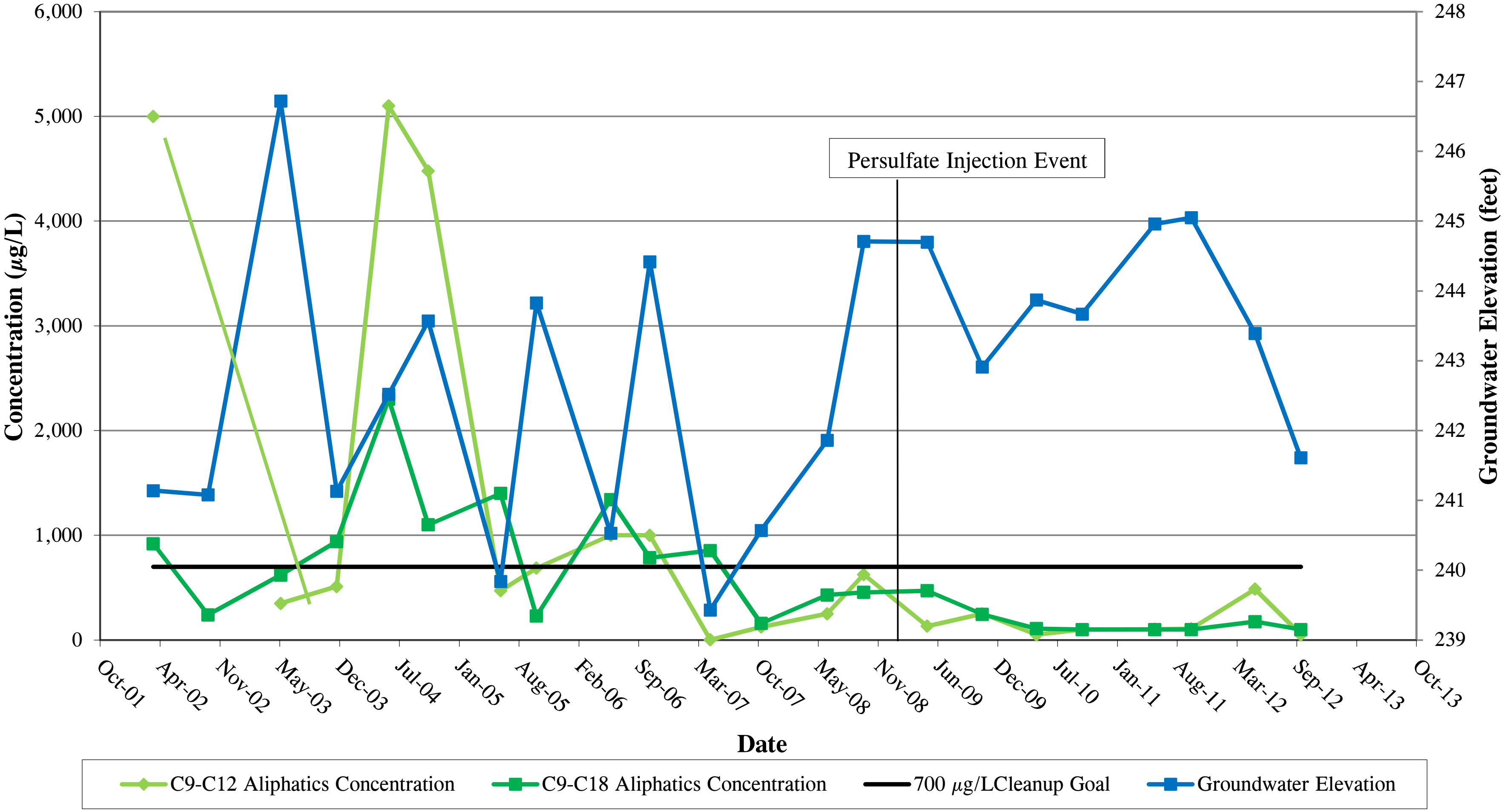
Groundwater Elevation and Analyte Concentrations
Chlorobenzene
Areas of Contamination 32 and 43A
Well 32M-01-18XBR



Groundwater Elevation and Analyte Concentrations
C_9-C_{10} Aromatics
Area of Contamination 32 and 43A
Well 32M-01-18XBR

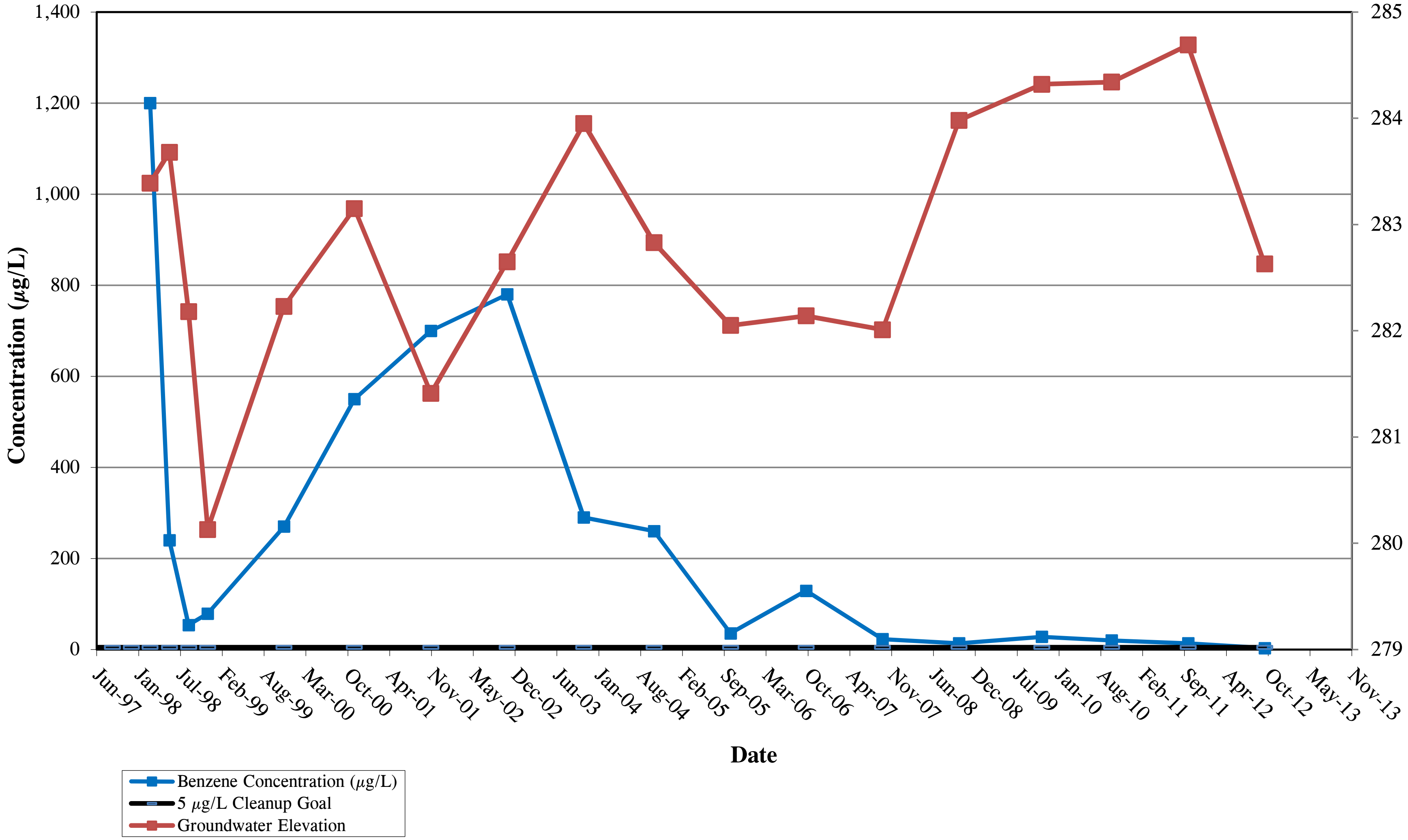


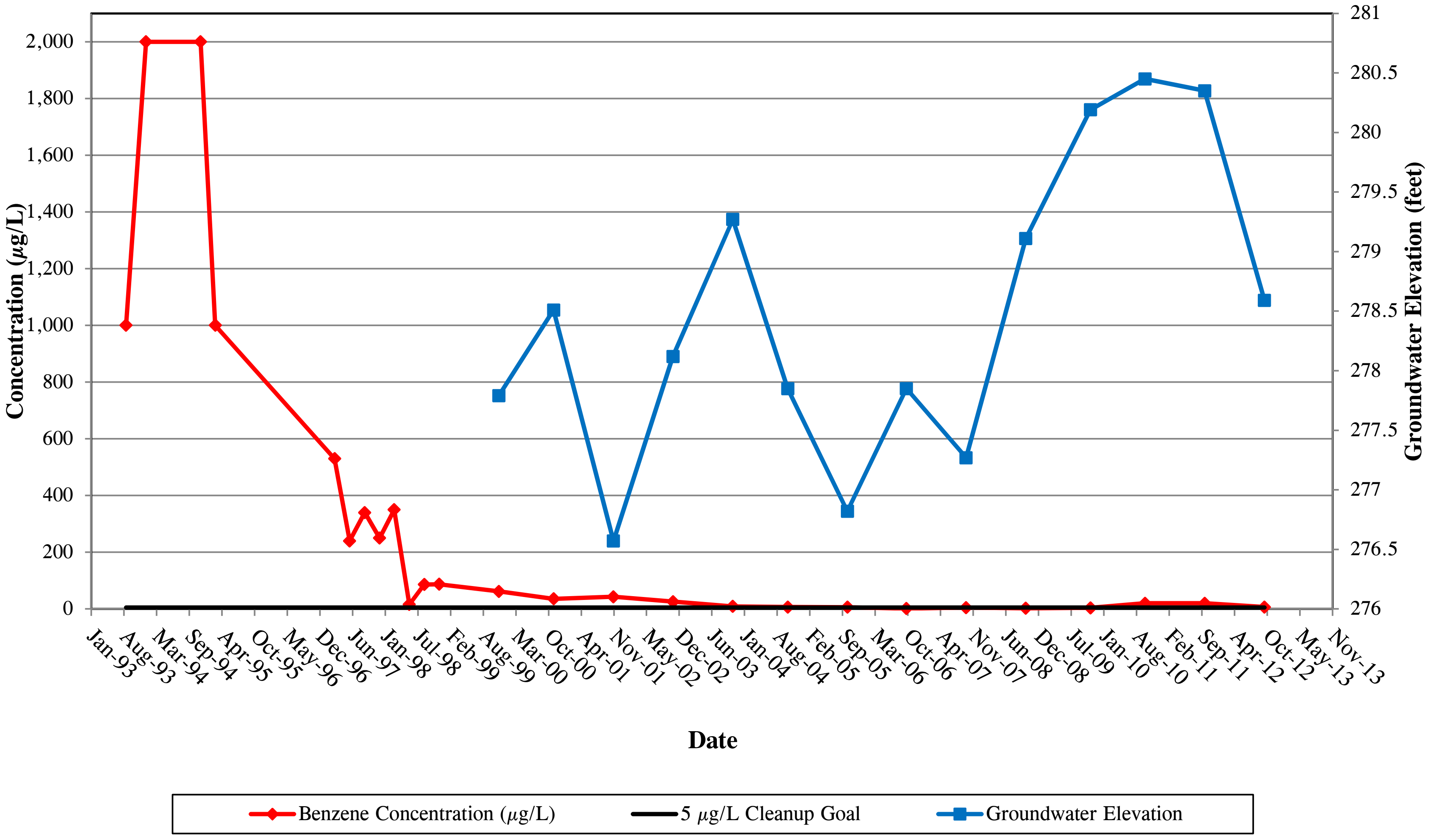
Groundwater Elevation and Analyte Concentrations
C_9-C_{12} (VPH) and C_9-C_{18} Aliphatics (EPH)
Areas of Contamination 32 and 43A
Well 32M-01-18XBR



AOC 43G

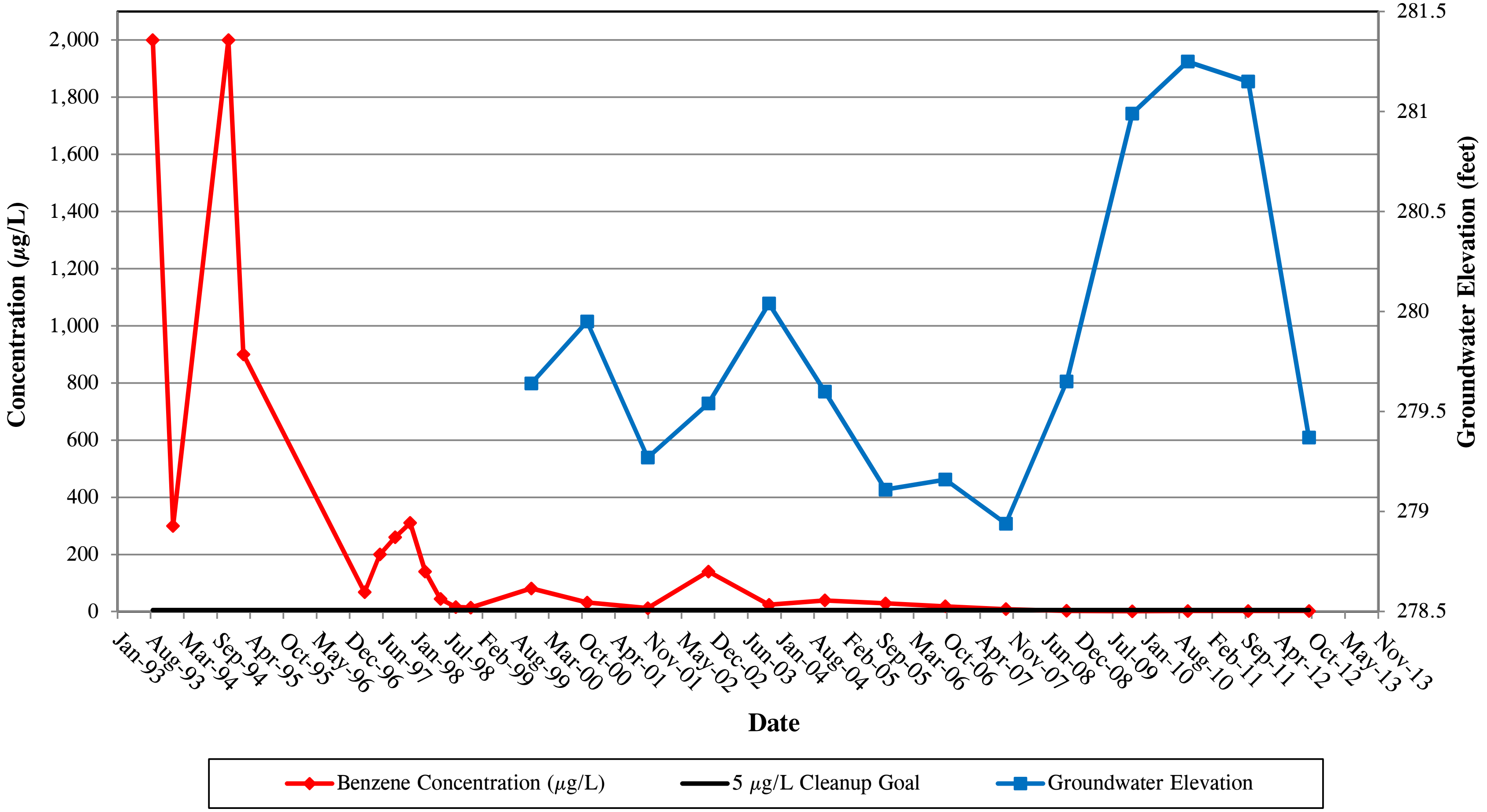
Groundwater Elevation and Analyte Concentrations
Benzene
Area of Contamination 43G
XGM-97-12X



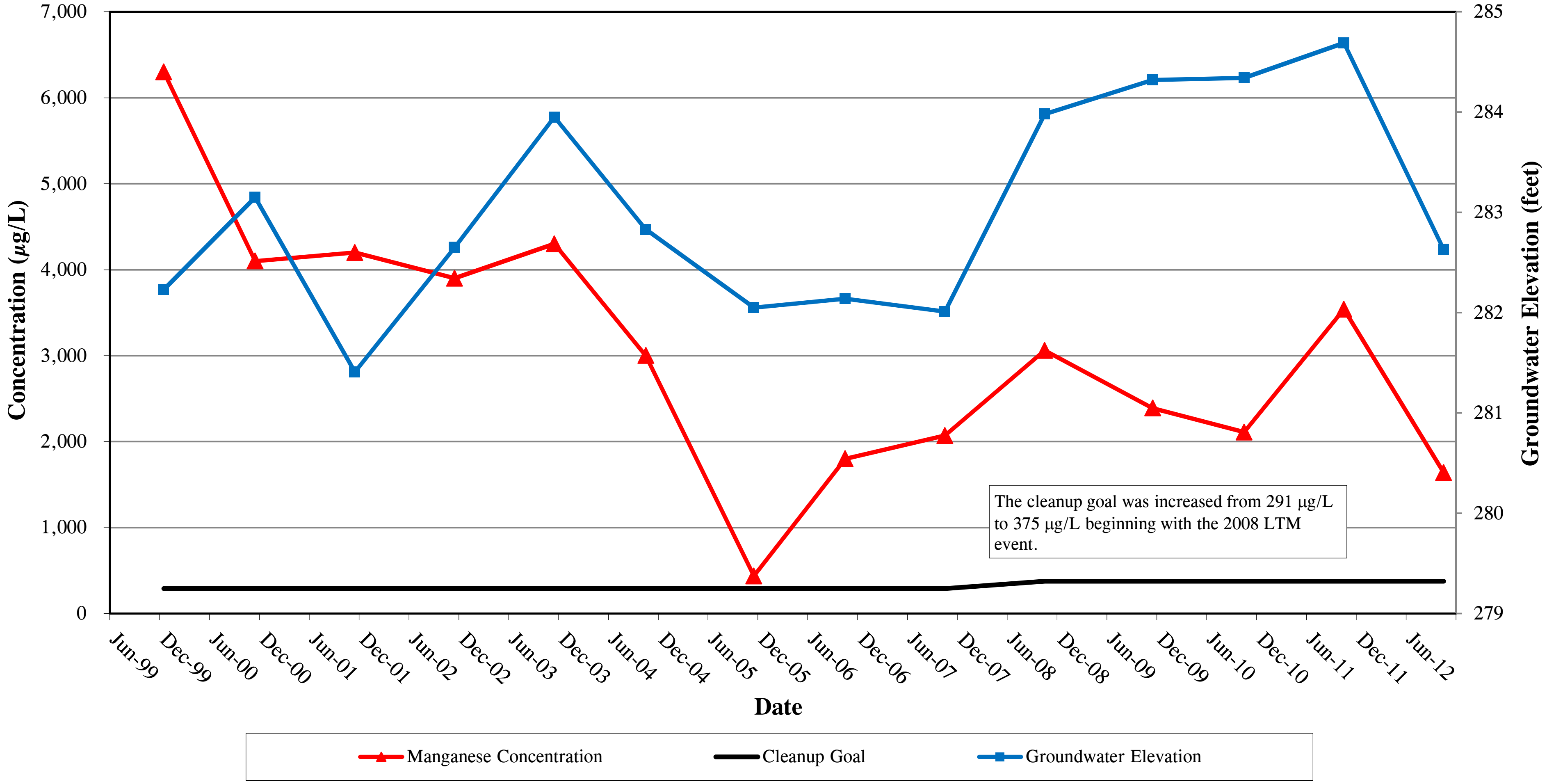


Groundwater Elevation and Analyte Concentrations
Benzene
Area of Contamination 43G
AAFES-2

Groundwater Elevation and Analyte Concentrations
Benzene
Area of Contamination 43G
XGM-93-02X



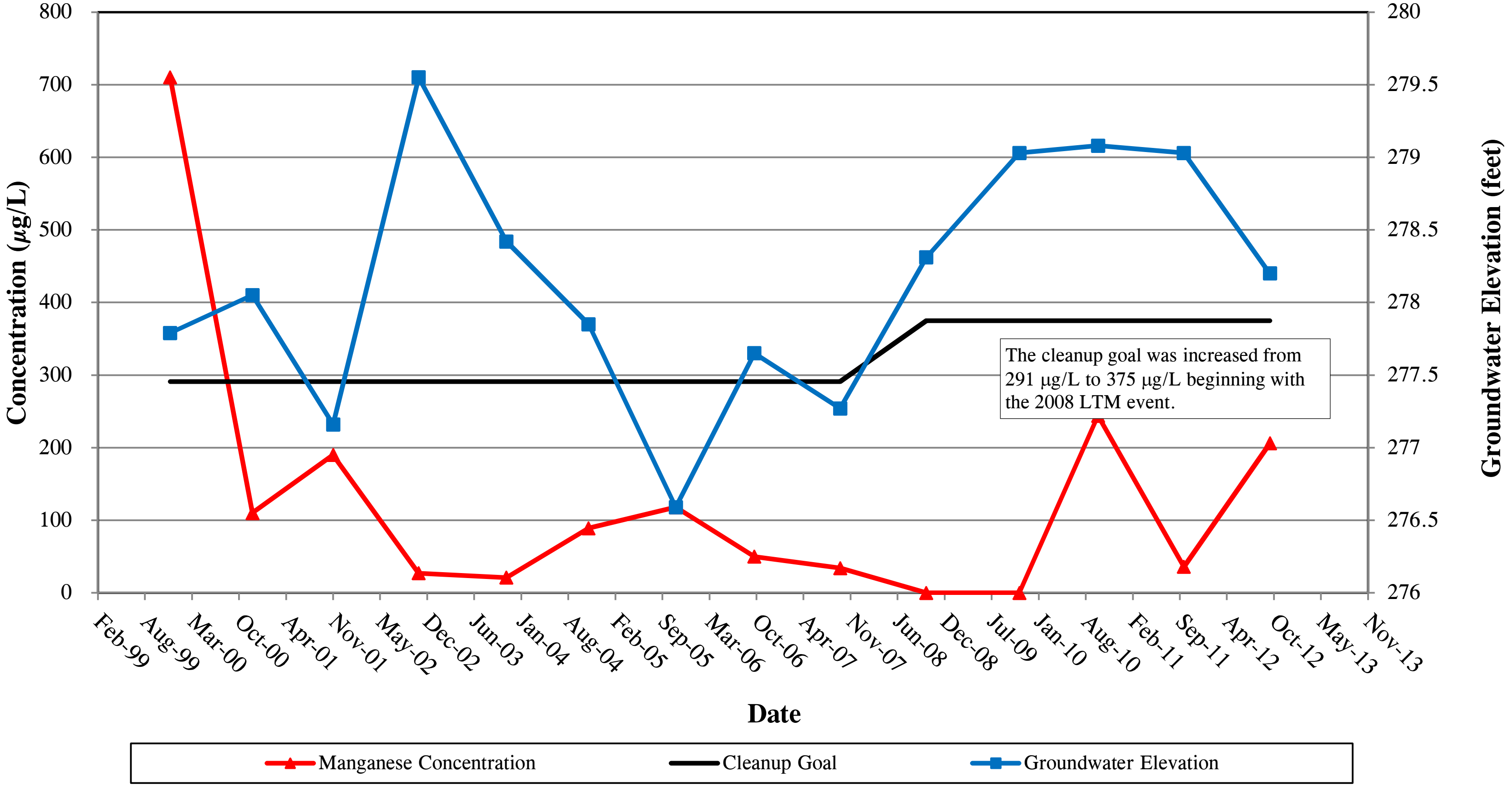
Groundwater Elevation and Analyte Concentrations
Manganese
Area of Contamination 43G
XGM-97-12X



The cleanup goal was increased from 291 µg/L to 375 µg/L beginning with the 2008 LTM event.

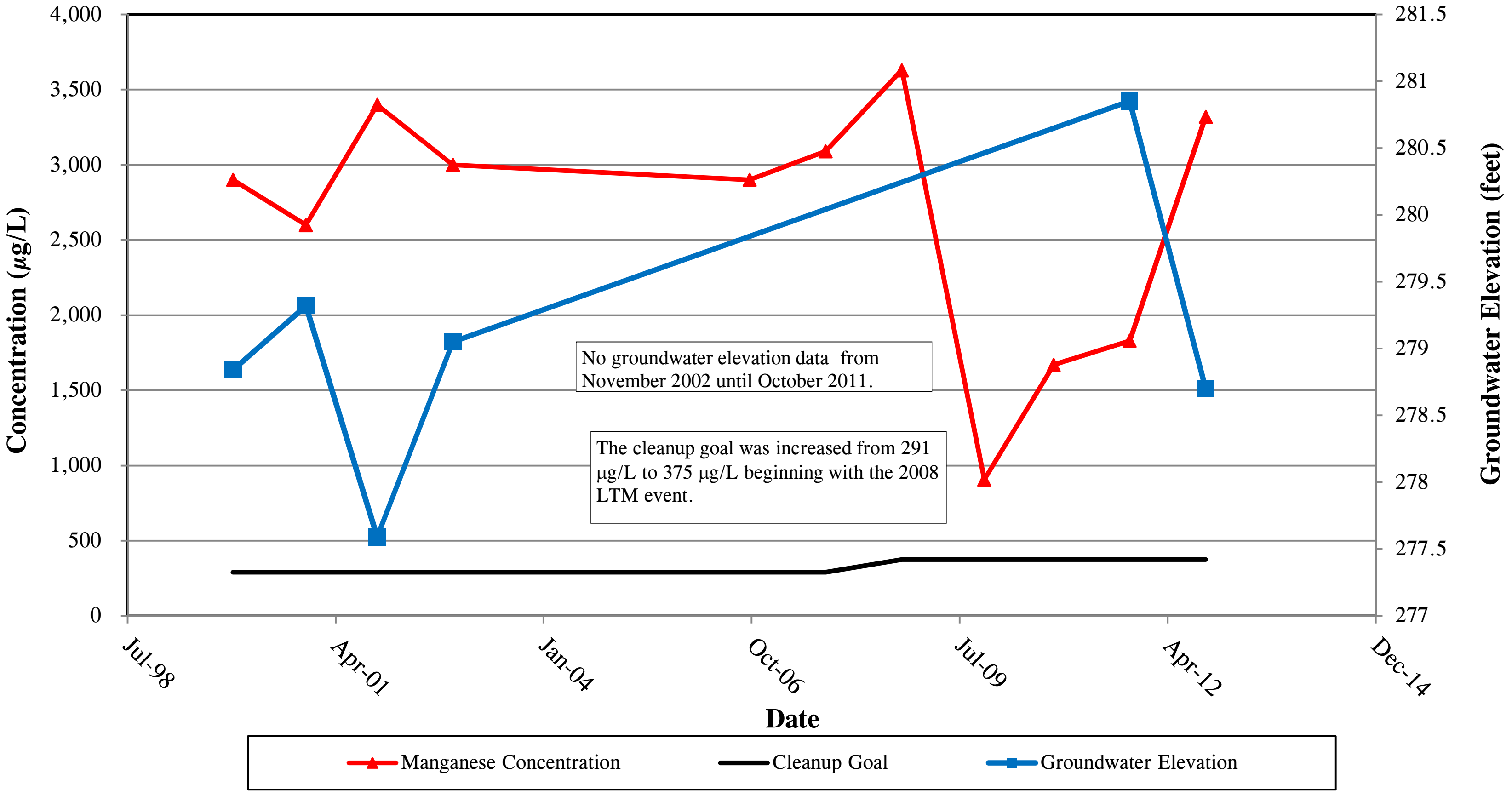
AAFES-6R was installed in January 2006 to replace well AAFES-6.

Groundwater Elevation and Analyte Concentrations
Manganese
Area of Contamination 43G
AAFES-05

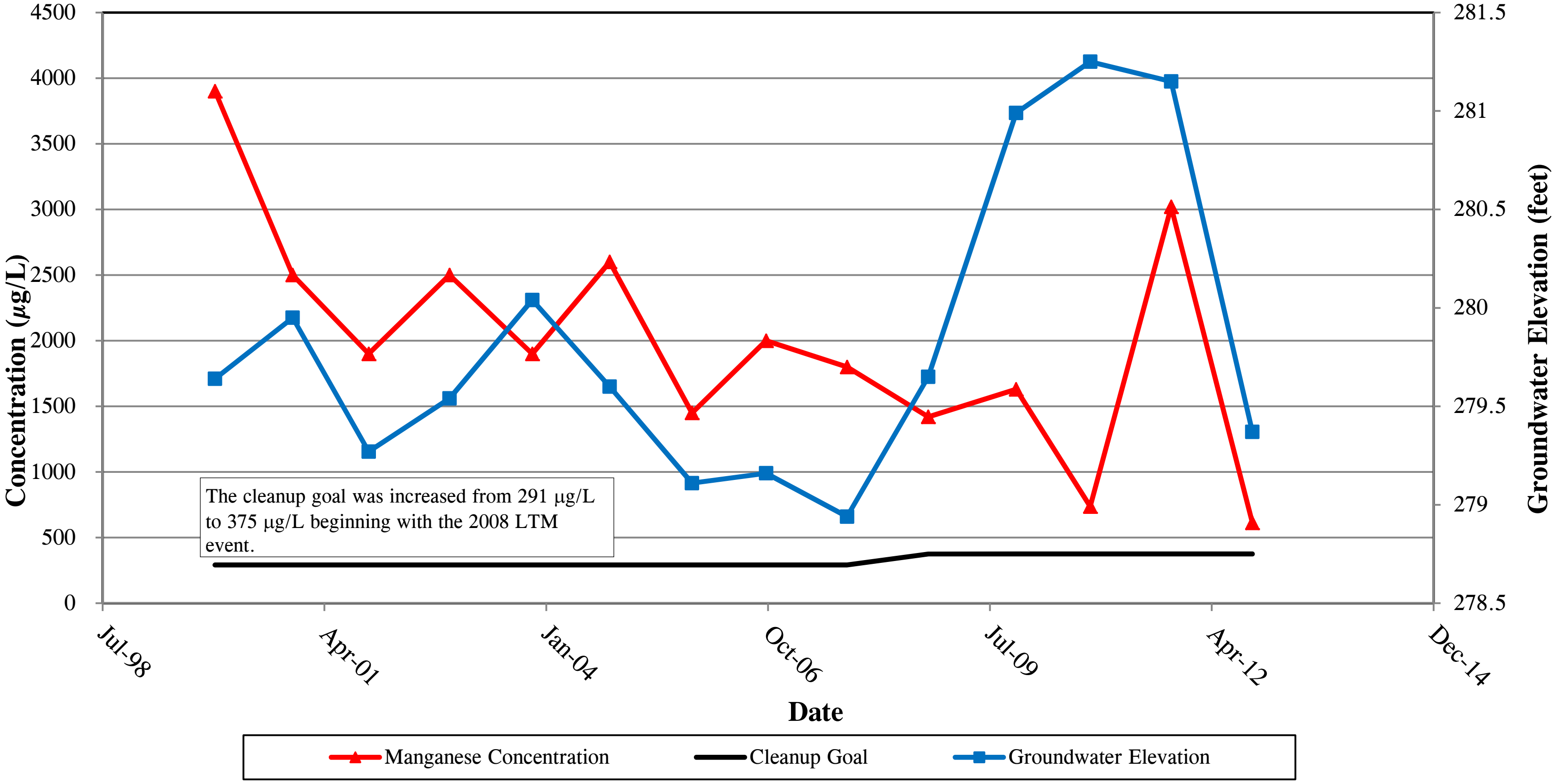


The cleanup goal was increased from 291 µg/L to 375 µg/L beginning with the 2008 LTM event.

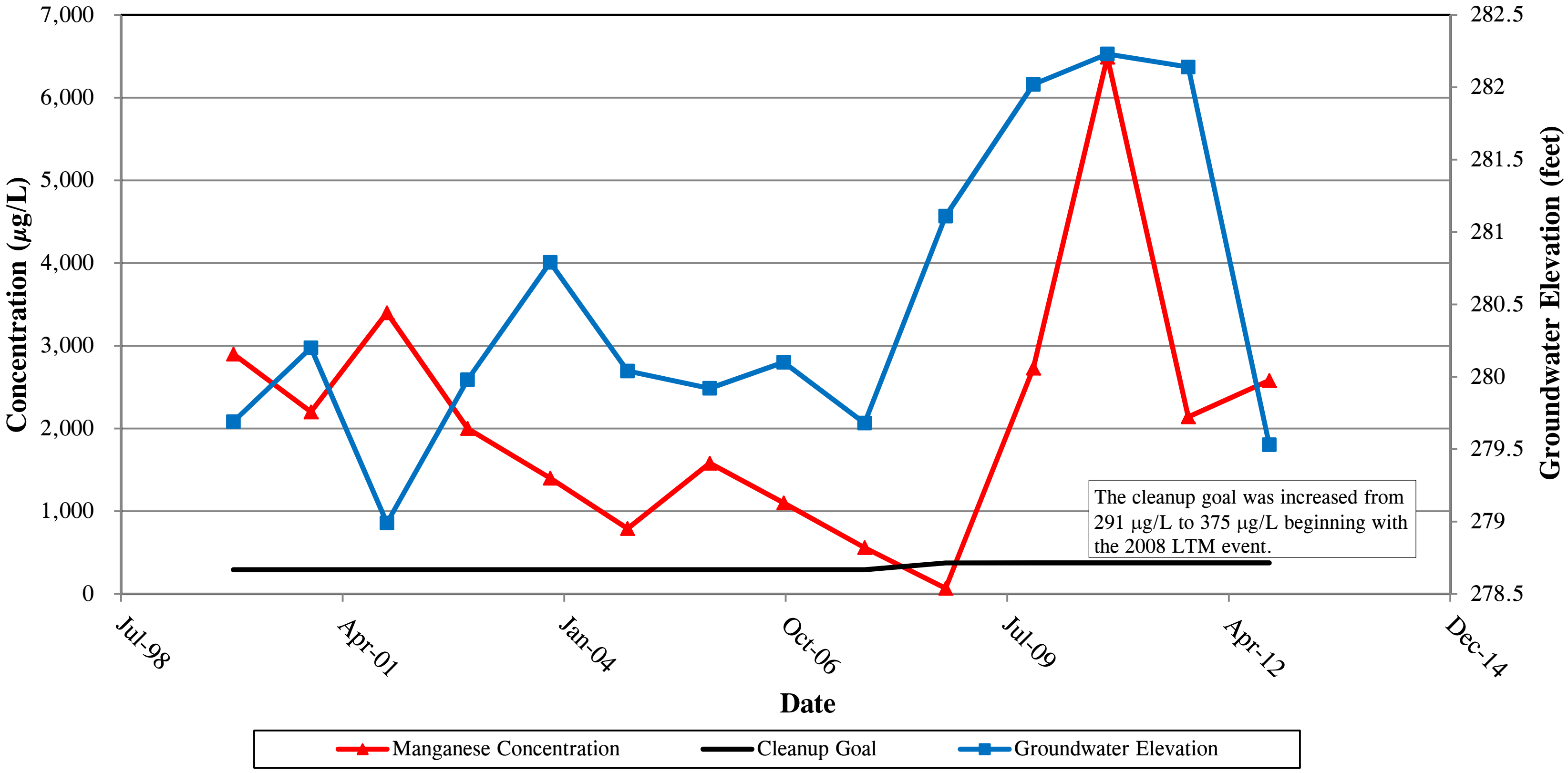
Groundwater Elevation and Analyte Concentrations
Manganese
Area of Contamination 43G
AAFES-06/6R



Groundwater Elevation and Analyte Concentrations
Manganese
Area of Contamination 43G
XGM-93-02X

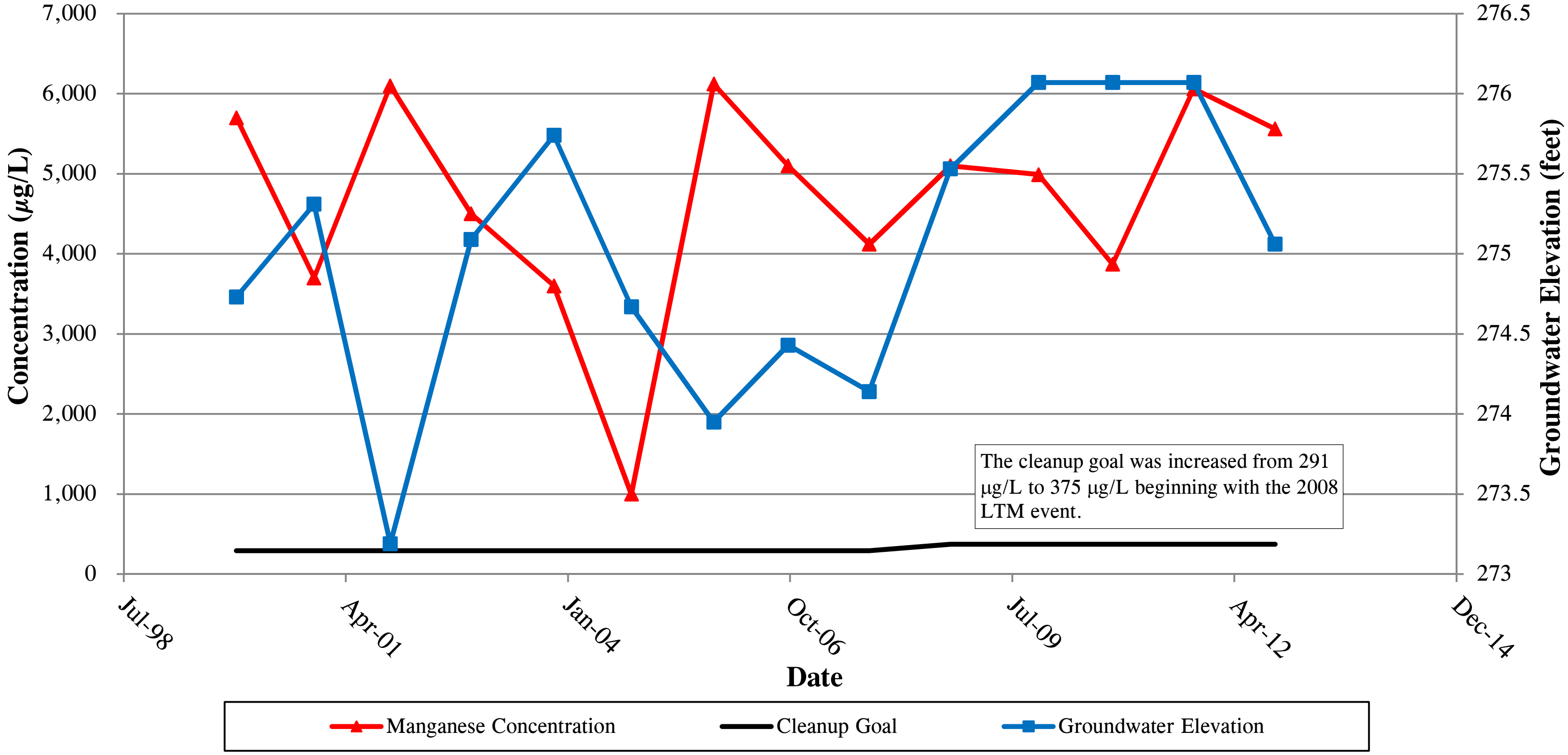


Groundwater Elevation and Analyte Concentrations
Manganese
Area of Contamination 43G
XGM-94-04X



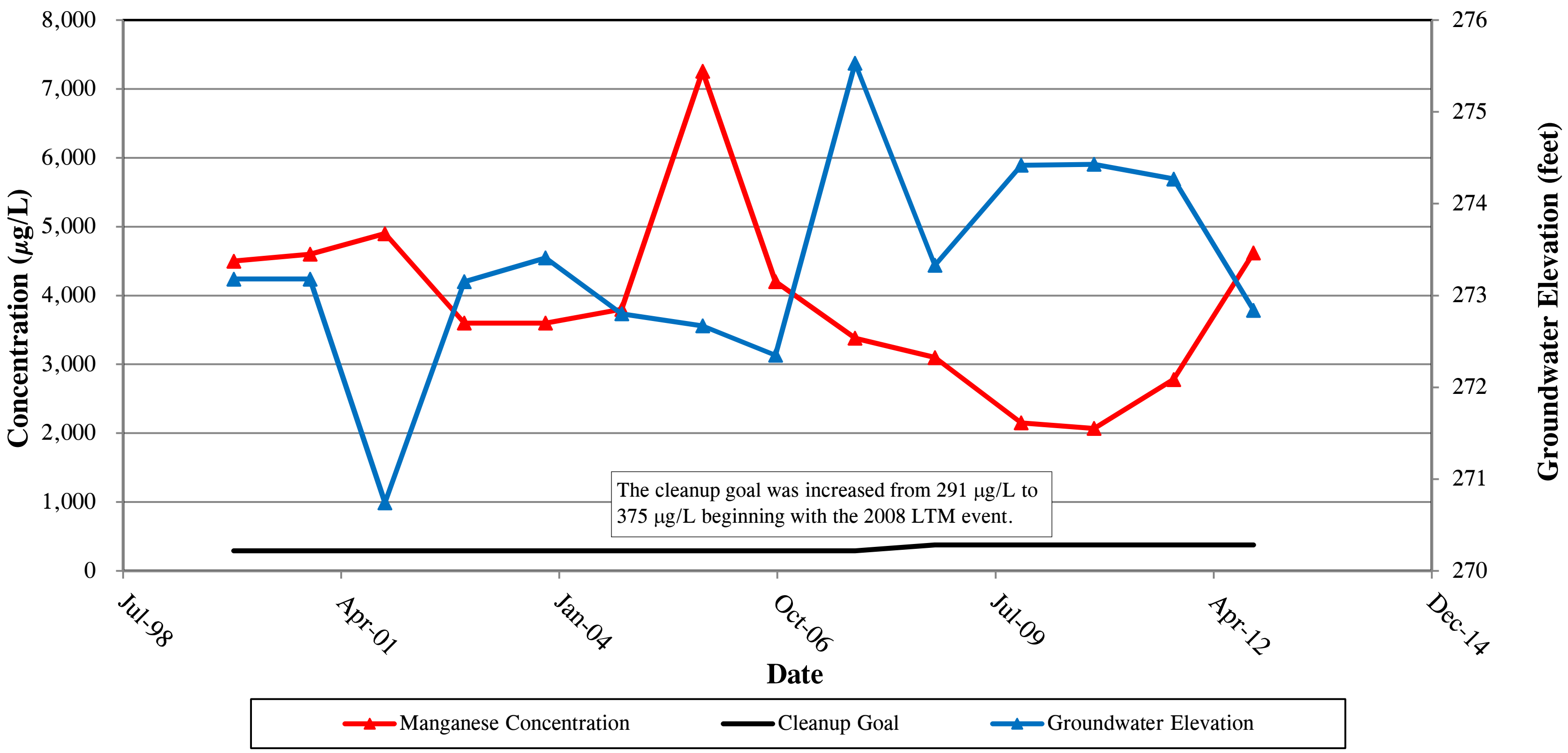
The cleanup goal was increased from 291 µg/L to 375 µg/L beginning with the 2008 LTM event.

Groundwater Elevation and Analyte Concentrations
Manganese
Area of Contamination 43G
XGM-94-07X



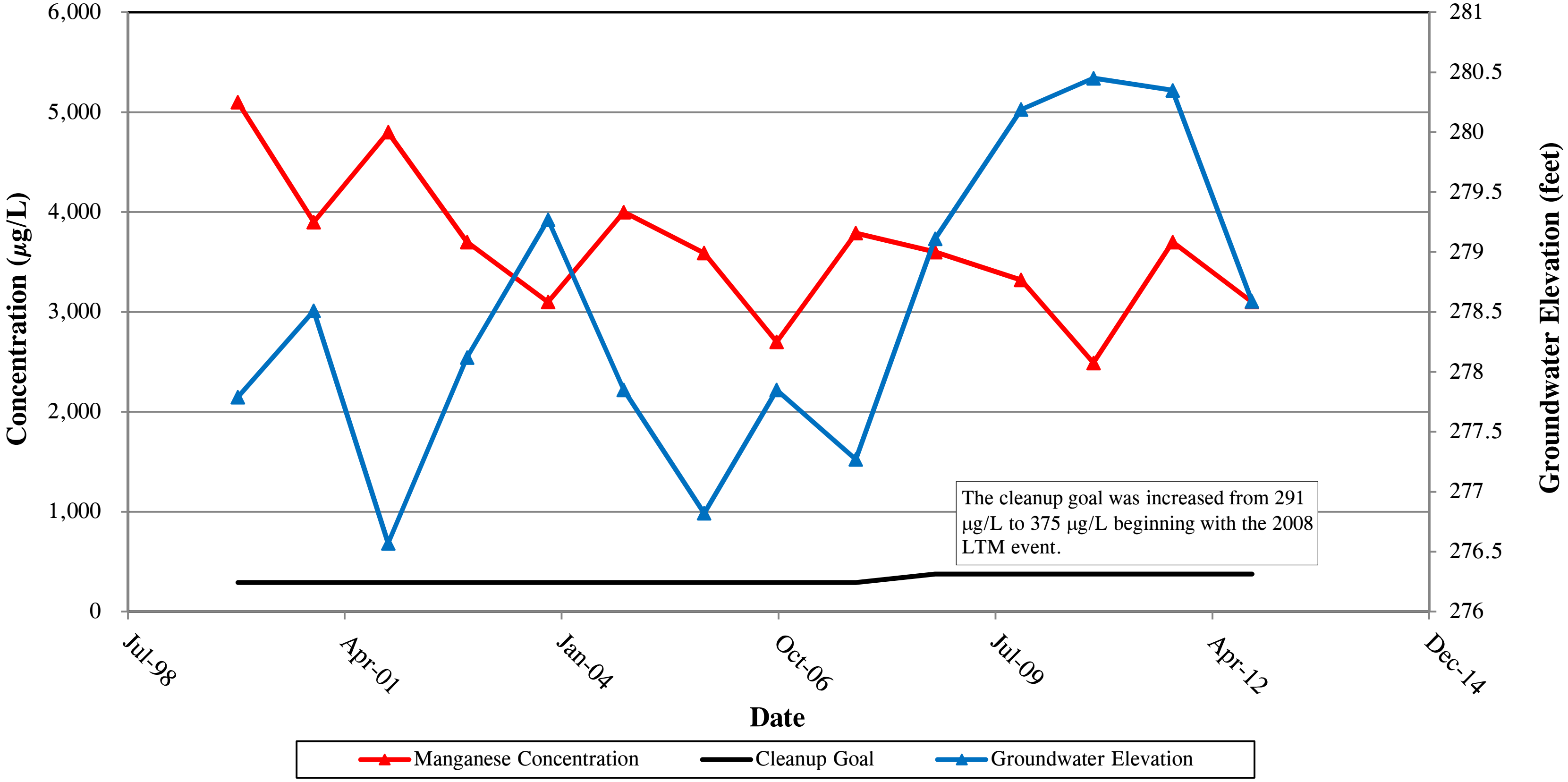
The cleanup goal was increased from 291 µg/L to 375 µg/L beginning with the 2008 LTM event.

Groundwater Elevation and Analyte Concentrations
Manganese
Area of Contamination 43G
XGM-94-08X



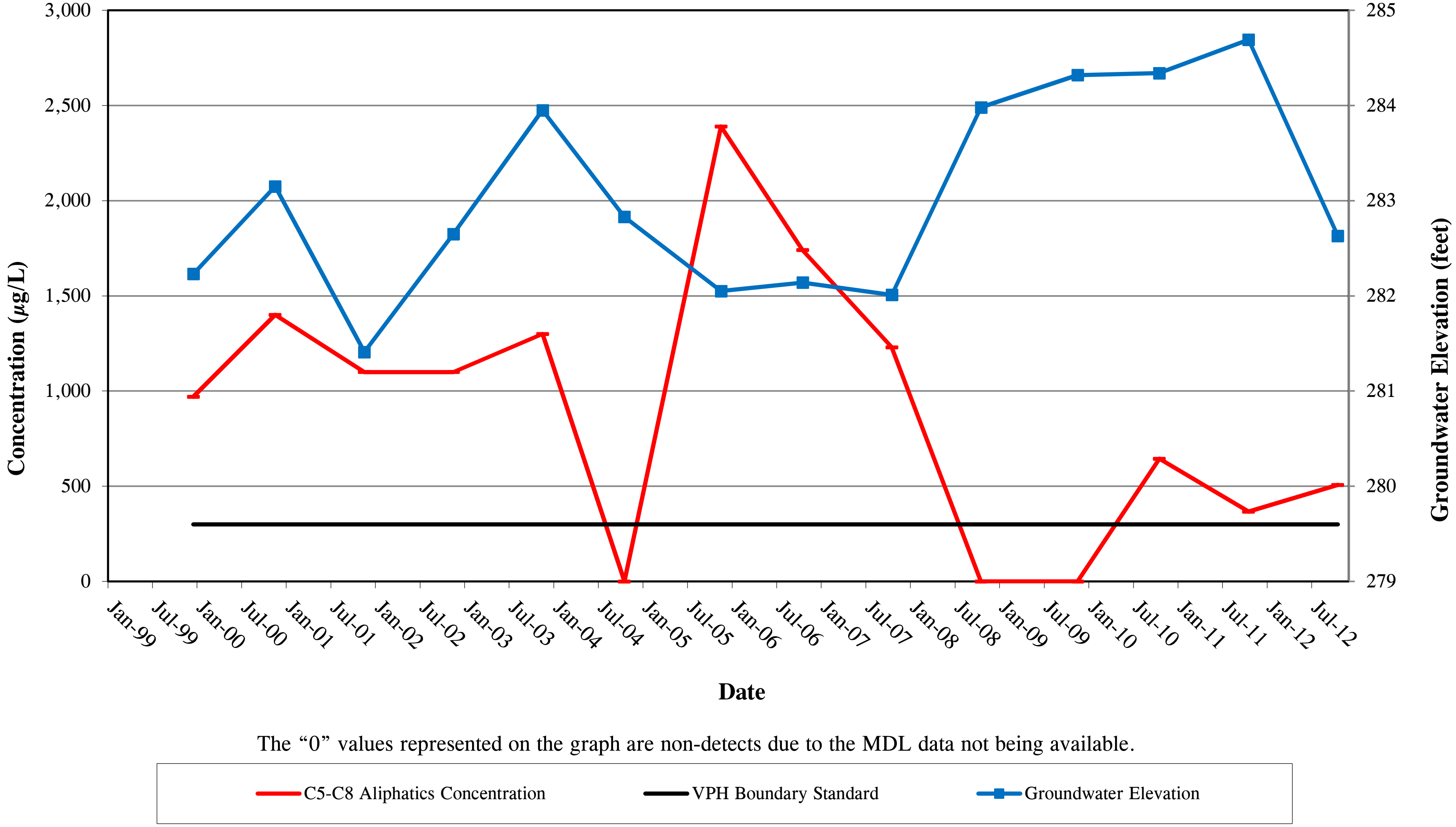
The cleanup goal was increased from 291 µg/L to 375 µg/L beginning with the 2008 LTM event.

Groundwater Elevation and Analyte Concentrations
Manganese
Area of Contamination 43G
AAFES-02



The cleanup goal was increased from 291 μg/L to 375 μg/L beginning with the 2008 LTM event.

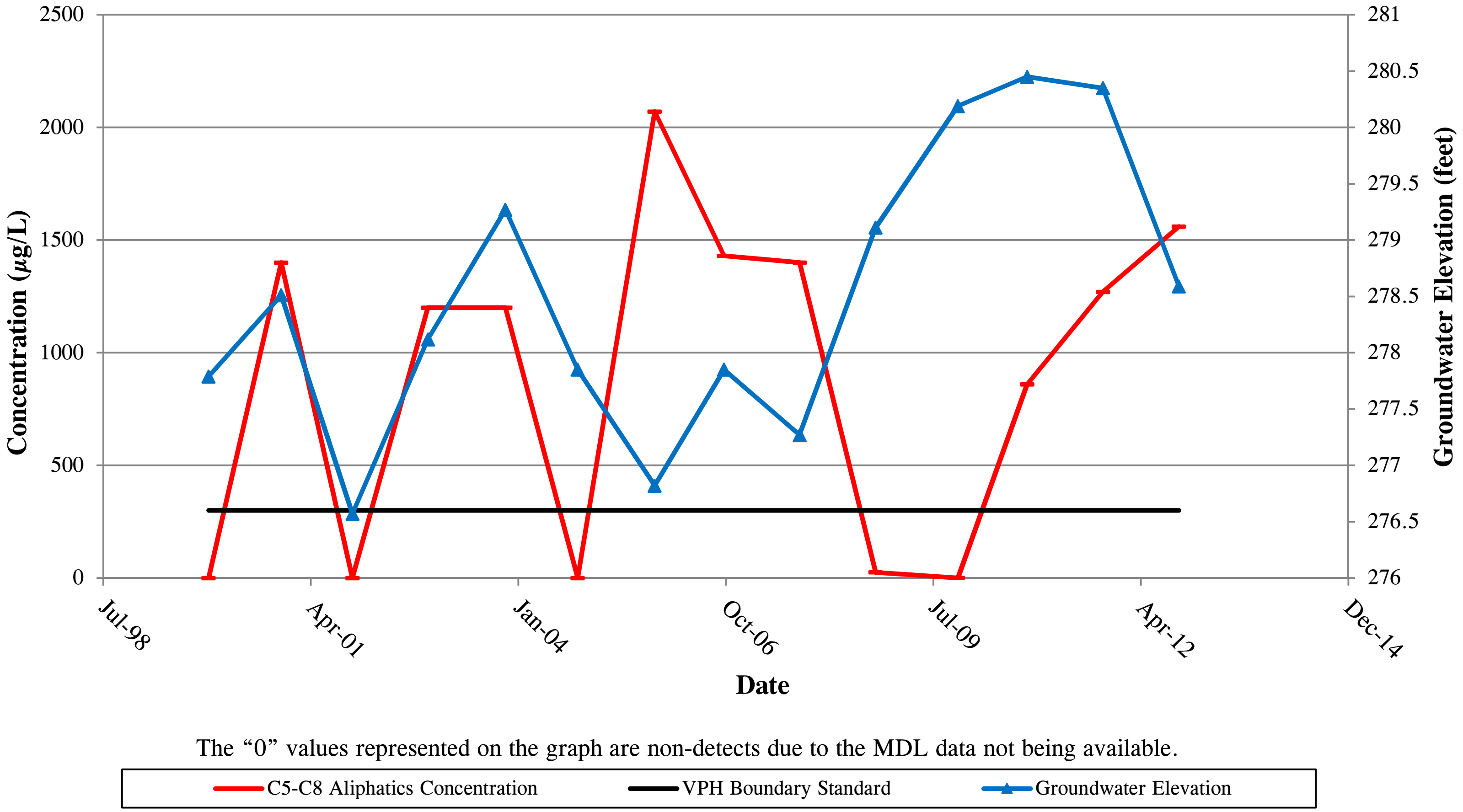
Groundwater Elevation and Analyte Concentrations
C_5-C_8 Aliphatics
Area of Contamination 43G
XGM-97-12X



The “0” values represented on the graph are non-detects due to the MDL data not being available.

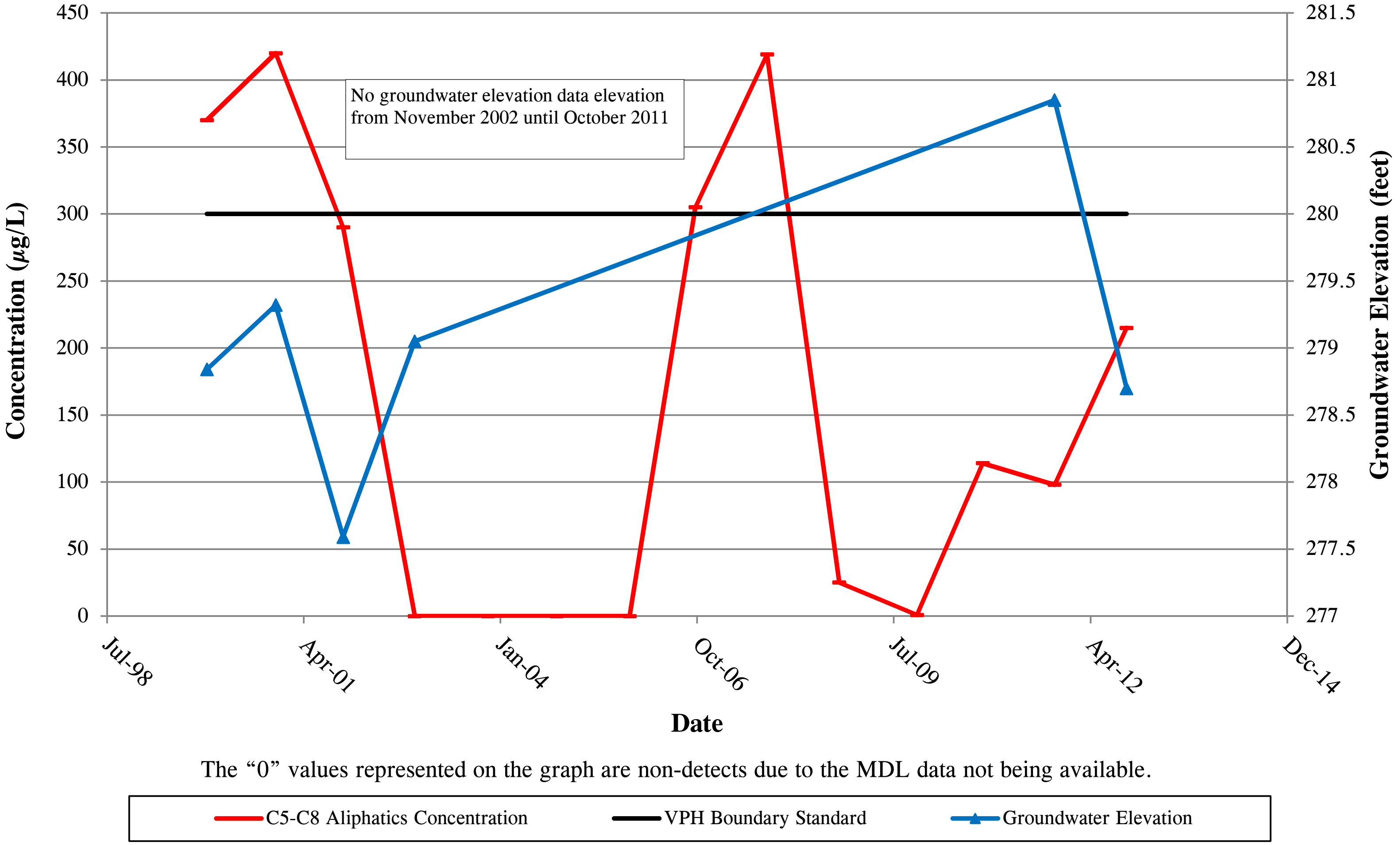
AAFES-6R was installed in January 2006 to replace abandoned well AAFES-6.

Groundwater Elevation and Analyte Concentrations
C_5-C_8 Aliphatics
Area of Contamination 43G
AAFES-02



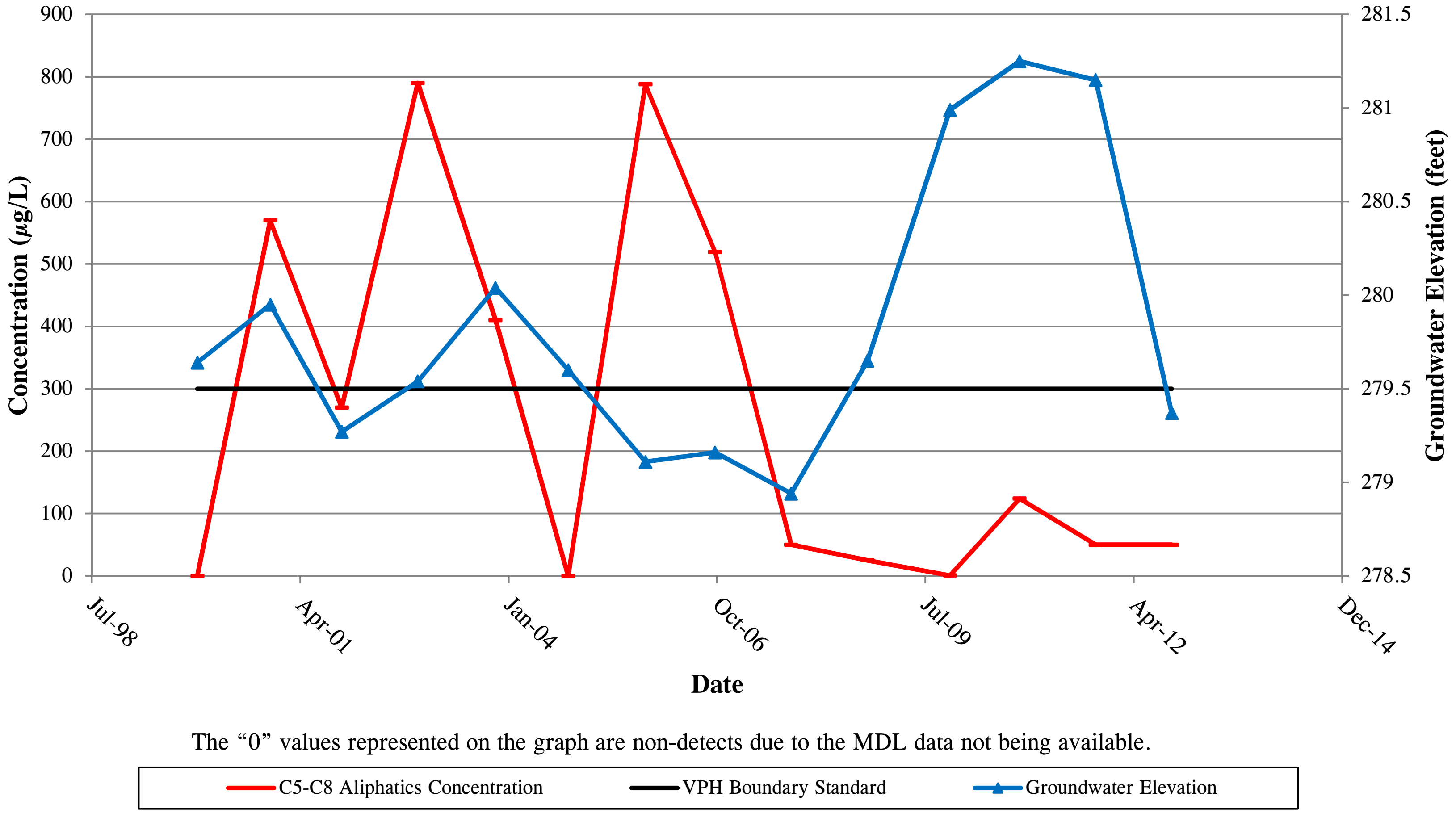
The “0” values represented on the graph are non-detects due to the MDL data not being available.

Groundwater Elevation and Analyte Concentrations
C_5-C_8 Aliphatics
Area of Contamination 43G
AAFES-06/6R



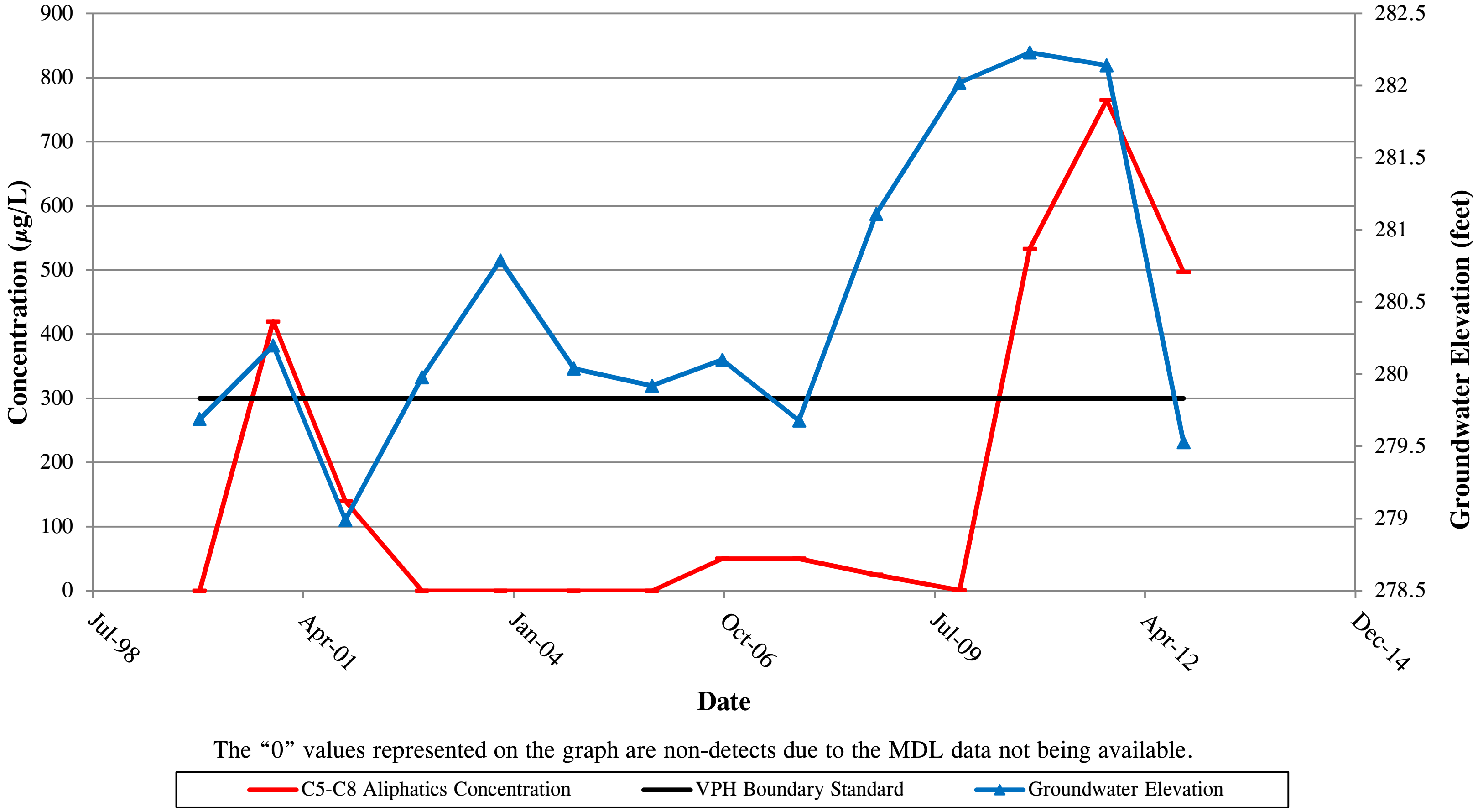
The “0” values represented on the graph are non-detects due to the MDL data not being available.

Groundwater Elevation and Analyte Concentrations
C_5-C_8 Aliphatics
Area of Contamination 43G
XGM-93-02X



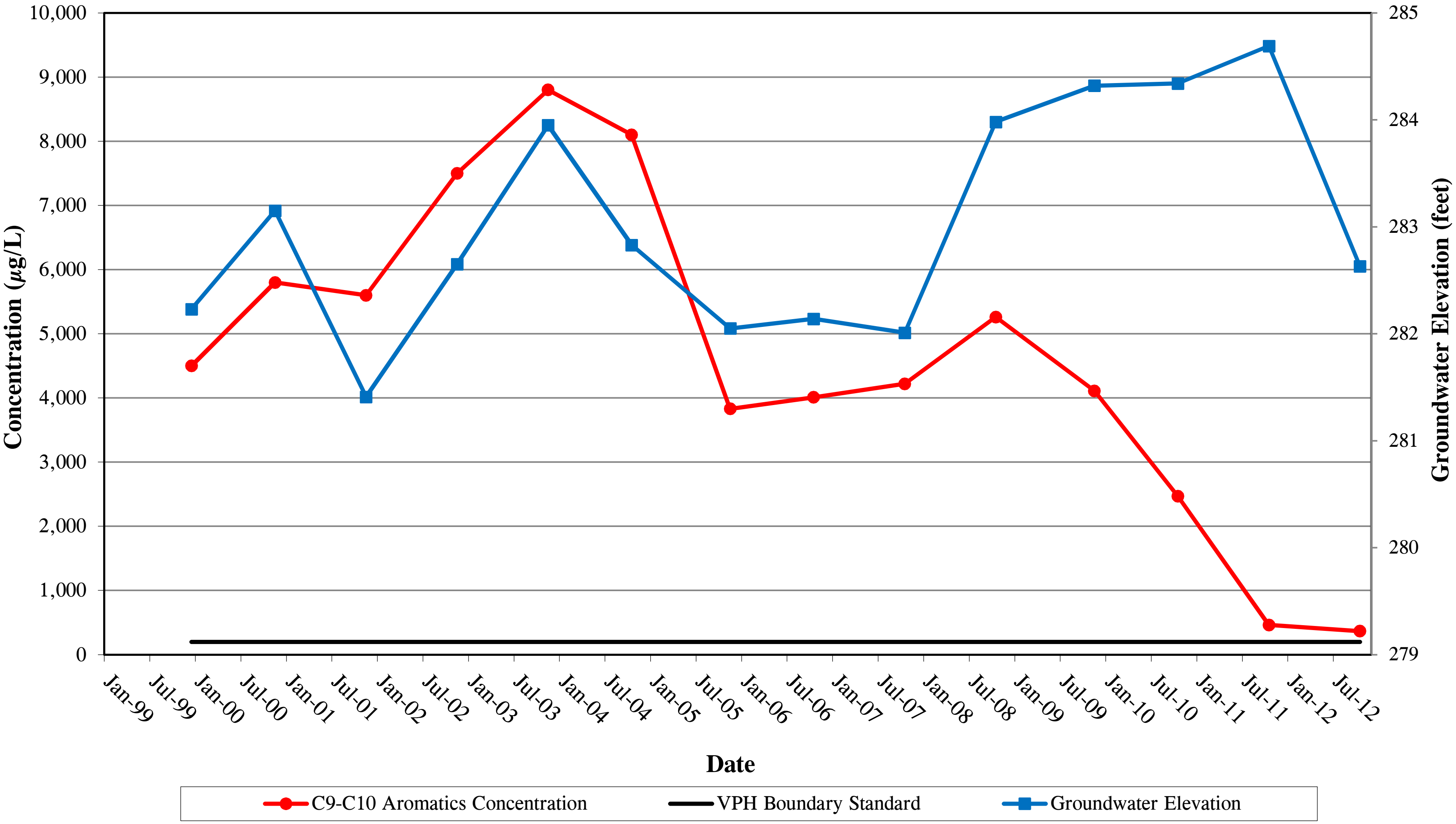
The “0” values represented on the graph are non-detects due to the MDL data not being available.

Groundwater Elevation and Analyte Concentrations
C_5-C_8 Aliphatics
Area of Contamination 43G
XGM-93-04X

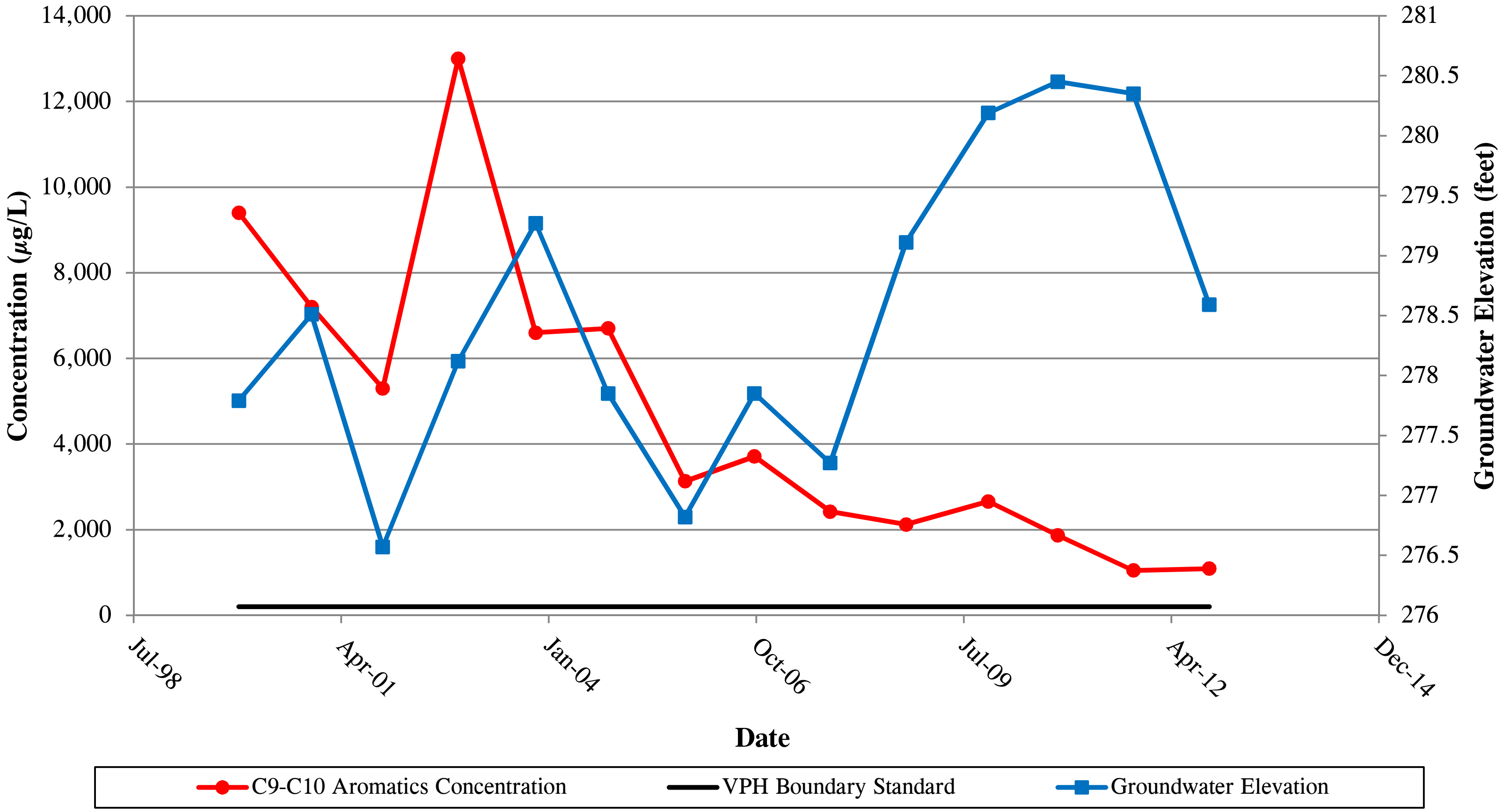


The “0” values represented on the graph are non-detects due to the MDL data not being available.

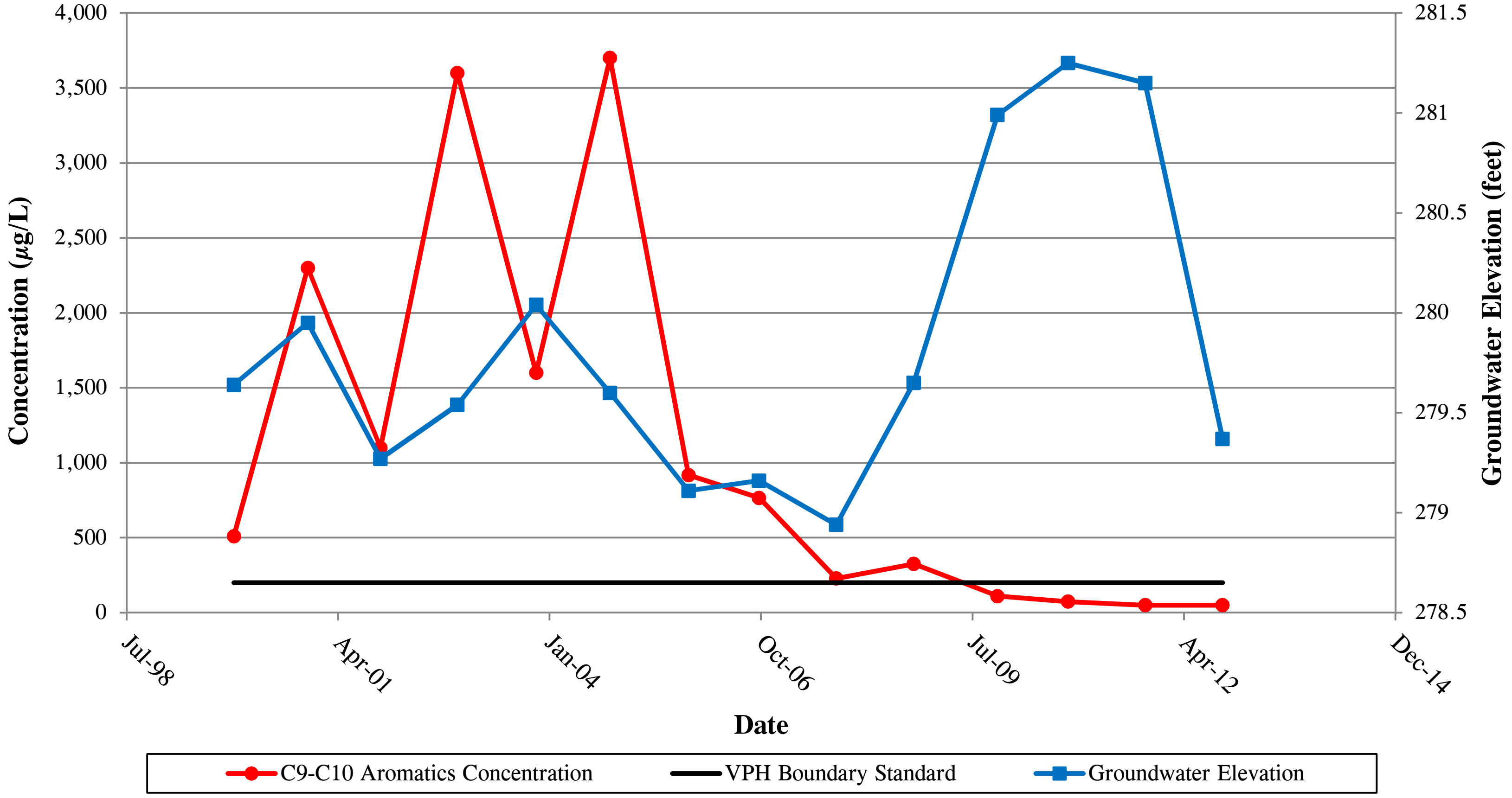
Groundwater Elevation and Analyte Concentrations
VPH C_9-C_{10} Aromatics
Area of Contamination 43G
XGM-97-12X



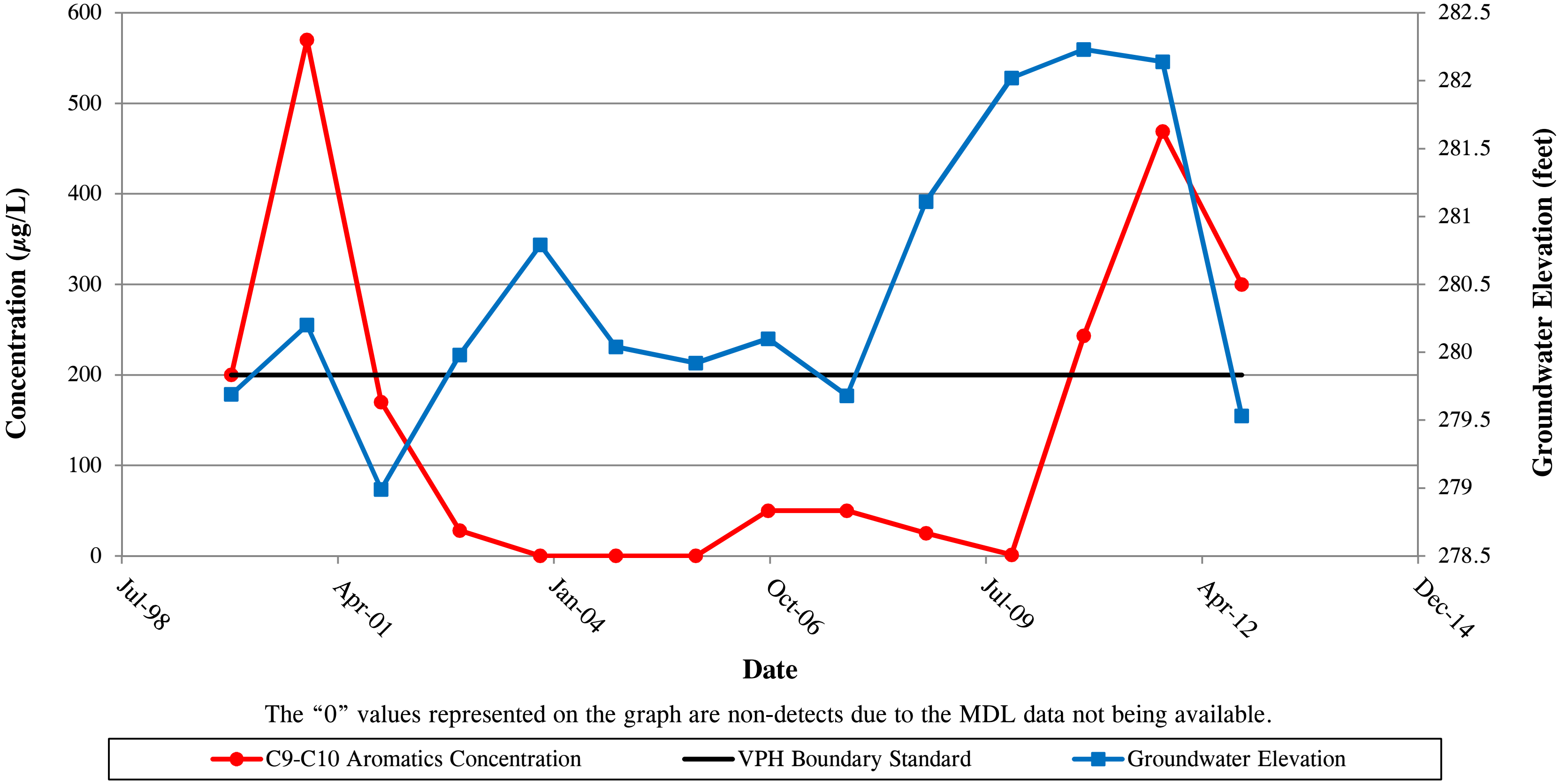
Groundwater Elevation and Analyte Concentrations
VPH C_9-C_{10} Aromatics
Area of Contamination 43G
AAFES-02



Groundwater Elevation and Analyte Concentrations
VPH C_9-C_{10} Aromatics
Area of Contamination 43G
XGM-93-02X

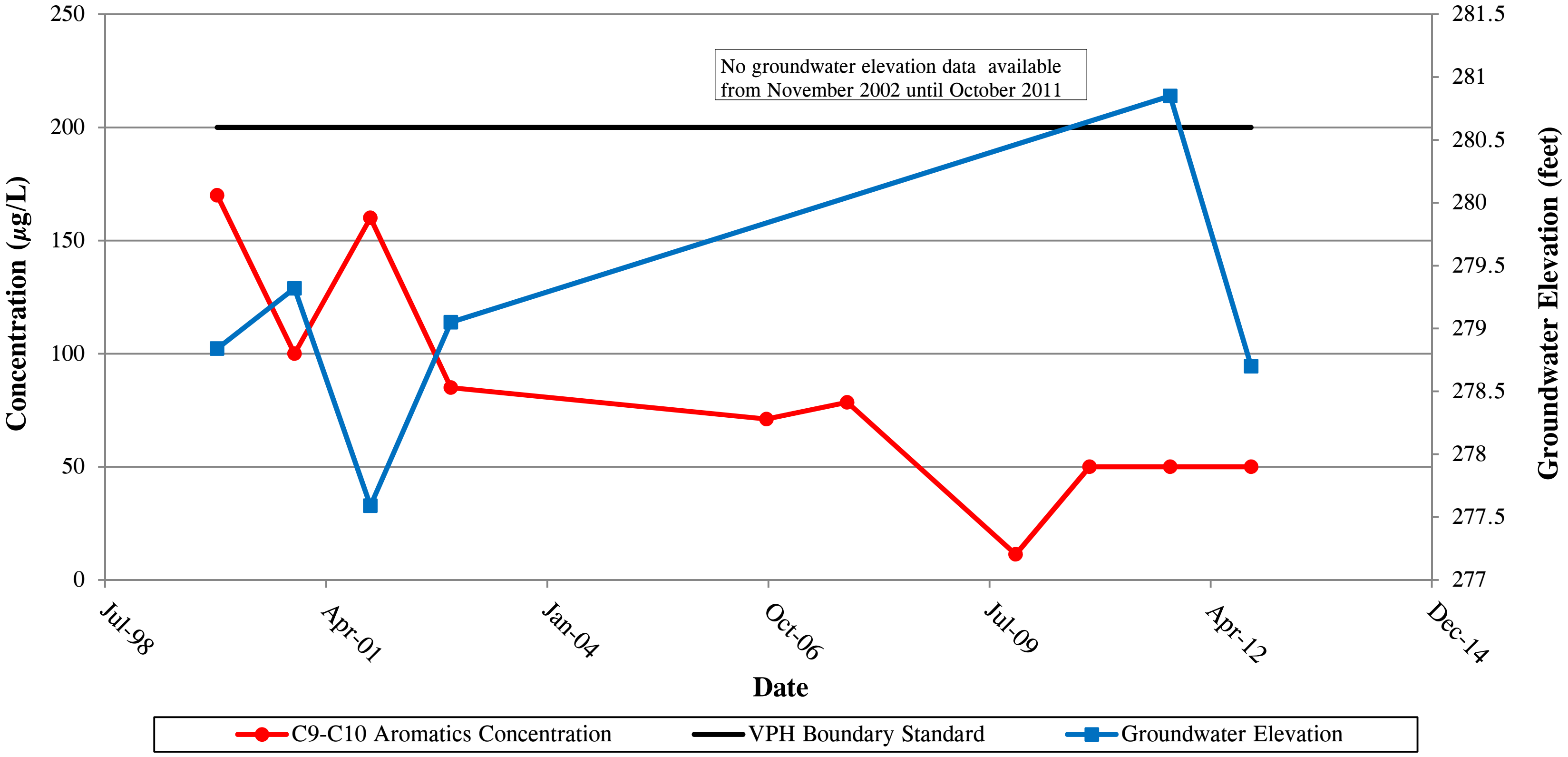


Groundwater Elevation and Analyte Concentrations
VPH C_9-C_{10} Aromatics
Area of Contamination 43G
XGM-94-04X



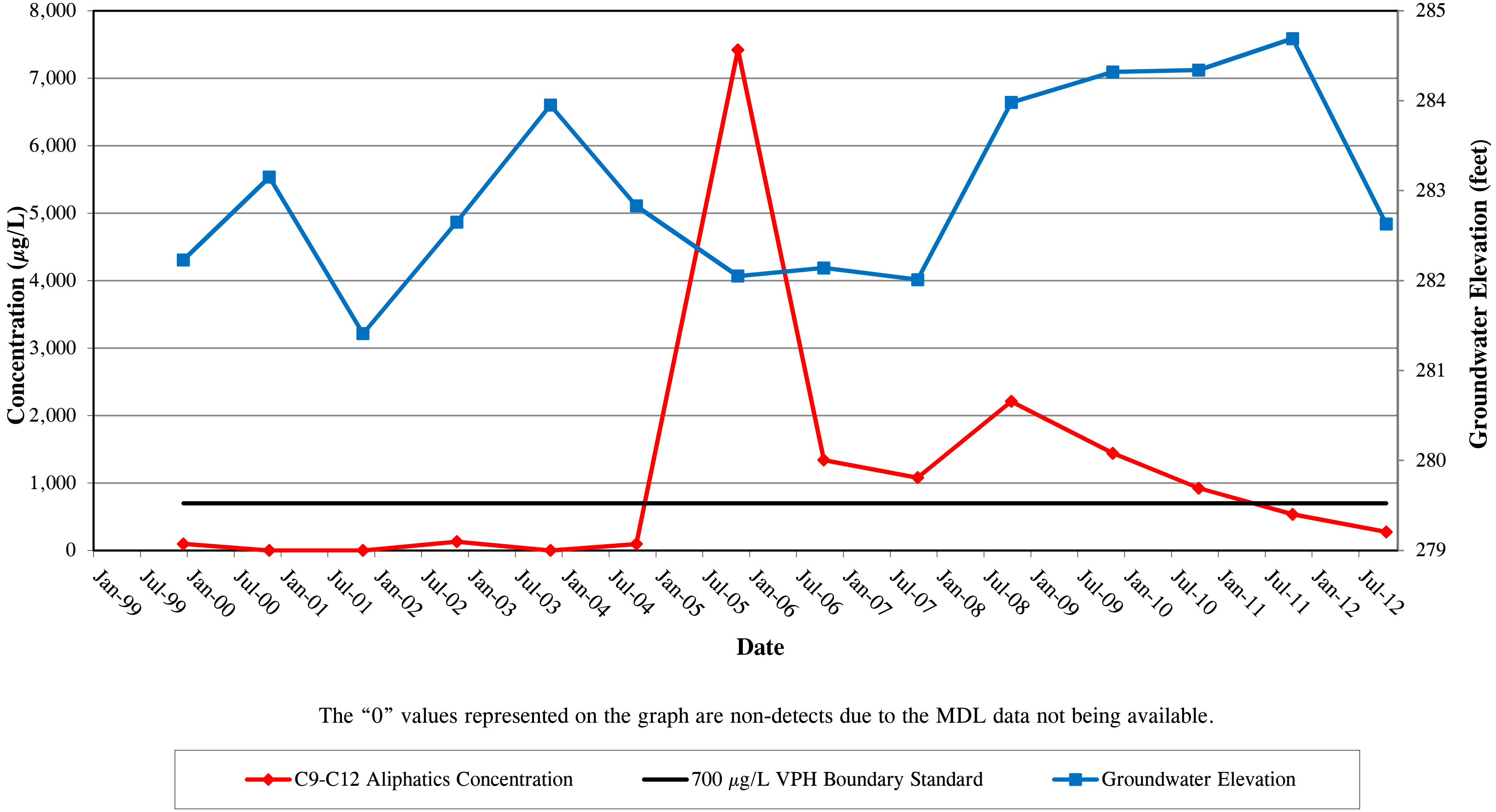
The "0" values represented on the graph are non-detects due to the MDL data not being available.

Groundwater Elevation and Analyte Concentrations
VPH C_9-C_{10} Aromatics
Area of Contamination 43G
AAFES-06/6R



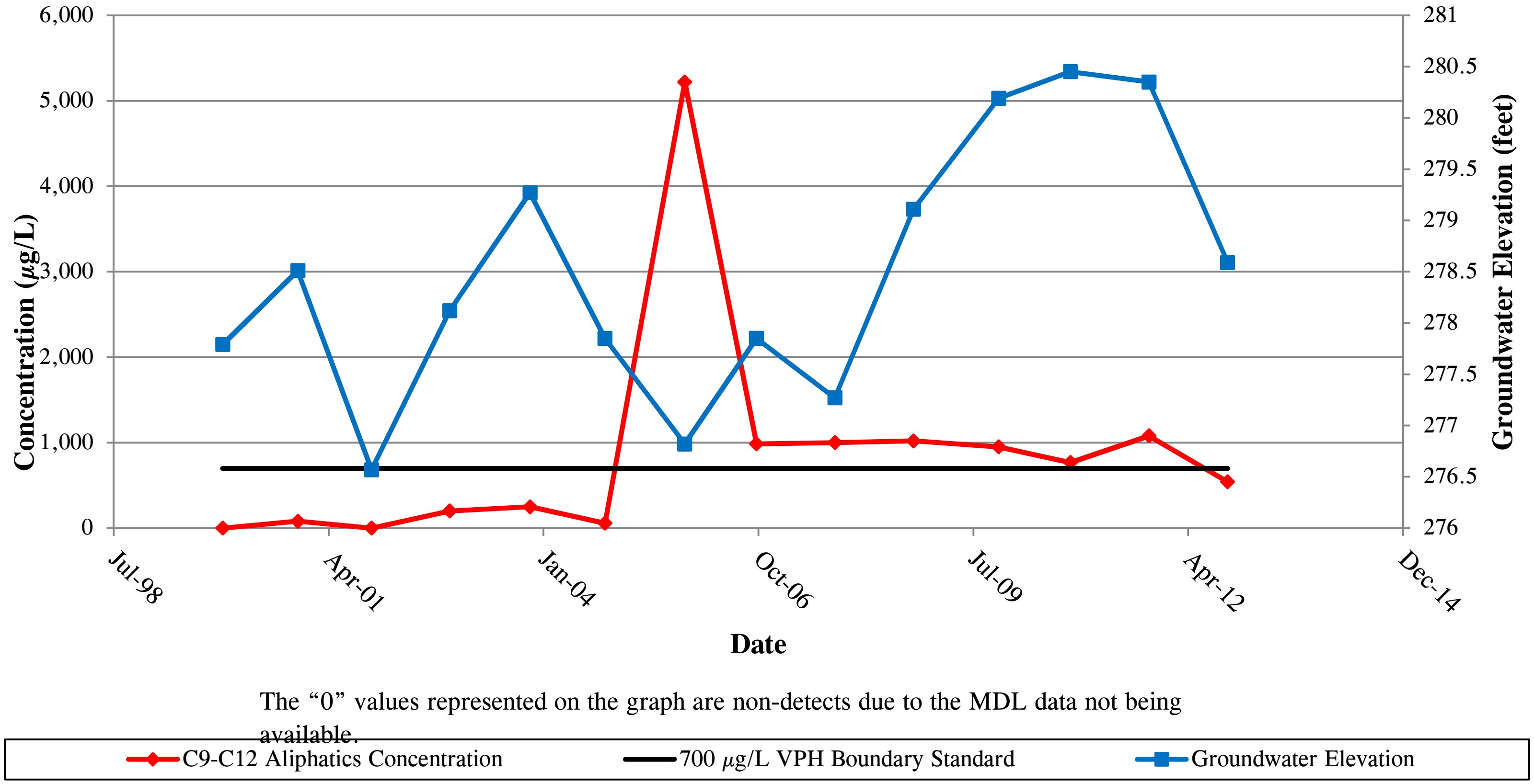
No groundwater elevation data available from November 2002 until October 2011

Groundwater Elevation and Analyte Concentrations
VPH C_9-C_{12} Aliphatics
Area of Contamination 43G
XGM-97-12X



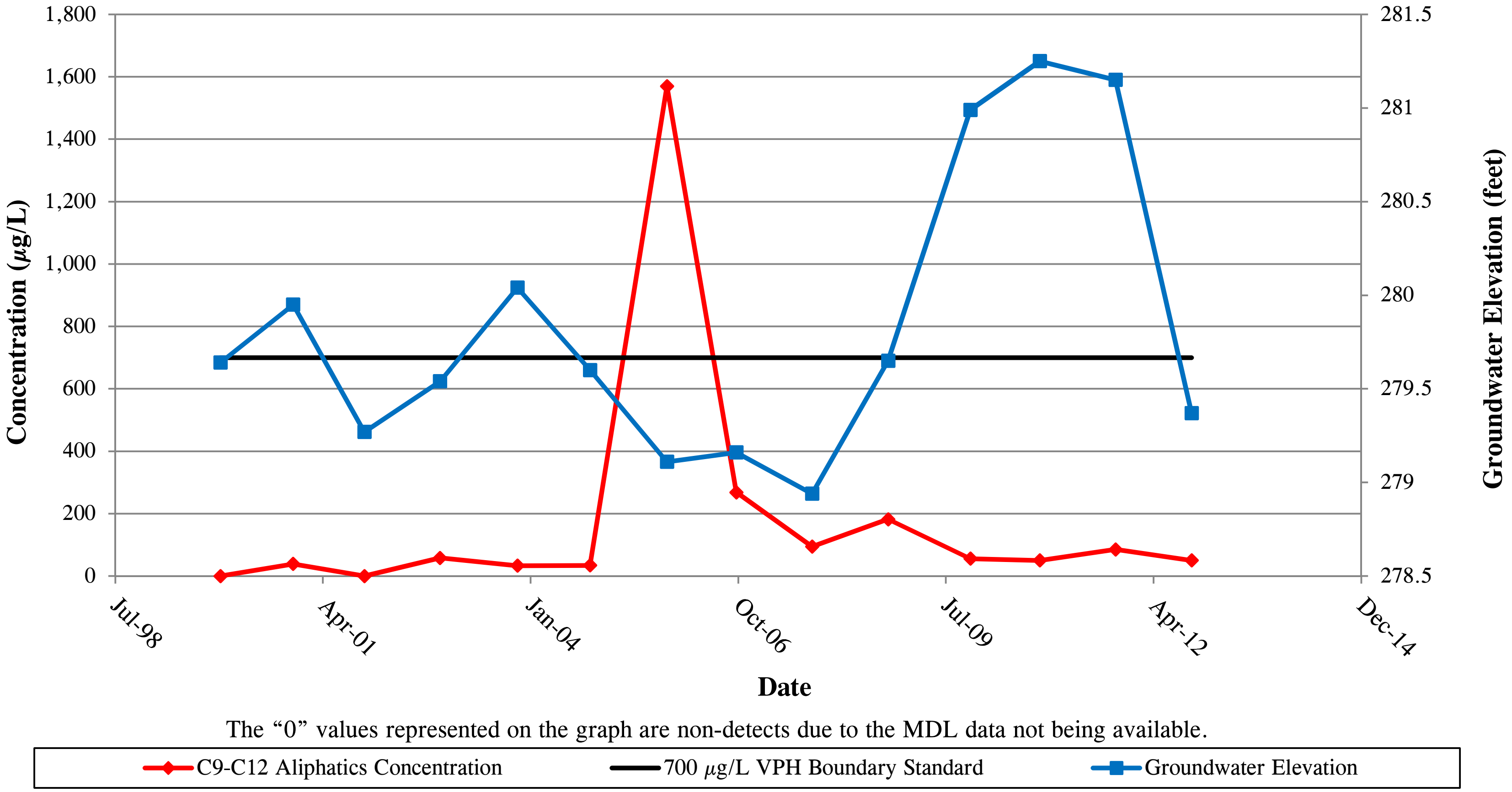
The “0” values represented on the graph are non-detects due to the MDL data not being available.

Groundwater Elevation and Analyte Concentrations
VPH C_9-C_{12} Aliphatics
Area of Contamination 43G
AAFES-2



The "0" values represented on the graph are non-detects due to the MDL data not being available.

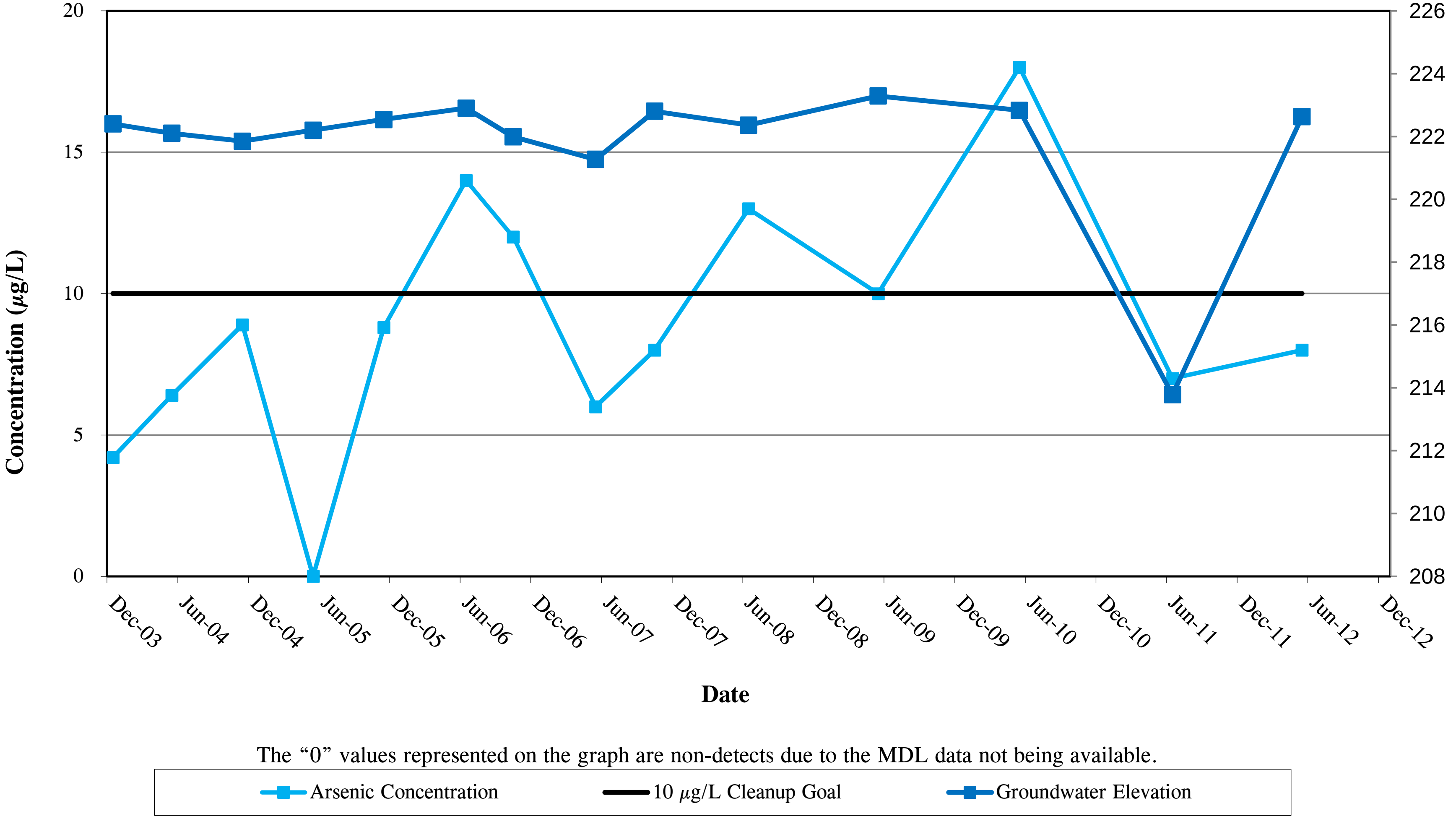
Groundwater Elevation and Analyte Concentrations
VPH C_9-C_{12} Aliphatics
Area of Contamination 43G
XGM-93-02X



The “0” values represented on the graph are non-detects due to the MDL data not being available.

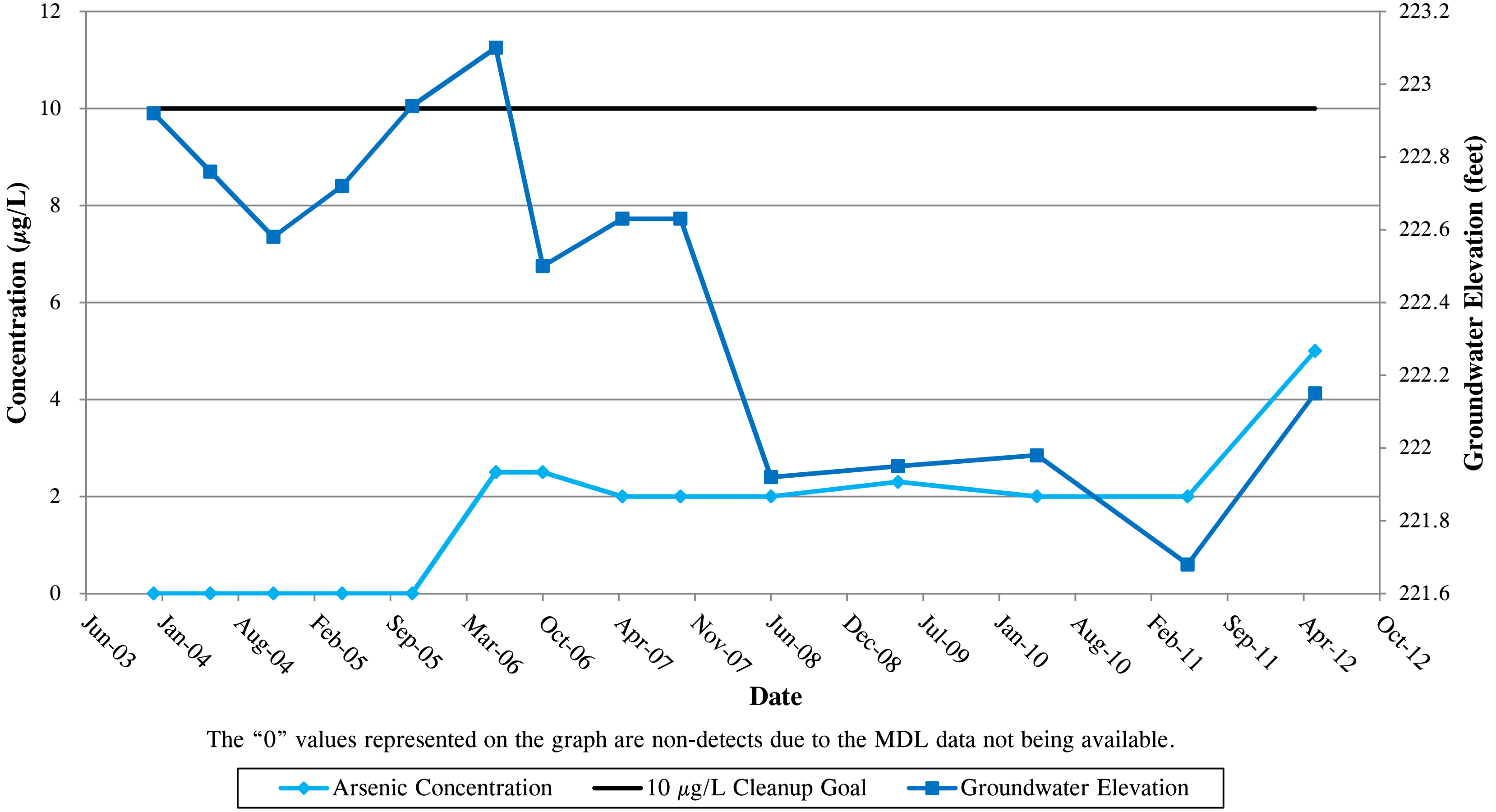
AOC 57

Groundwater Elevation and Analyte Concentrations
Arsenic
Area of Contamination 57 - Area 2
57M-03-02X



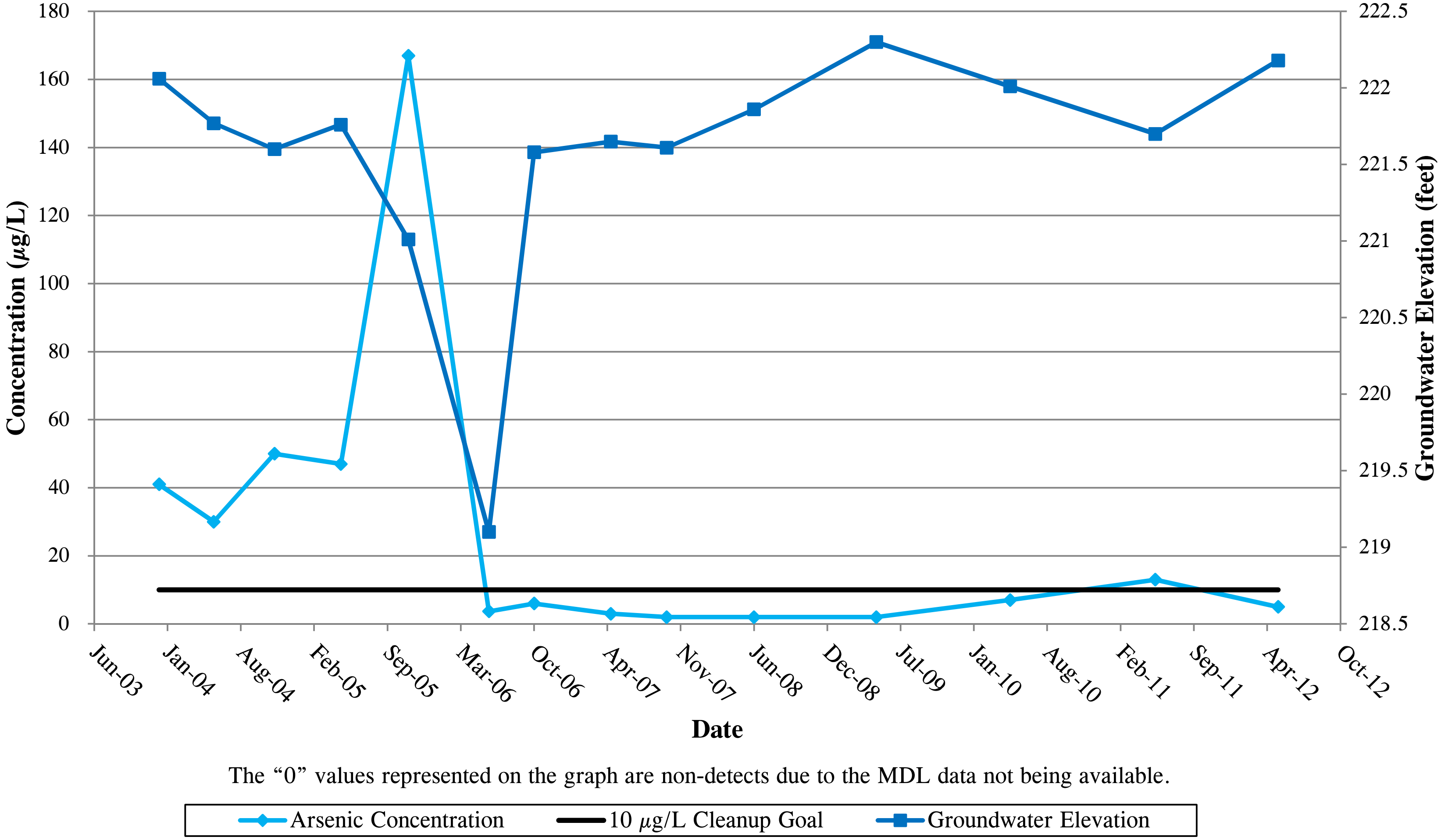
The “0” values represented on the graph are non-detects due to the MDL data not being available.

Groundwater Elevation and Analyte Concentrations
Arsenic
Area of Contamination 57 - Area 2
57M-03-03X



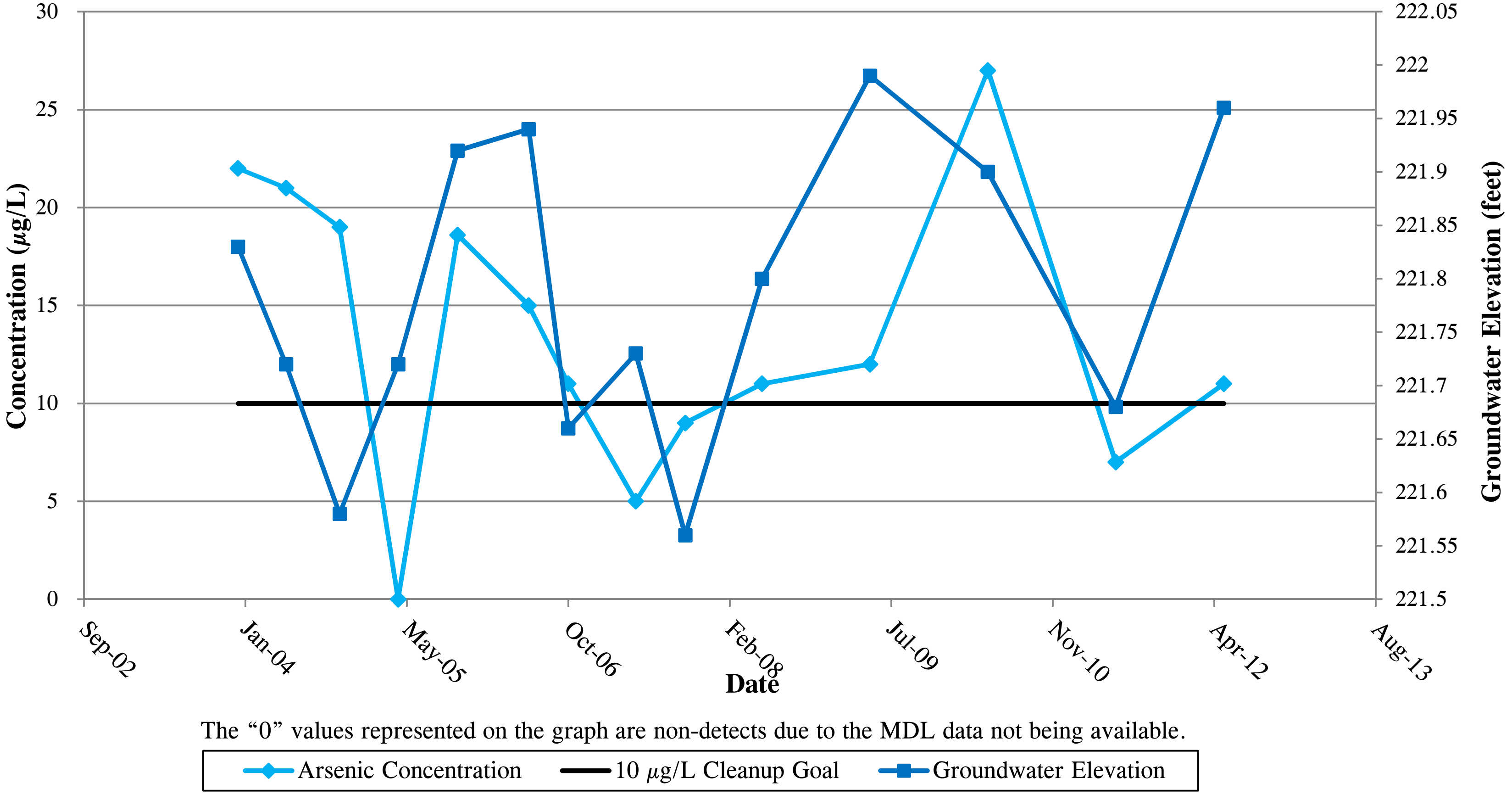
The “0” values represented on the graph are non-detects due to the MDL data not being available.

Groundwater Elevation and Analyte Concentrations
Arsenic
Area of Contamination 57 - Area 2
57M-03-04X



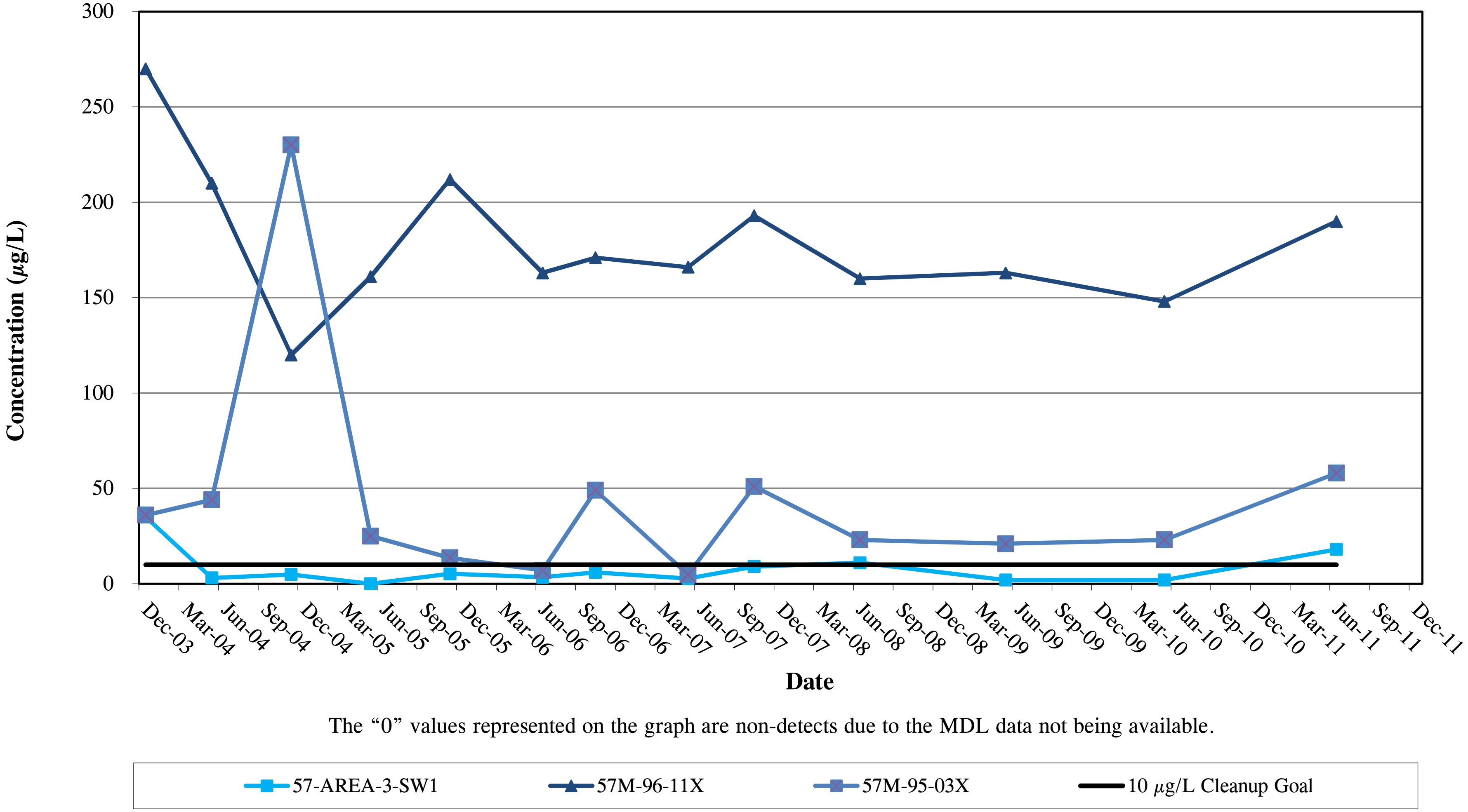
The “0” values represented on the graph are non-detects due to the MDL data not being available.

Groundwater Elevation and Analyte Concentrations
Arsenic
Area of Contamination 57 - Area 2
57M-03-05X



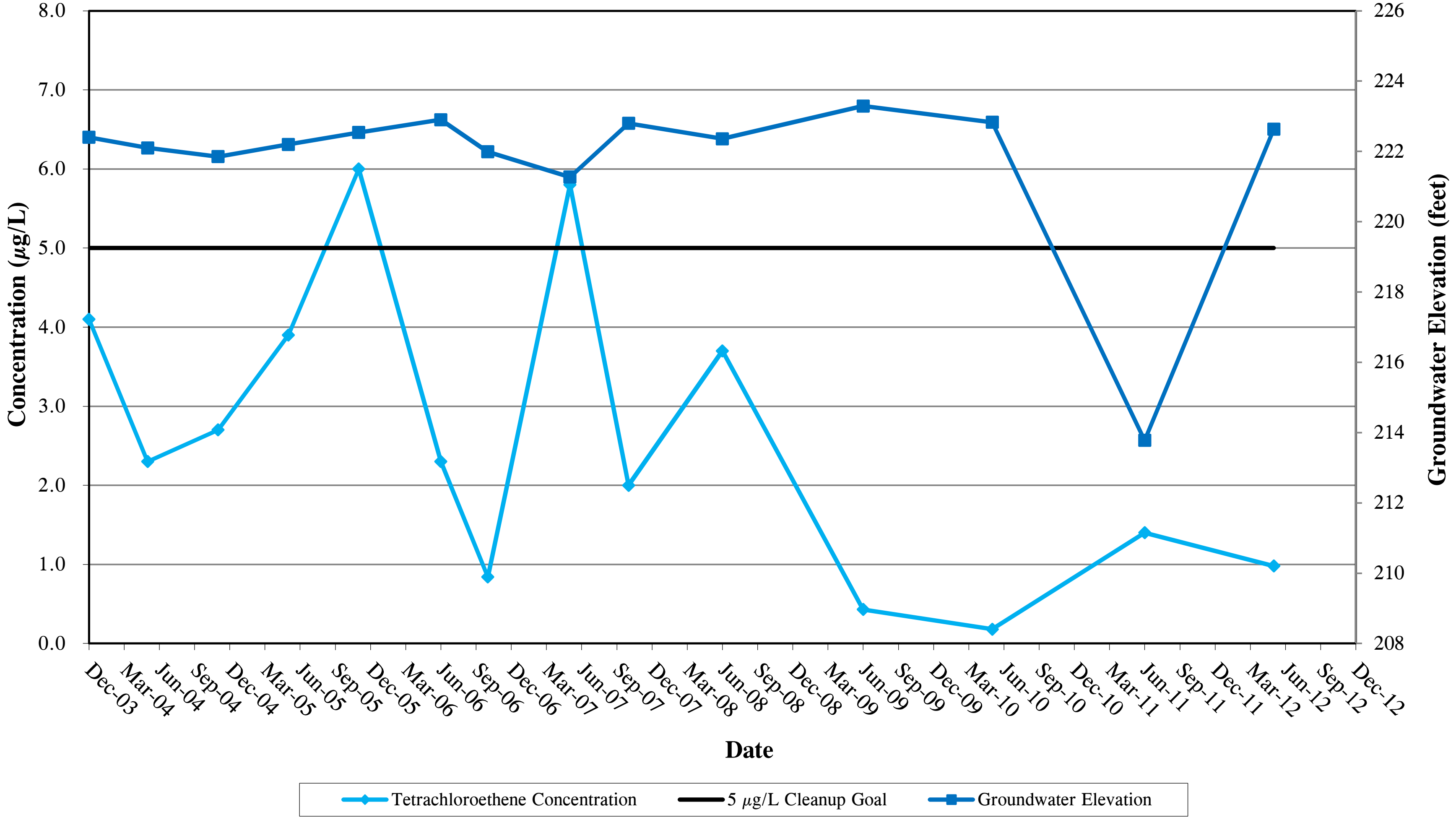
The “0” values represented on the graph are non-detects due to the MDL data not being available.

Long-Term Trends
Arsenic
Area of Contamination 57 - Area 3

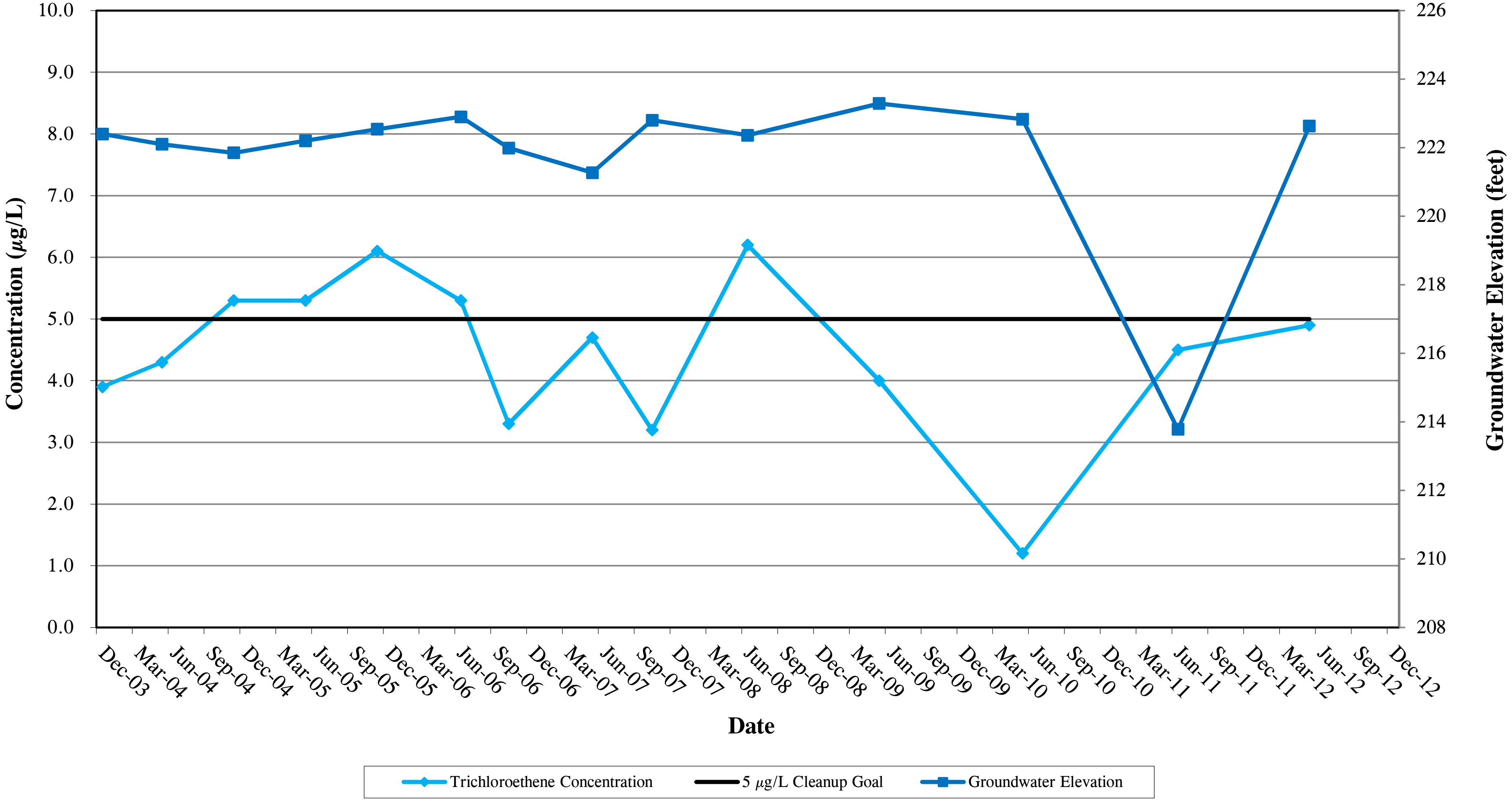


The “0” values represented on the graph are non-detects due to the MDL data not being available.

Groundwater Elevation and Analyte Concentrations
Tetrachloroethene
Area of Contamination 57 - Area 2
57M-03-02X

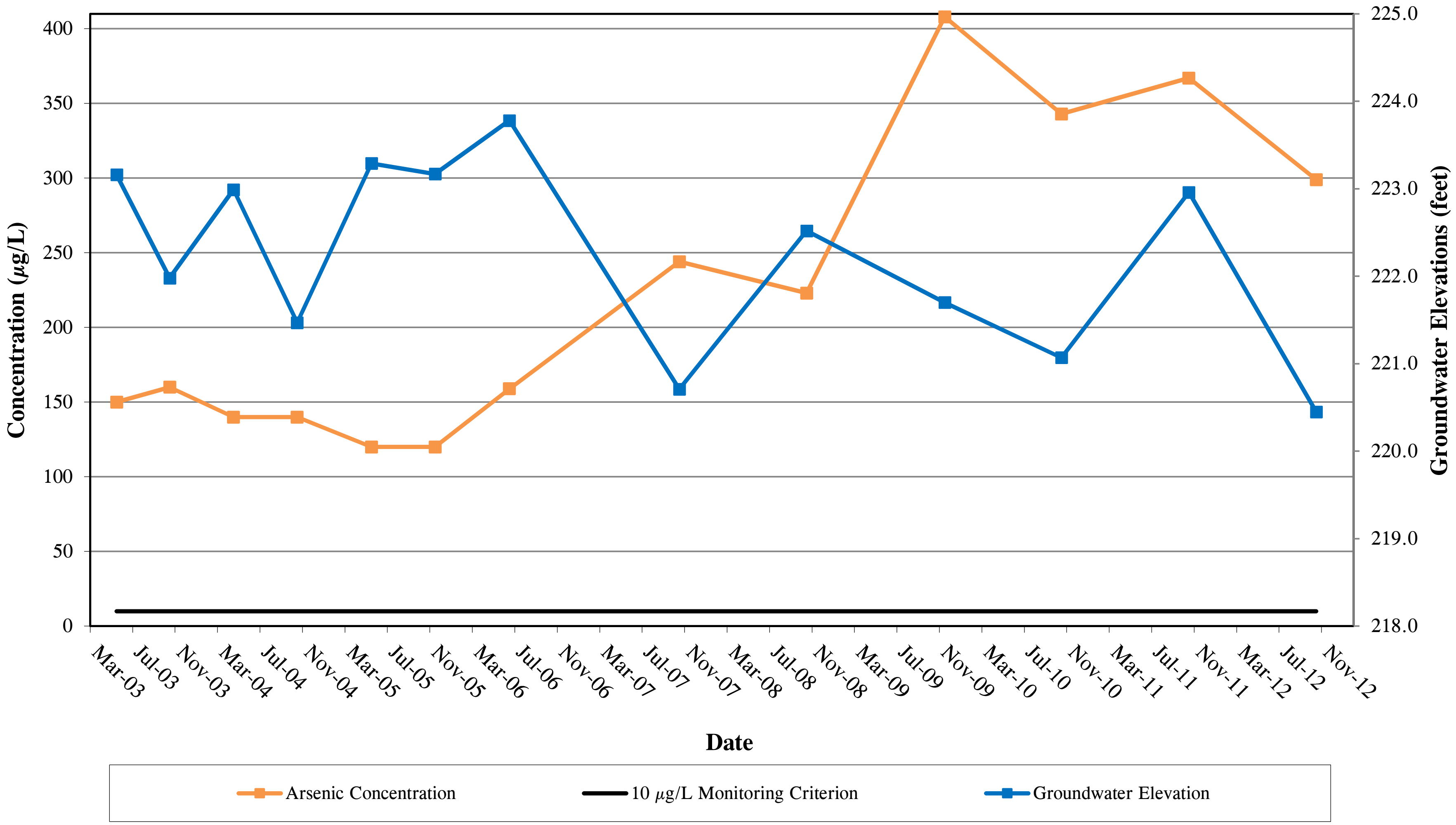


Groundwater Elevation and Analyte Concentrations
Trichloroethene
Area of Contamination 57 - Area 2
57M-03-02X

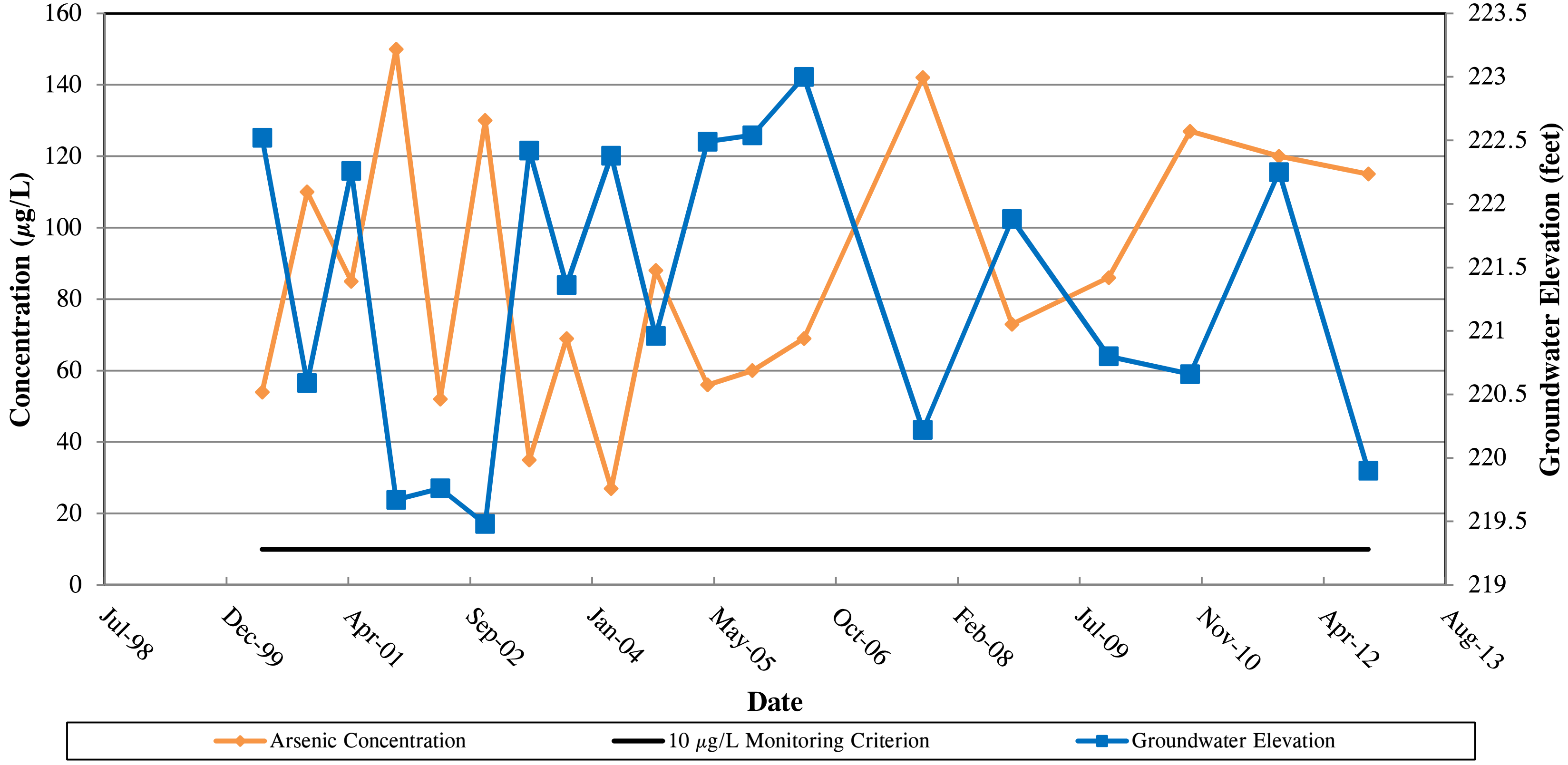


AOC 69W

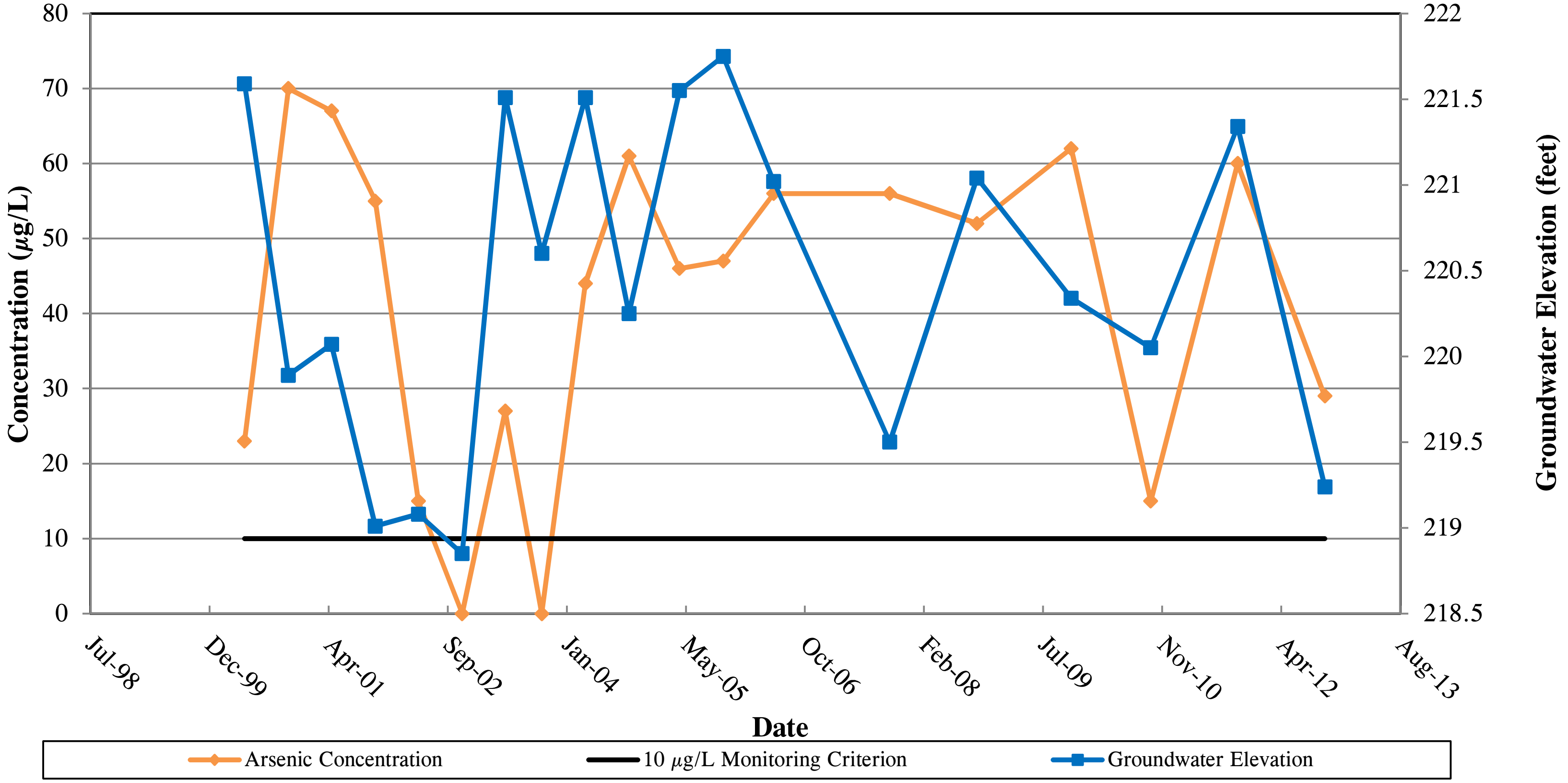
Groundwater Elevation and Analyte Concentrations
Arsenic
Area of Contamination 69W
ZWM-99-22X



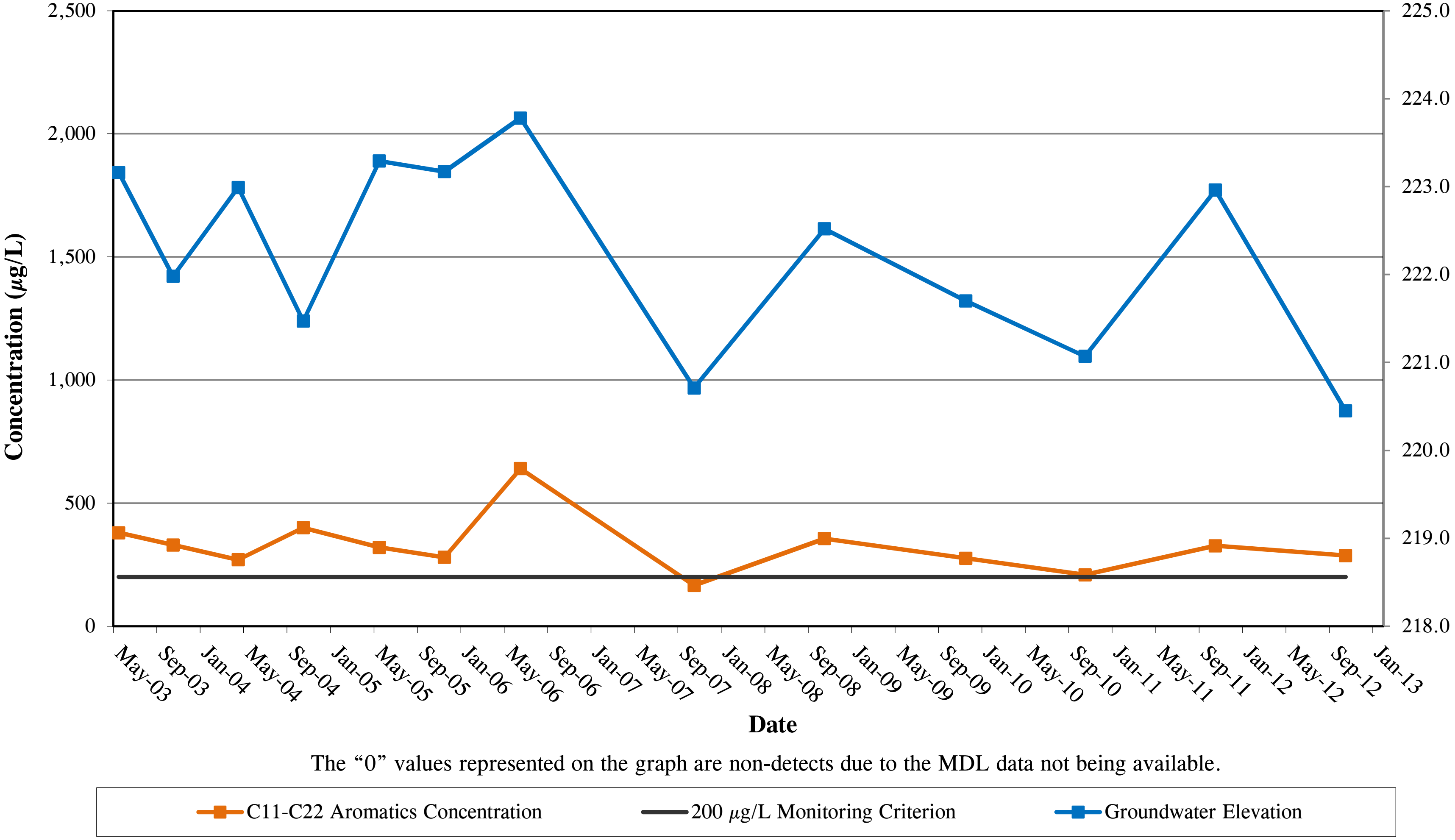
Groundwater Elevation and Analyte Concentrations
Arsenic
Area of Contamination 69W
69W-94-13



Groundwater Elevation and Analyte Concentrations
Arsenic
Area of Contamination 69W
ZWM-99-23X

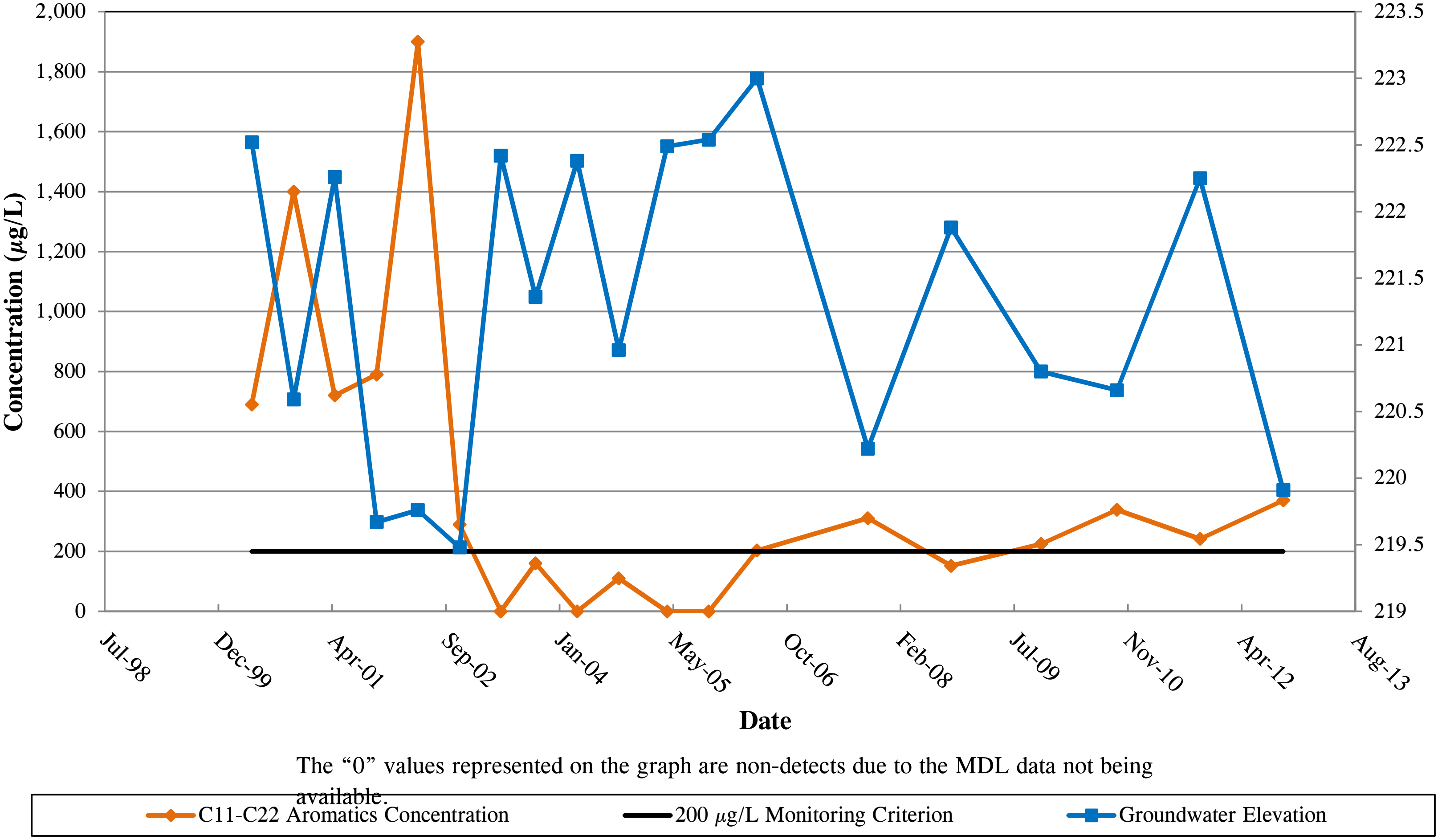


Groundwater Elevation and Analyte Concentrations
C_{11}-C_{22} Aromatics
Area of Contamination 69W
ZWM-99-22X



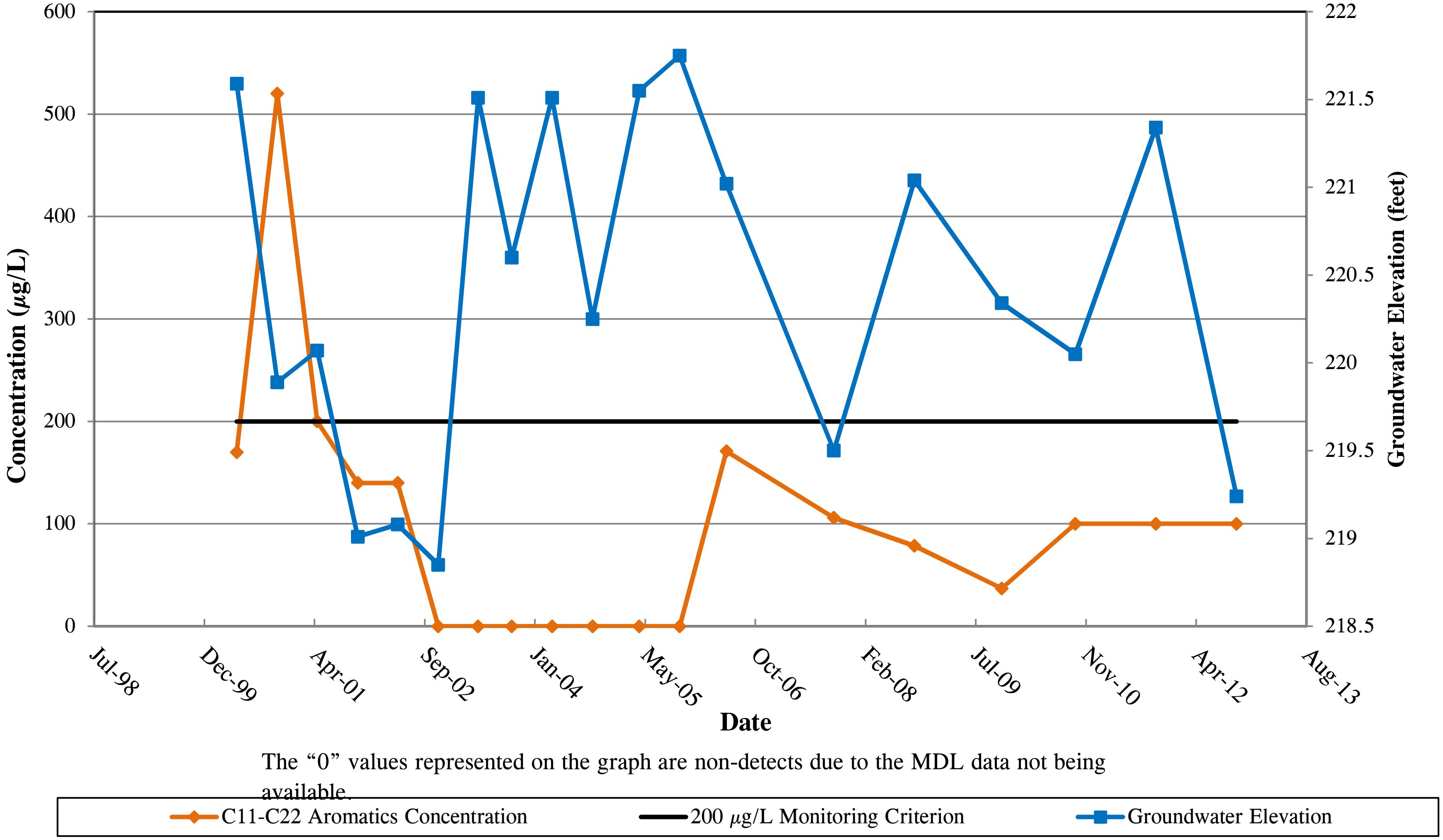
The “0” values represented on the graph are non-detects due to the MDL data not being available.

Groundwater Elevation and Analyte Concentrations
C_{11}-C_{22} Aromatics
Area of Contamination 69W
69W-94-13



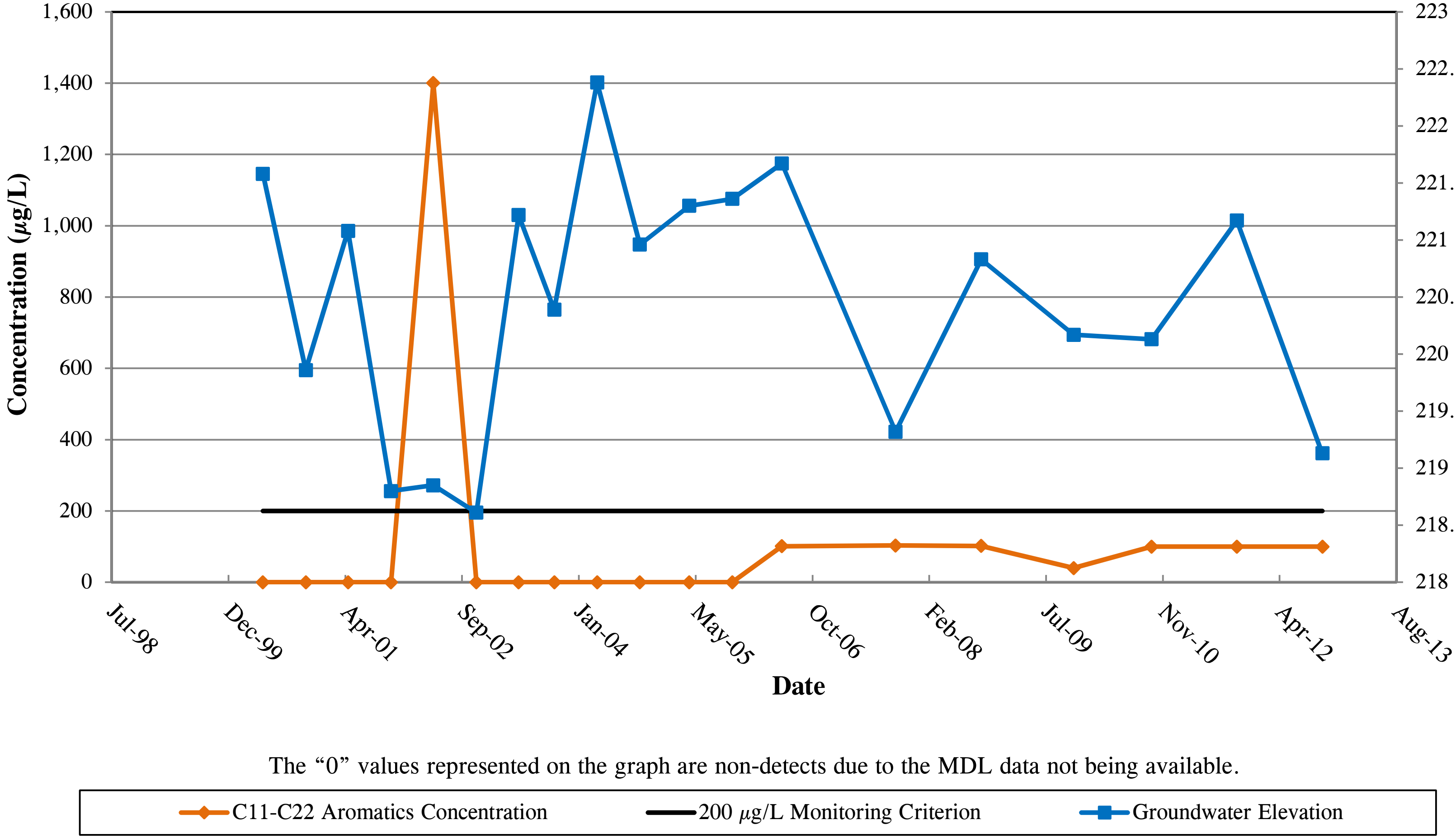
The “0” values represented on the graph are non-detects due to the MDL data not being available.

Groundwater Elevation and Analyte Concentrations
C_{11}-C_{22} Aromatics
Area of Contamination 69W
ZWM-99-23X



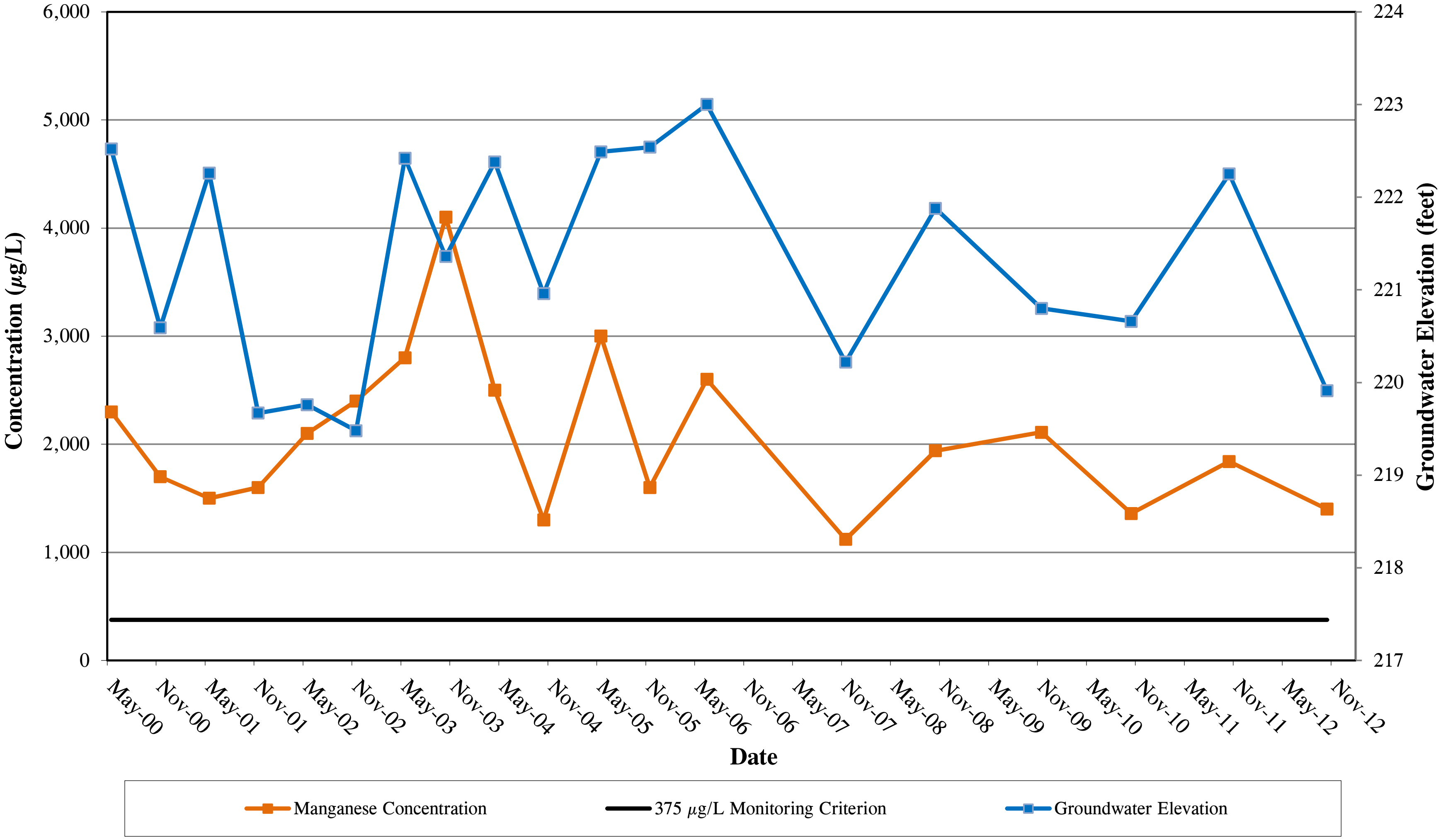
The “0” values represented on the graph are non-detects due to the MDL data not being available.

Groundwater Elevation and Analyte Concentrations
C_{11}-C_{22} Aromatics
Area of Contamination 69W
ZWM-95-15X

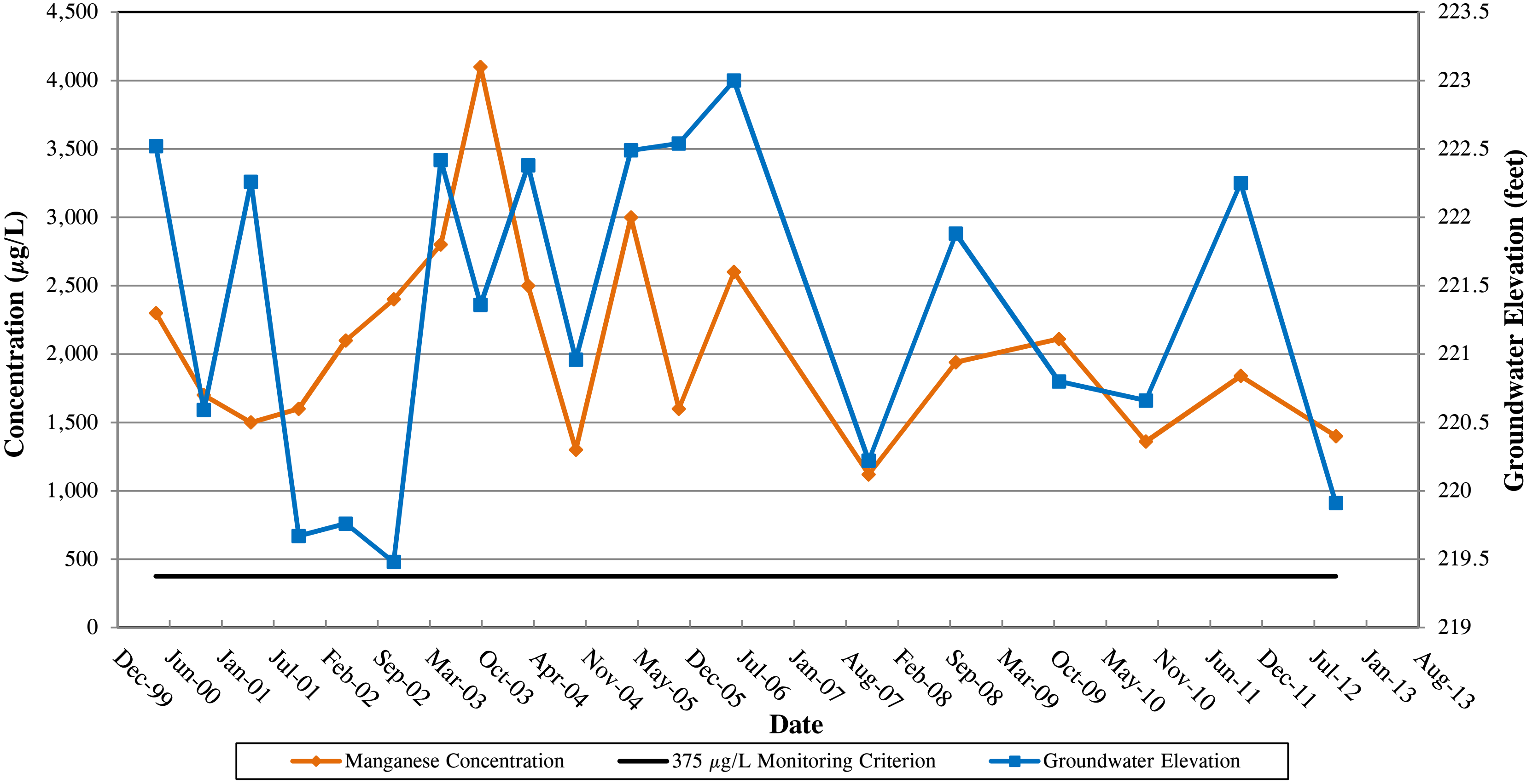


The “0” values represented on the graph are non-detects due to the MDL data not being available.

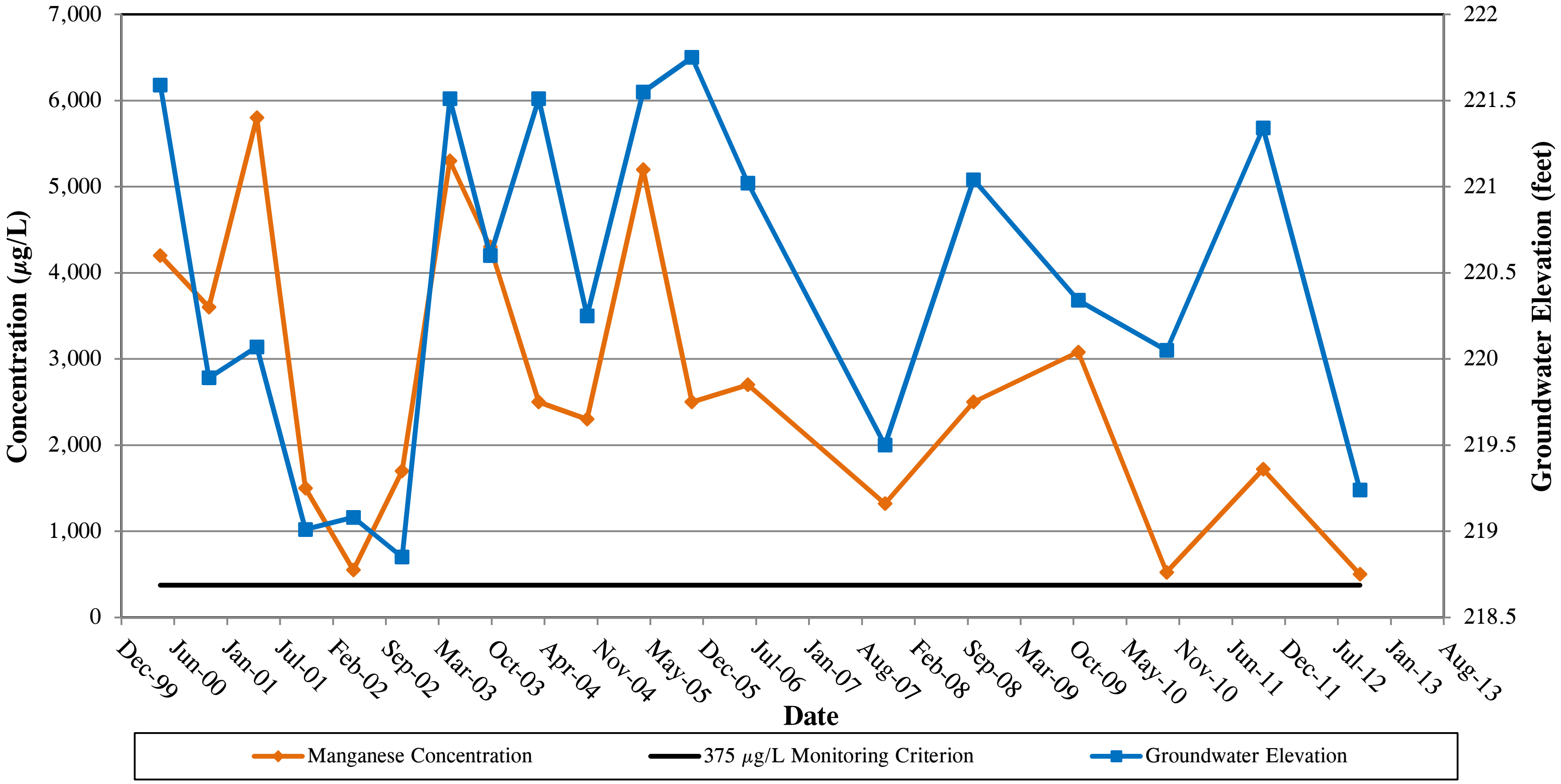
Groundwater Elevation and Analyte Concentrations
Manganese
Area of Contamination 69W
ZWM-99-22X



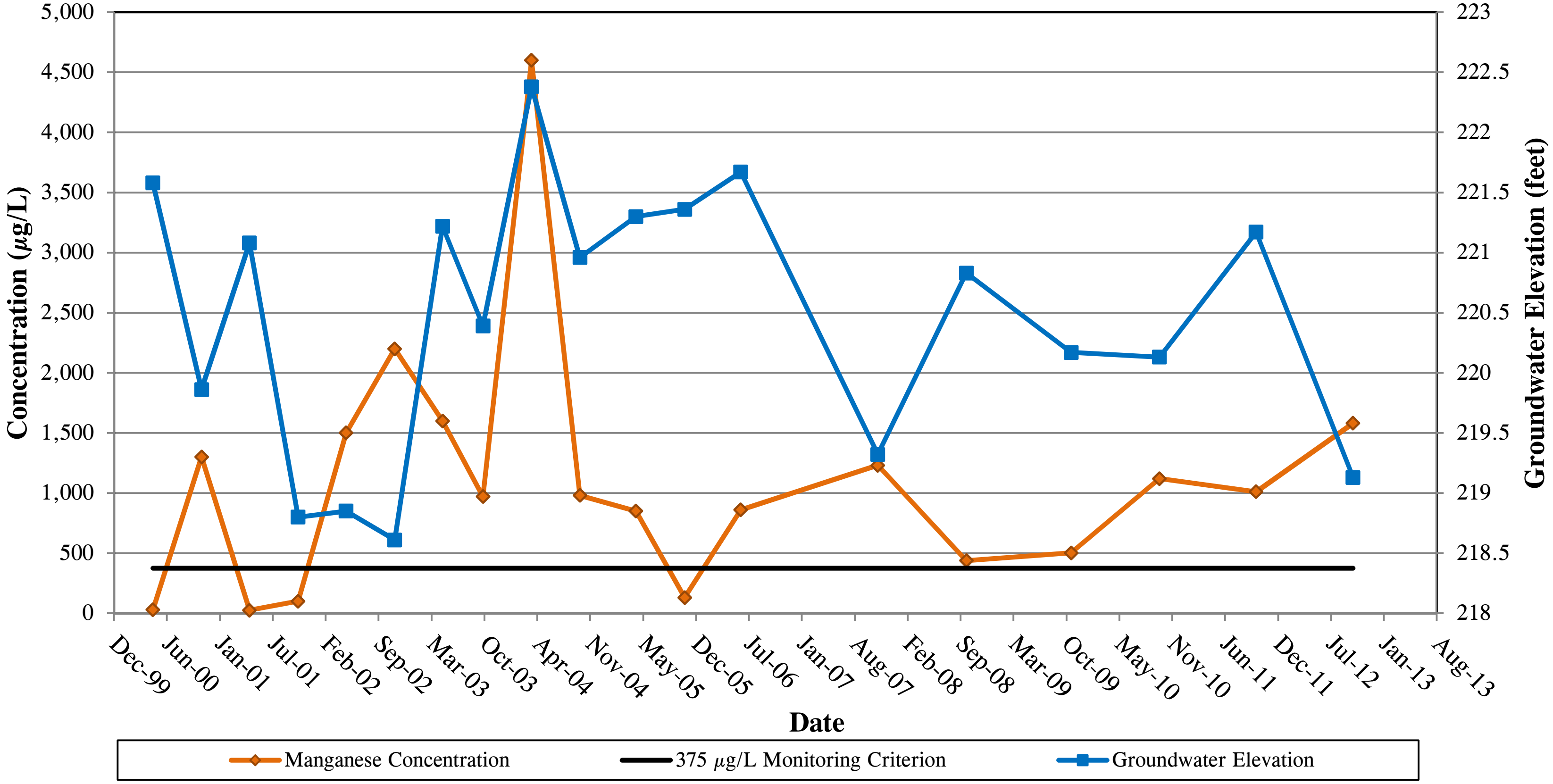
Groundwater Elevation and Analyte Concentration
Manganese
Area of Contamination 69W
69W-94-13



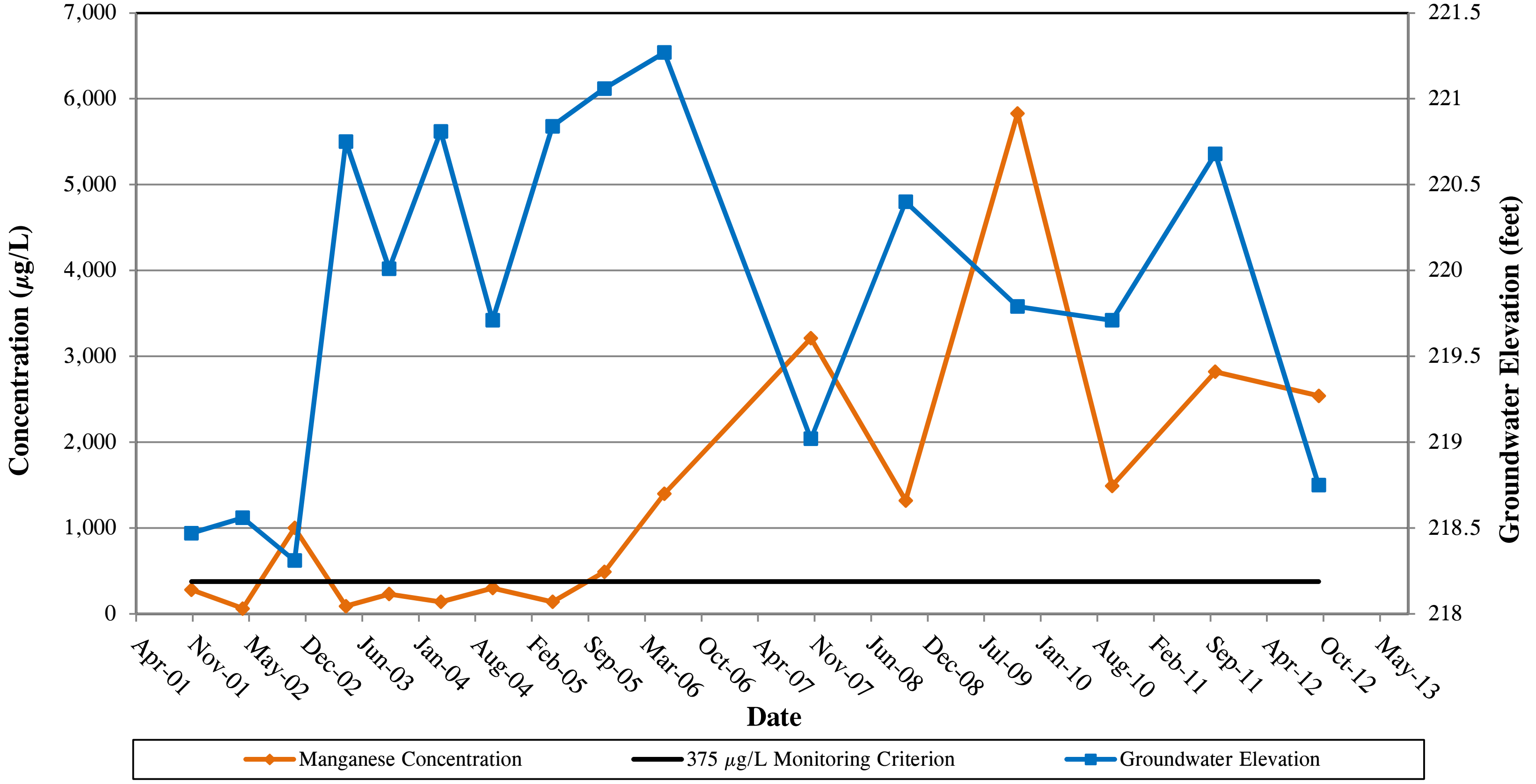
Groundwater Elevation and Analyte Concentrations
Manganese
Area of Contamination 69W
ZWM-99-23X



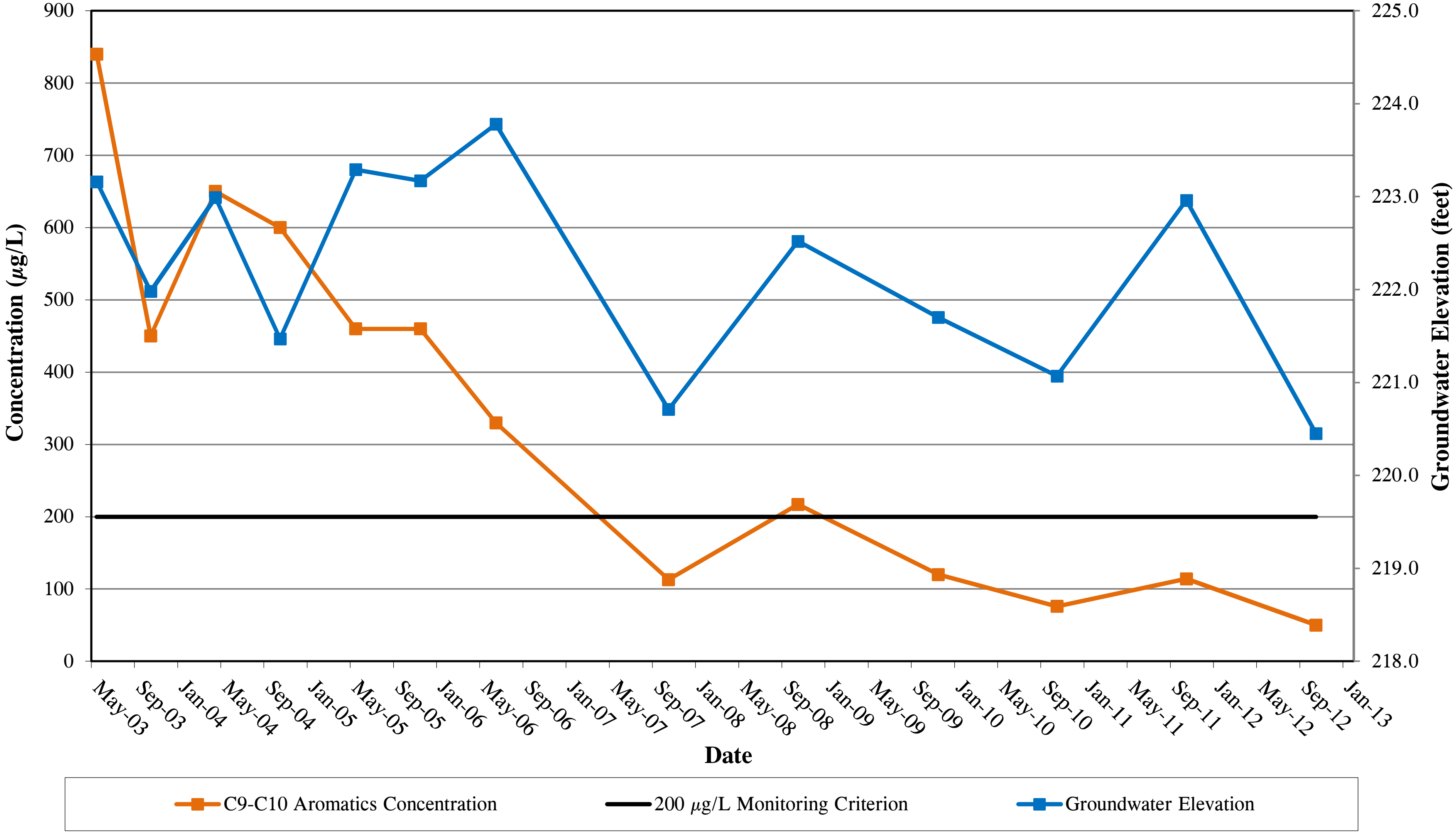
Groundwater Elevation and Analyte Concentrations
Manganese
Area of Contamination 69W
ZWM-95-15X



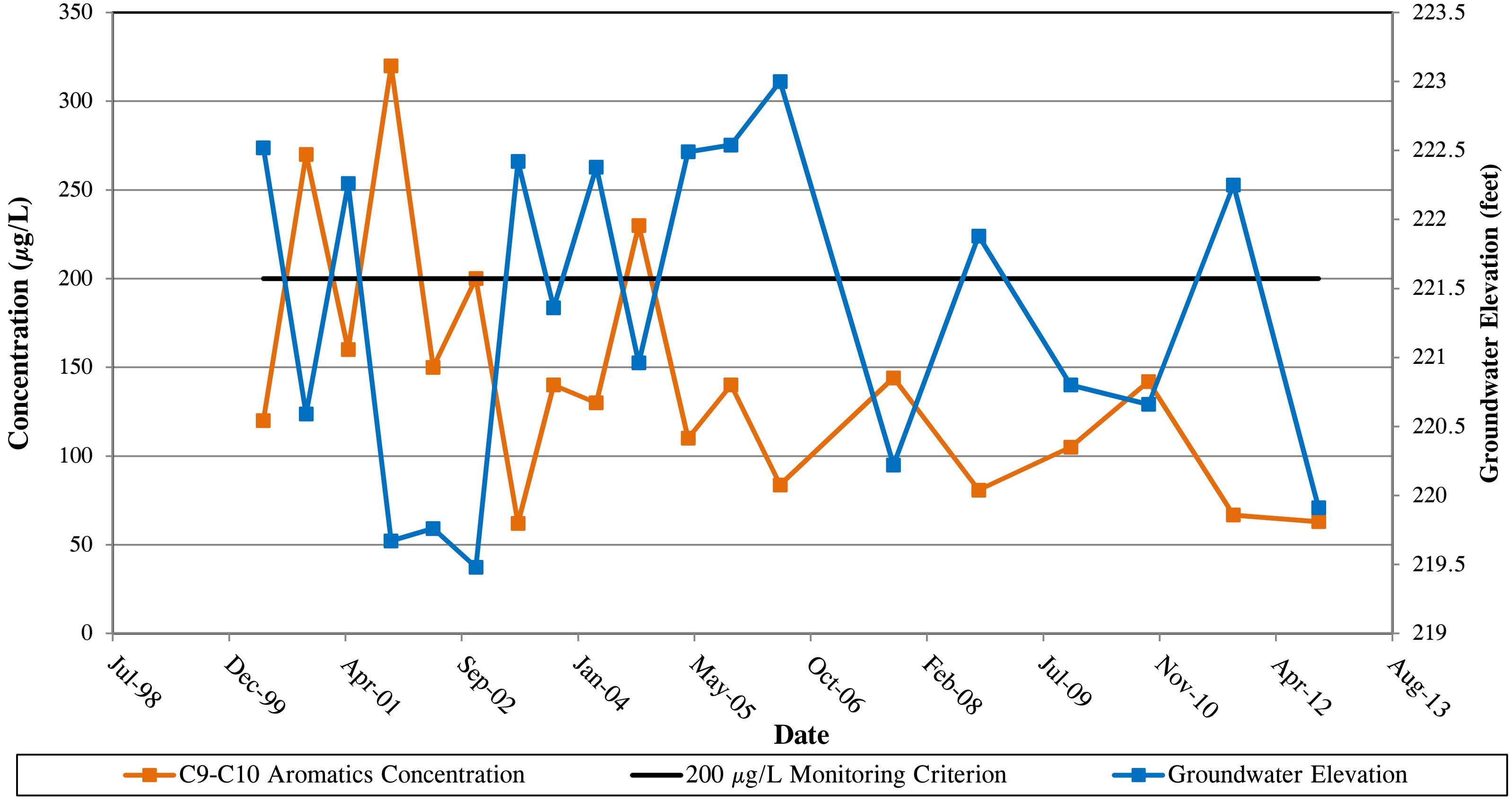
Groundwater Elevation and Analyte Concentrations
Manganese
Area of Contamination 69W
ZWM-01-25X



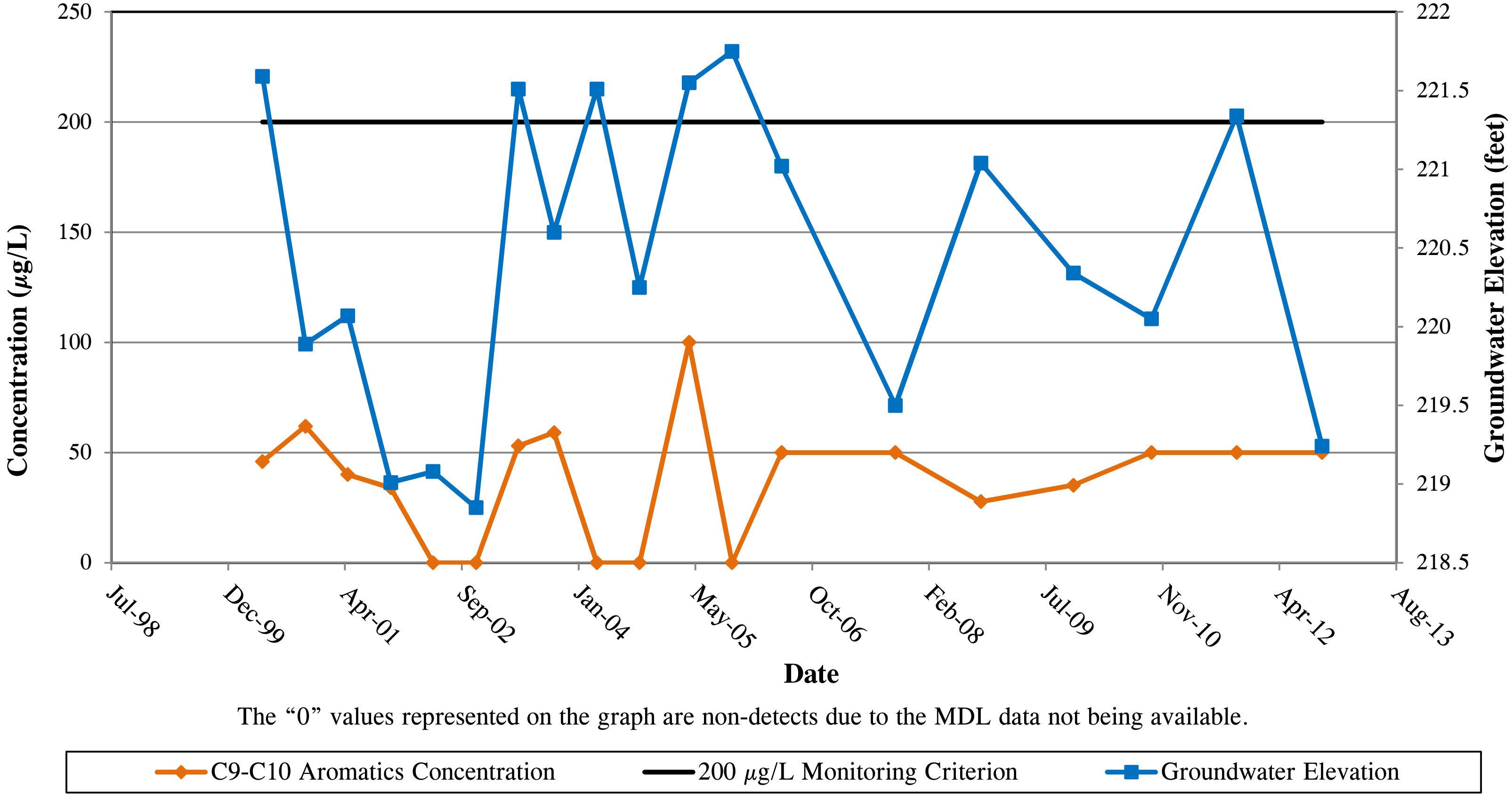
Groundwater Elevation and Analyte Concentrations
C_9-C_{10} Aromatics
Area of Contamination 69W
ZWM-99-22X



Groundwater Elevation and Analyte Concentrations
C_9-C_{10} Aromatics
Area of Contamination 69W
69W-94-13



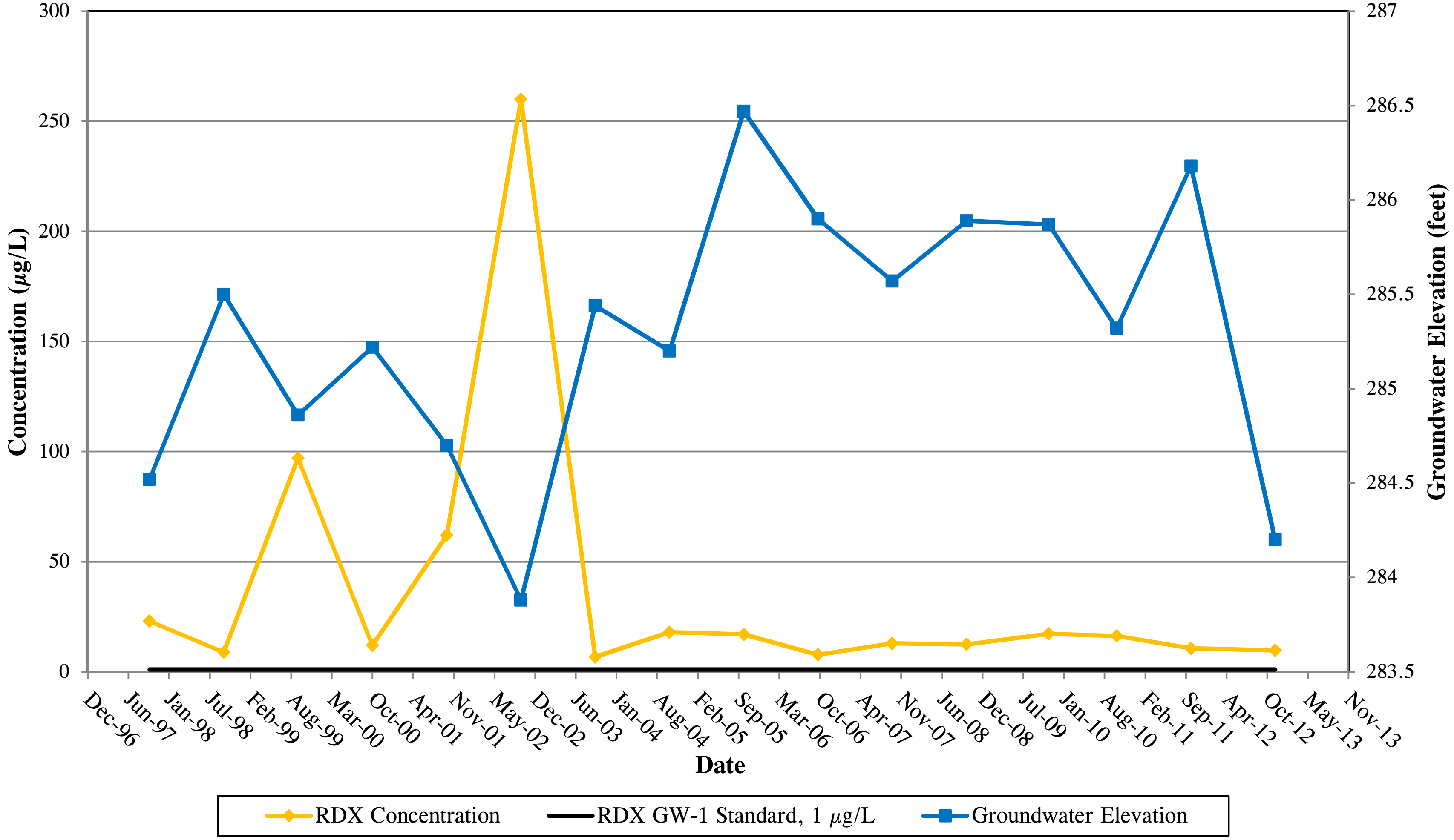
Groundwater Elevation and Analyte Concentrations
C_9-C_{10} Aromatics
Area of Contamination 69W
ZWM-99-23X



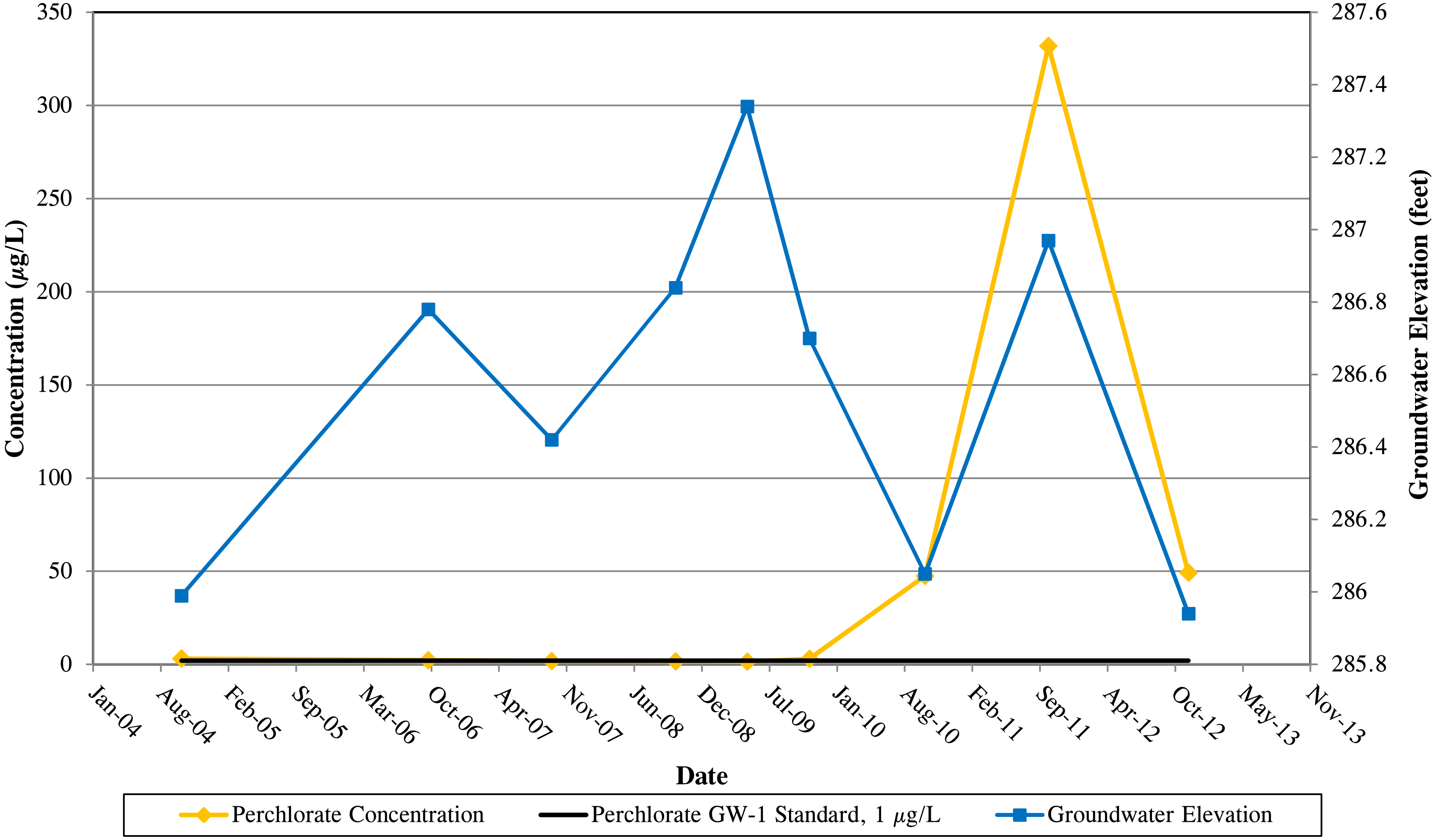
The “0” values represented on the graph are non-detects due to the MDL data not being available.

SPIA

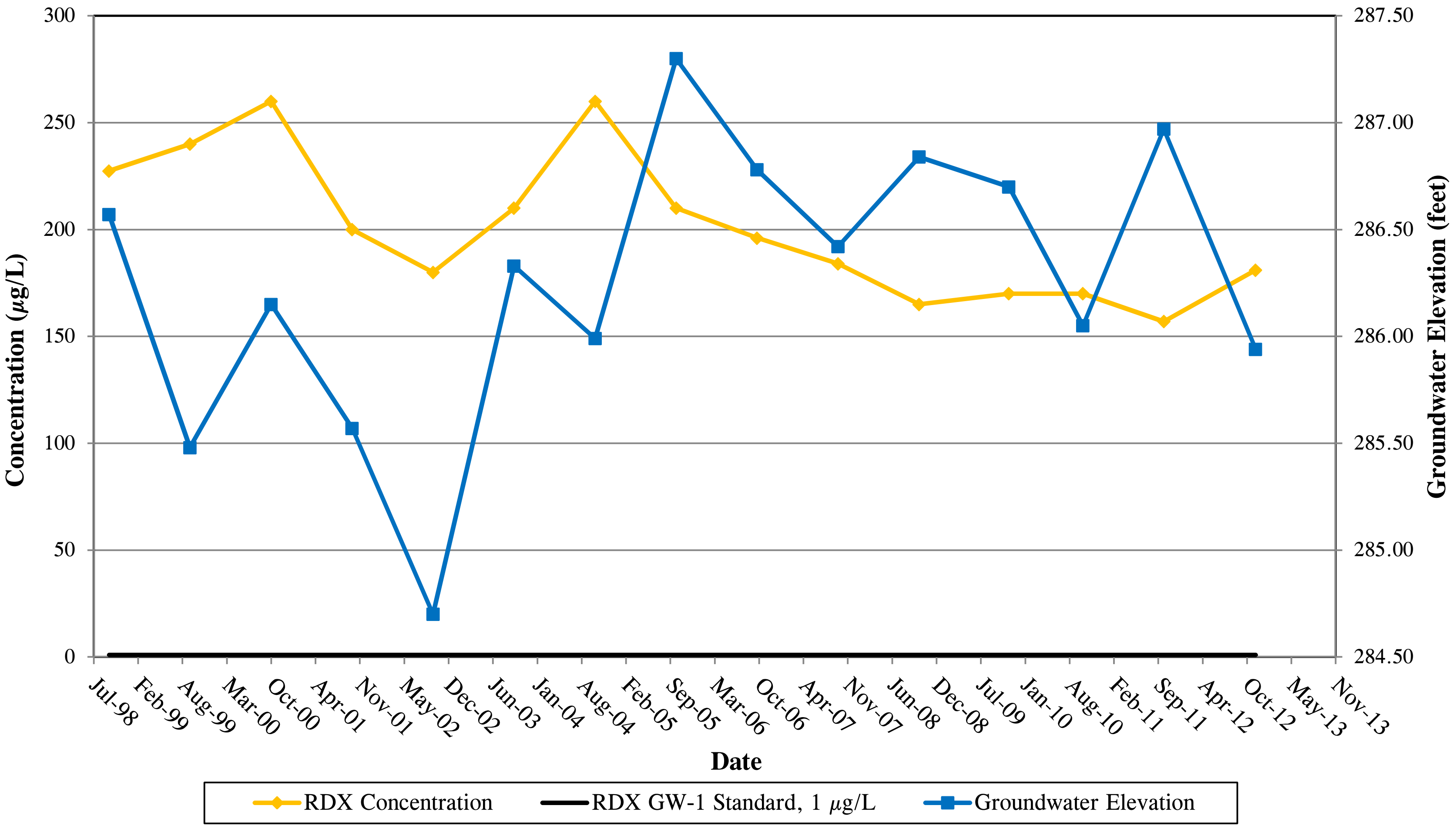
Groundwater Elevation and Analyte Concentrations
RDX
SPIA
26M-92-03X



Groundwater Elevation and Analyte Concentrations
Perchlorate
SPIA
26M-92-04X

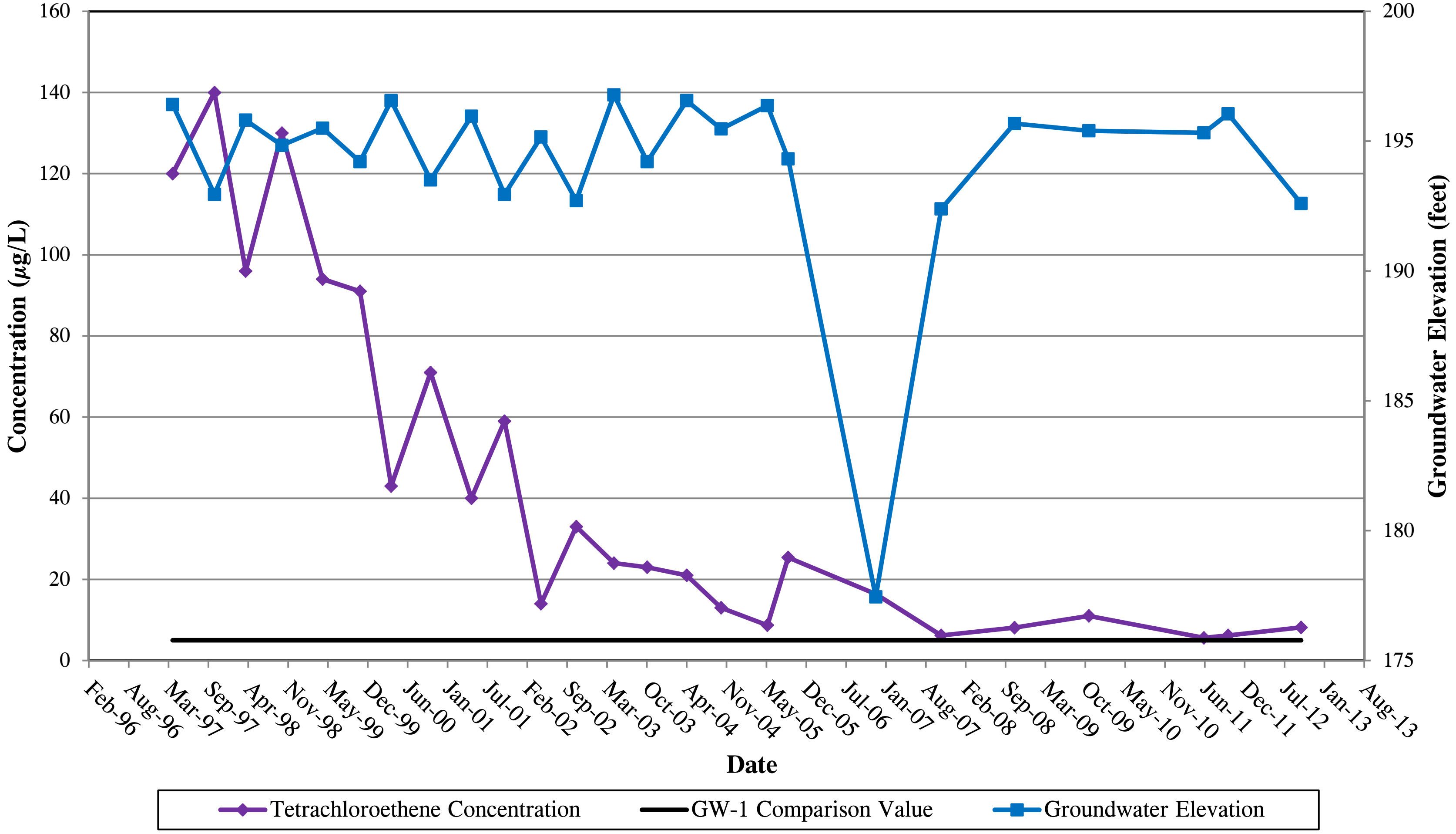


Groundwater Elevation and Analyte Concentrations
RDX
SPIA
26M-92-04X

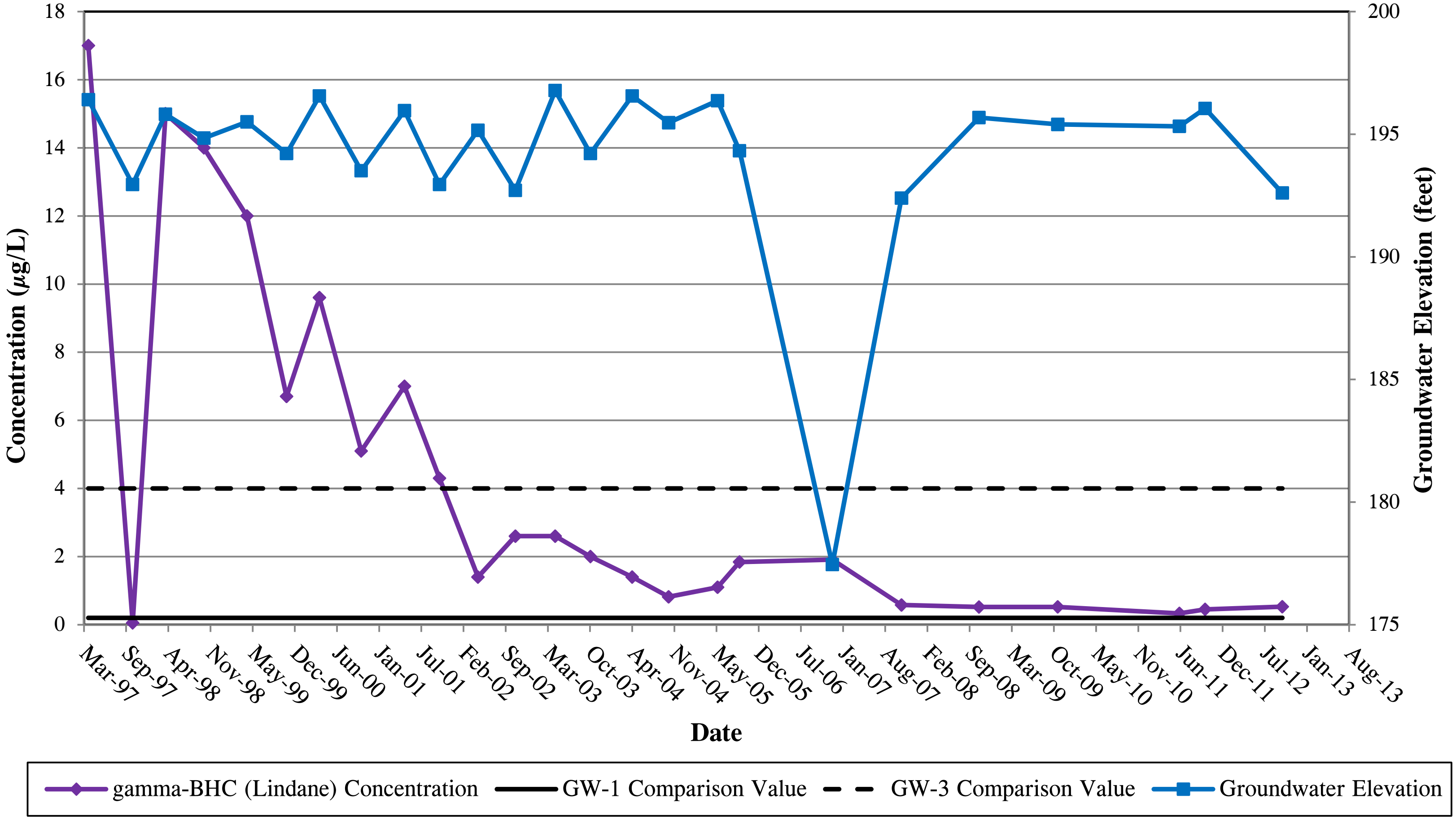


SUDBURY

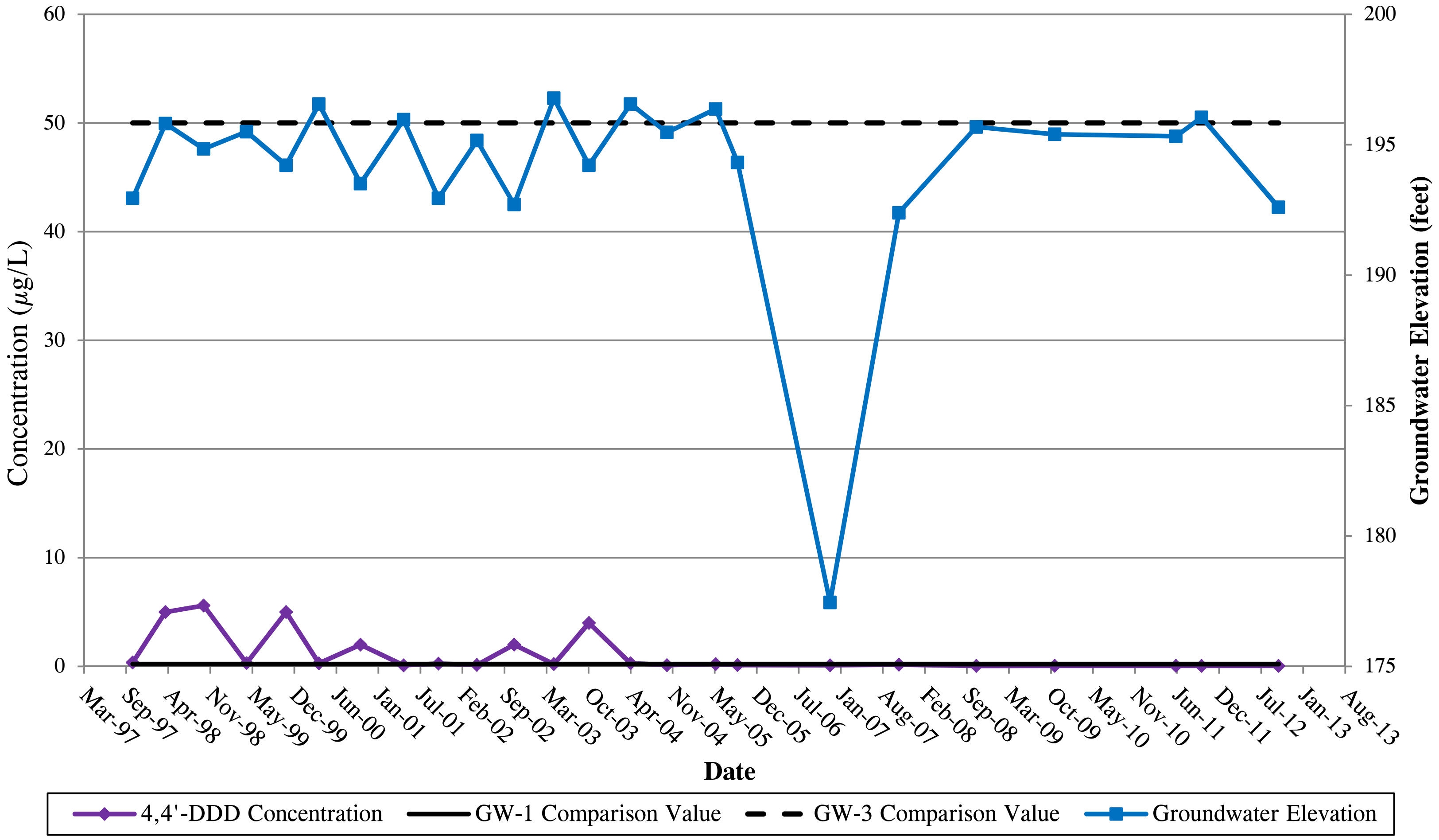
Groundwater Elevation and Analyte Concentrations
Tetrachloroethene
Sudbury Landfill - AOC A7
OHM-A7-08



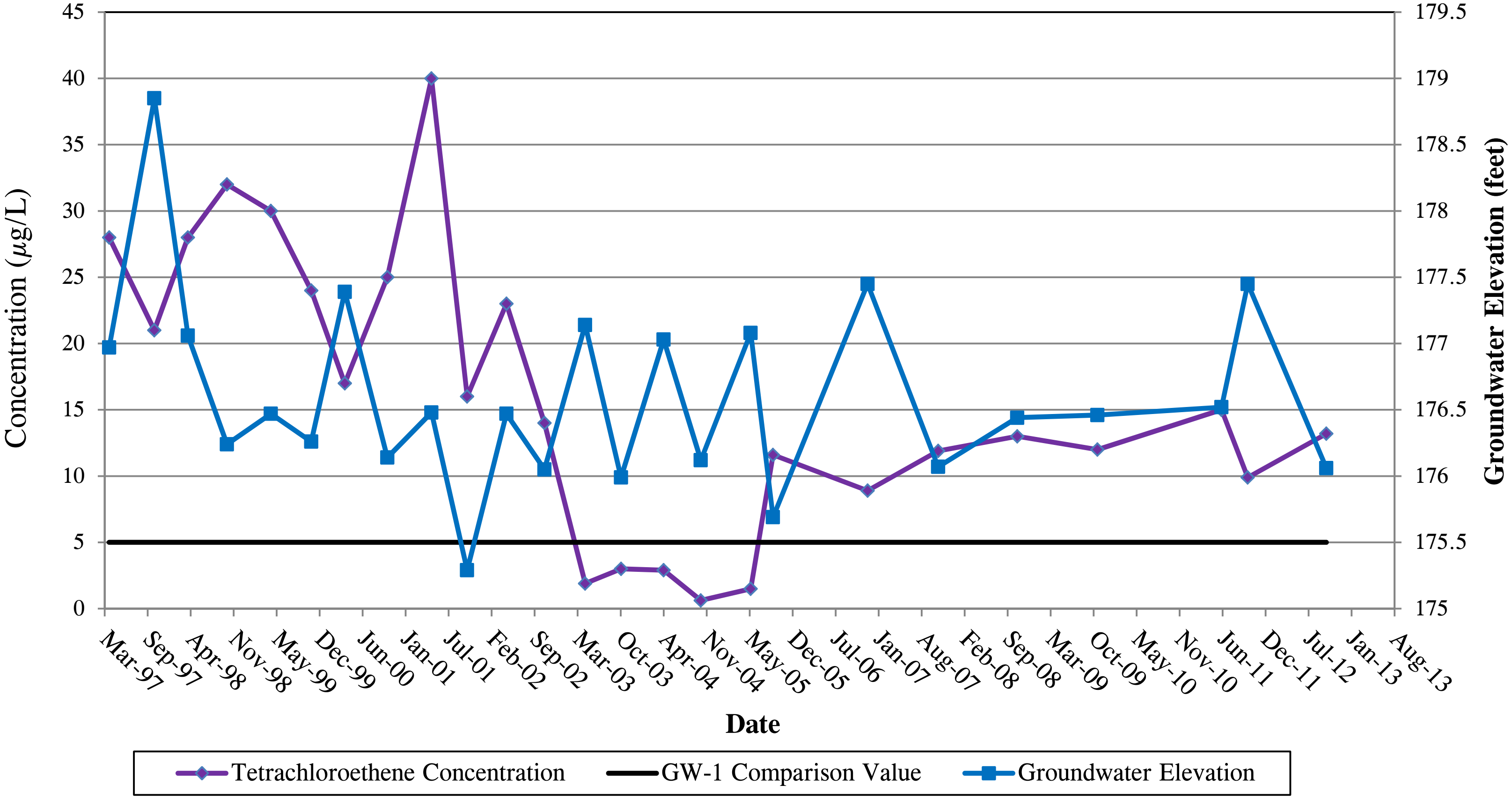
Groundwater Elevation and Analyte Concentrations
gamma-BHC (Lindane)
Sudbury Landfill - AOC A7
OHM-A7-08



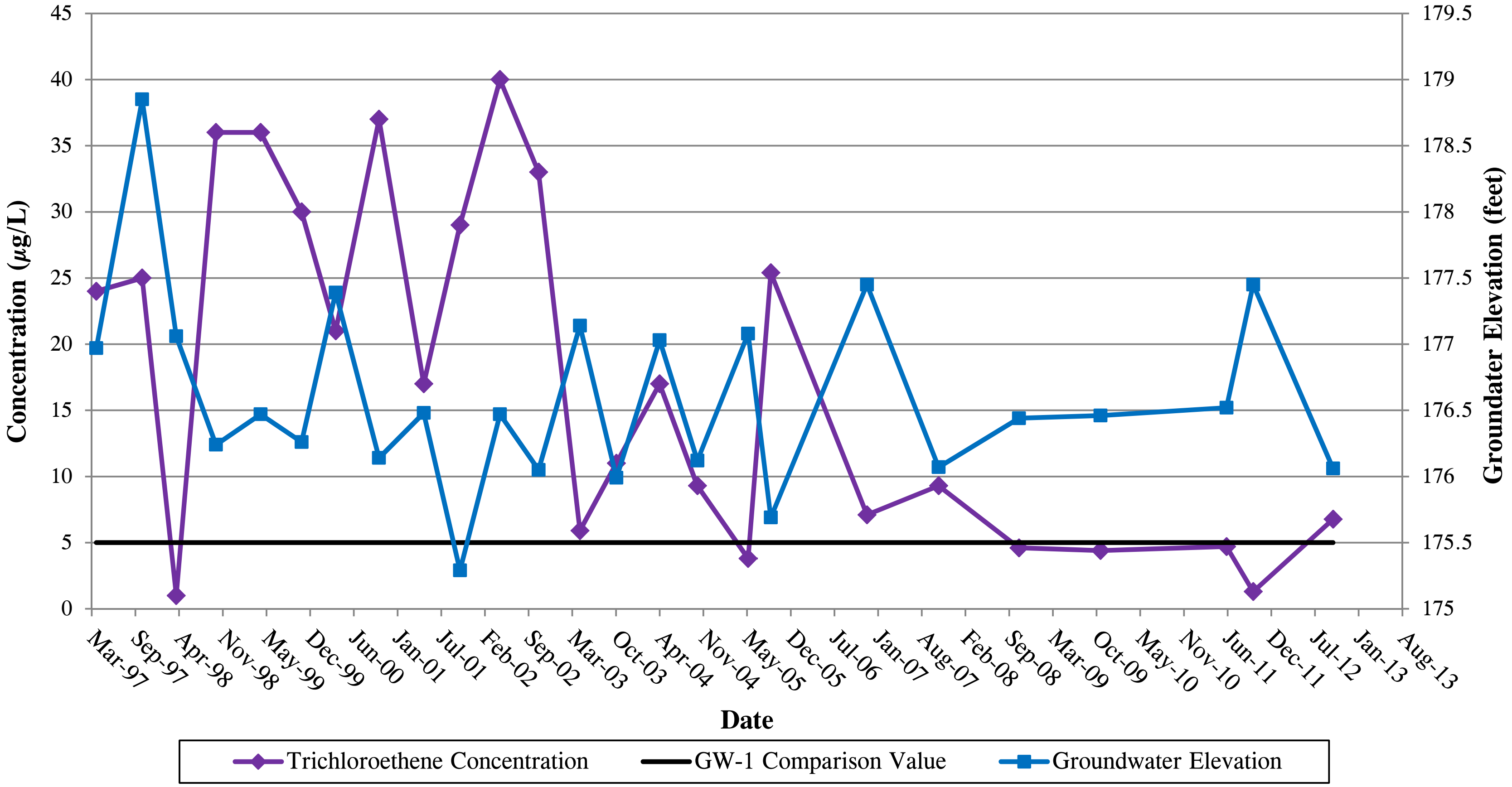
Groundwater Elevation and Analyte Concentrations
4,4'-DDD
Sudbury Landfill - AOC A7
OHM-A7-08



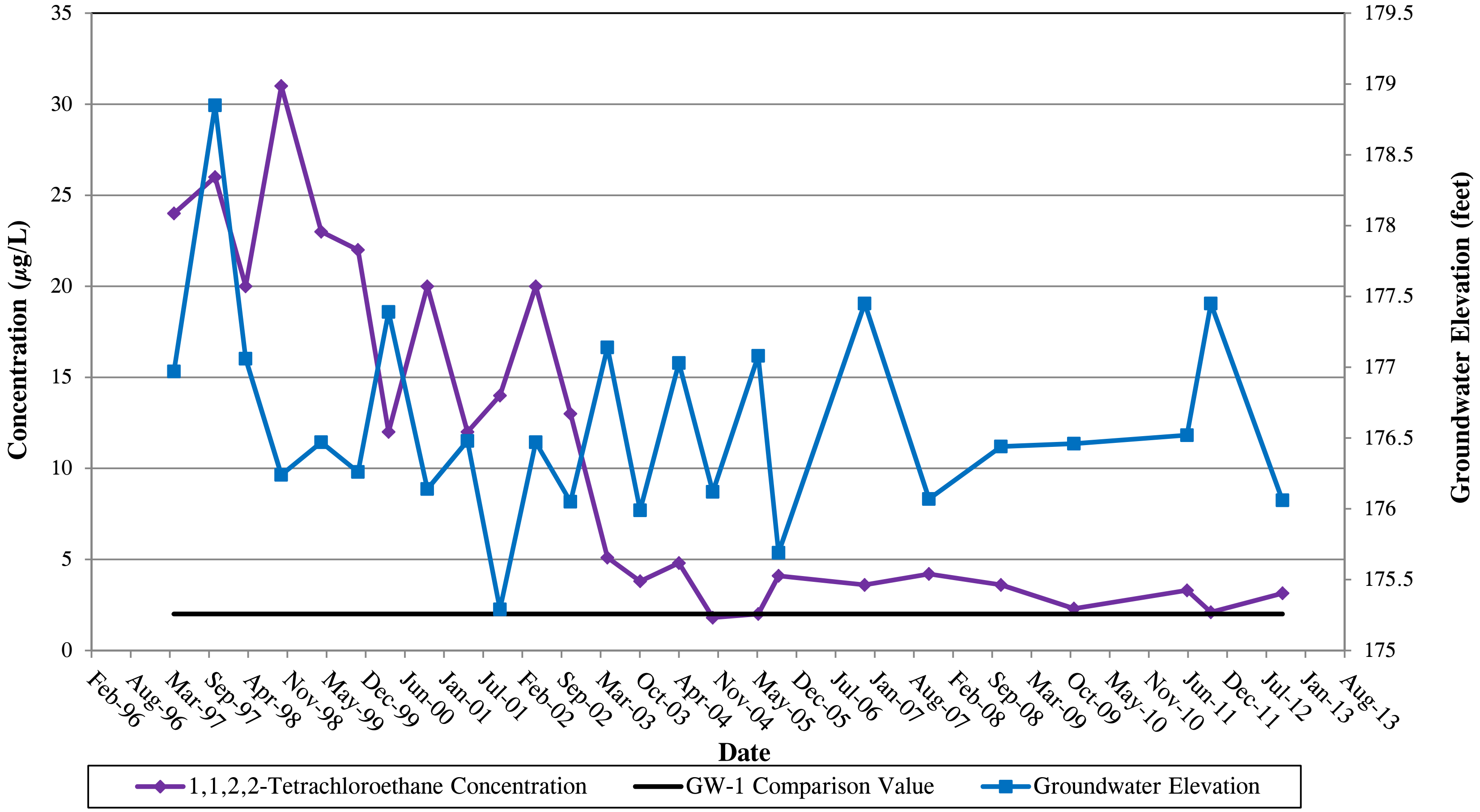
Groundwater Elevation and Analyte Concentrations
Tetrachloroethene
Sudbury Landfill - AOC A7
JO-A07-M63/SUD-A07-065 ('07 and beyond)



Groundwater Elevation and Analyte Concentrations
Trichloroethene
Sudbury Landfill - AOC A7
JO-A07-M63 SUD-A07-065 ('07 and beyond)



Groundwater Elevation and Analyte Concentrations
1,1,2,2-Tetrachloroethane
Sudbury Landfill - AOC A7
JO-A07-M63/SUD-A07-065 ('07 and beyond)



ATTACHMENT C

MANN-KENDALL STATISTICAL RESULTS

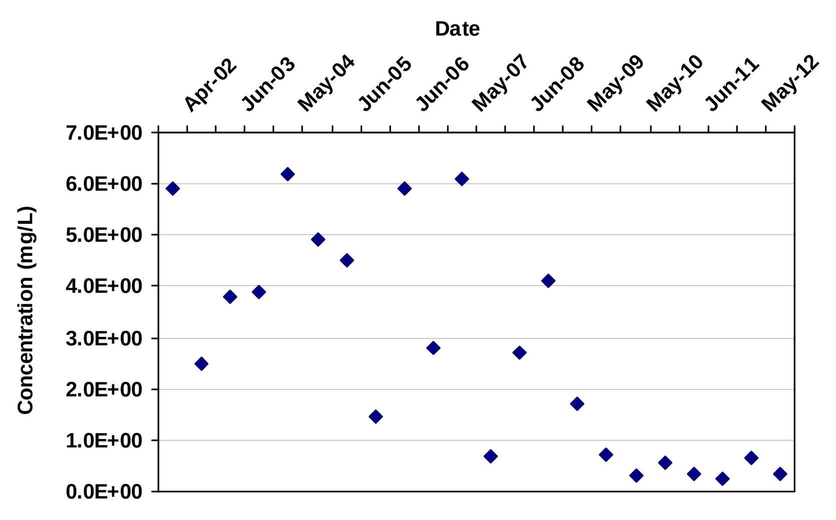
Key for Mann-Kendall Naming Convention Inconsistencies	
Actual analyte name in document	**Mann-Kendall Output Name[1]**
Trichloroethene	Trichloroethylene (TCE)
Tetrachloroethene	Tetrachloroethylene (PCE)
Volatile Petroleum Hydrocarbons C9-C12	Volatile Petroleum Hydrocarbons C8-C12
Extractable Petroleum Hydrocarbons C11 – C22 Aromatics	C10-C12 Petroleum Hydrocarbons, Aromati
RDX	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine
4,4’-DDD	p,p-DDD

[1] Analyte names included in the Mann-Kendall analysis output pages were the closest names available in the associated database.

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Well:	32M-01-18XBR	**Time Period:**	4/1/2002 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	1,2-DICHLOROBENZENE	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-127

Confidence in Trend:

100.0%

Coefficient of Variation:

0.79

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	4/1/2002	1,2-DICHLOROBENZ	5.9E+00		1	1
32M-01-18XBR	S	10/1/2002	1,2-DICHLOROBENZ	2.5E+00		1	1
32M-01-18XBR	S	6/1/2003	1,2-DICHLOROBENZ	3.8E+00		1	1
32M-01-18XBR	S	12/1/2003	1,2-DICHLOROBENZ	3.9E+00		1	1
32M-01-18XBR	S	5/1/2004	1,2-DICHLOROBENZ	6.2E+00		1	1
32M-01-18XBR	S	10/1/2004	1,2-DICHLOROBENZ	4.9E+00		1	1
32M-01-18XBR	S	6/1/2005	1,2-DICHLOROBENZ	4.5E+00		1	1
32M-01-18XBR	S	10/1/2005	1,2-DICHLOROBENZ	1.5E+00		1	1
32M-01-18XBR	S	6/8/2006	1,2-DICHLOROBENZ	5.9E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	10/17/2006	1,2-DICHLOROBENZ	2.8E+00		1	1
32M-01-18XBR	S	5/7/2007	1,2-DICHLOROBENZ	6.1E+00		1	1
32M-01-18XBR	S	10/24/2007	1,2-DICHLOROBENZ	6.9E-01		1	1
32M-01-18XBR	S	6/1/2008	1,2-DICHLOROBENZ	2.7E+00		1	1
32M-01-18XBR	S	10/1/2008	1,2-DICHLOROBENZ	4.1E+00		1	1
32M-01-18XBR	S	5/1/2009	1,2-DICHLOROBENZ	1.7E+00		1	1
32M-01-18XBR	S	11/1/2009	1,2-DICHLOROBENZ	7.3E-01		1	1
32M-01-18XBR	S	5/1/2010	1,2-DICHLOROBENZ	3.0E-01		1	1
32M-01-18XBR	S	10/1/2010	1,2-DICHLOROBENZ	5.7E-01		1	1
32M-01-18XBR	S	6/1/2011	1,2-DICHLOROBENZ	3.4E-01		1	1
32M-01-18XBR	S	10/1/2011	1,2-DICHLOROBENZ	2.6E-01		1	1
32M-01-18XBR	S	5/1/2012	1,2-DICHLOROBENZ	6.4E-01		1	1
32M-01-18XBR	S	10/1/2012	1,2-DICHLOROBENZ	3.4E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well: 32M-01-18XBR

Well Type: S

COC: 1,3-DICHLOROBENZENE

Time Period: 4/1/2002 **to** 10/1/2012

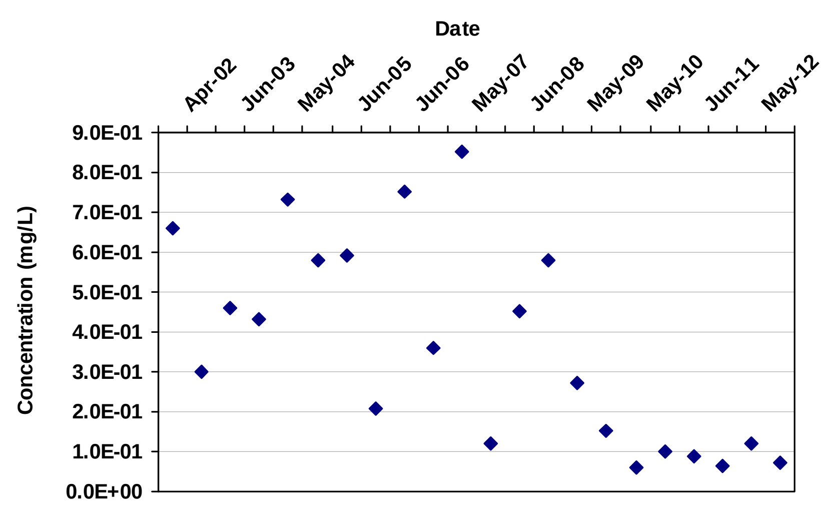
Consolidation Period: No Time Consolidation

Duplicate Consolidation: Median

Consolidation Type: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

-115

Confidence in Trend:

100.0%

Coefficient of Variation:

0.71

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	4/1/2002	1,3-DICHLOROBENZ	6.6E-01		1	1
32M-01-18XBR	S	10/1/2002	1,3-DICHLOROBENZ	3.0E-01		1	1
32M-01-18XBR	S	6/1/2003	1,3-DICHLOROBENZ	4.6E-01		1	1
32M-01-18XBR	S	12/1/2003	1,3-DICHLOROBENZ	4.3E-01		1	1
32M-01-18XBR	S	5/1/2004	1,3-DICHLOROBENZ	7.3E-01		1	1
32M-01-18XBR	S	10/1/2004	1,3-DICHLOROBENZ	5.8E-01		1	1
32M-01-18XBR	S	6/1/2005	1,3-DICHLOROBENZ	5.9E-01		1	1
32M-01-18XBR	S	10/1/2005	1,3-DICHLOROBENZ	2.1E-01		1	1
32M-01-18XBR	S	6/8/2006	1,3-DICHLOROBENZ	7.5E-01		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	10/17/2006	1,3-DICHLOROBENZ	3.6E-01		1	1
32M-01-18XBR	S	5/7/2007	1,3-DICHLOROBENZ	8.5E-01		1	1
32M-01-18XBR	S	10/24/2007	1,3-DICHLOROBENZ	1.2E-01		1	1
32M-01-18XBR	S	6/1/2008	1,3-DICHLOROBENZ	4.5E-01		1	1
32M-01-18XBR	S	10/1/2008	1,3-DICHLOROBENZ	5.8E-01		1	1
32M-01-18XBR	S	5/1/2009	1,3-DICHLOROBENZ	2.7E-01		1	1
32M-01-18XBR	S	11/1/2009	1,3-DICHLOROBENZ	1.5E-01		1	1
32M-01-18XBR	S	5/1/2010	1,3-DICHLOROBENZ	5.9E-02		1	1
32M-01-18XBR	S	10/1/2010	1,3-DICHLOROBENZ	1.0E-01		1	1
32M-01-18XBR	S	6/1/2011	1,3-DICHLOROBENZ	8.6E-02		1	1
32M-01-18XBR	S	10/1/2011	1,3-DICHLOROBENZ	6.4E-02		1	1
32M-01-18XBR	S	5/1/2012	1,3-DICHLOROBENZ	1.2E-01		1	1
32M-01-18XBR	S	10/1/2012	1,3-DICHLOROBENZ	7.0E-02		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

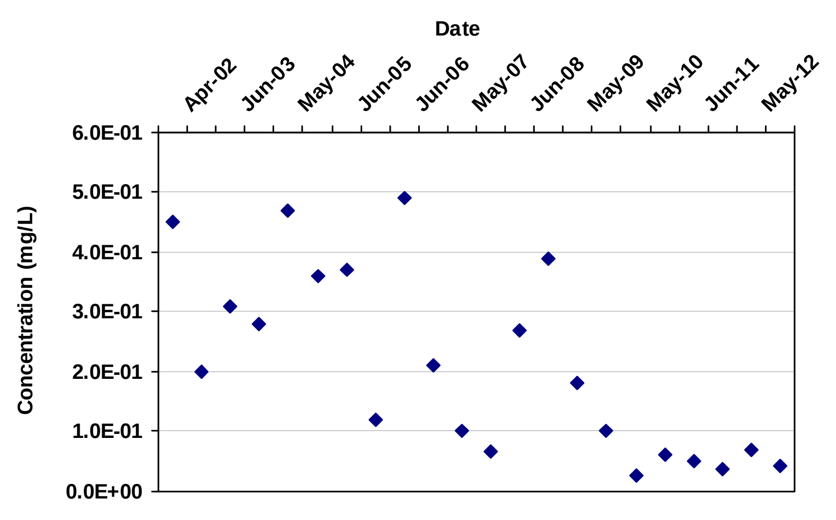
Project: AOC 32-43A, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well:	32M-01-18XBR	**Time Period:**	4/1/2002 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	1,4-DICHLOROBENZENE	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-126

Confidence in Trend:

100.0%

Coefficient of Variation:

0.74

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	4/1/2002	1,4-DICHLOROBENZ	4.5E-01		1	1
32M-01-18XBR	S	10/1/2002	1,4-DICHLOROBENZ	2.0E-01		1	1
32M-01-18XBR	S	6/1/2003	1,4-DICHLOROBENZ	3.1E-01		1	1
32M-01-18XBR	S	12/1/2003	1,4-DICHLOROBENZ	2.8E-01		1	1
32M-01-18XBR	S	5/1/2004	1,4-DICHLOROBENZ	4.7E-01		1	1
32M-01-18XBR	S	10/1/2004	1,4-DICHLOROBENZ	3.6E-01		1	1
32M-01-18XBR	S	6/1/2005	1,4-DICHLOROBENZ	3.7E-01		1	1
32M-01-18XBR	S	10/1/2005	1,4-DICHLOROBENZ	1.2E-01		1	1
32M-01-18XBR	S	6/8/2006	1,4-DICHLOROBENZ	4.9E-01		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	10/17/2006	1,4-DICHLOROBENZ	2.1E-01		1	1
32M-01-18XBR	S	5/7/2007	1,4-DICHLOROBENZ	1.0E-01		1	1
32M-01-18XBR	S	10/24/2007	1,4-DICHLOROBENZ	6.7E-02		1	1
32M-01-18XBR	S	6/1/2008	1,4-DICHLOROBENZ	2.7E-01		1	1
32M-01-18XBR	S	10/1/2008	1,4-DICHLOROBENZ	3.9E-01		1	1
32M-01-18XBR	S	5/1/2009	1,4-DICHLOROBENZ	1.8E-01		1	1
32M-01-18XBR	S	11/1/2009	1,4-DICHLOROBENZ	1.0E-01		1	1
32M-01-18XBR	S	5/1/2010	1,4-DICHLOROBENZ	2.6E-02		1	1
32M-01-18XBR	S	10/1/2010	1,4-DICHLOROBENZ	6.2E-02		1	1
32M-01-18XBR	S	6/1/2011	1,4-DICHLOROBENZ	5.0E-02		1	1
32M-01-18XBR	S	10/1/2011	1,4-DICHLOROBENZ	3.7E-02		1	1
32M-01-18XBR	S	5/1/2012	1,4-DICHLOROBENZ	6.9E-02		1	1
32M-01-18XBR	S	10/1/2012	1,4-DICHLOROBENZ	4.2E-02		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well: 32M-01-18XBR

Well Type: S

COC: C12-C16 PETROLEUM HYDROCARB

Time Period: 4/1/2002 **to** 10/1/2012

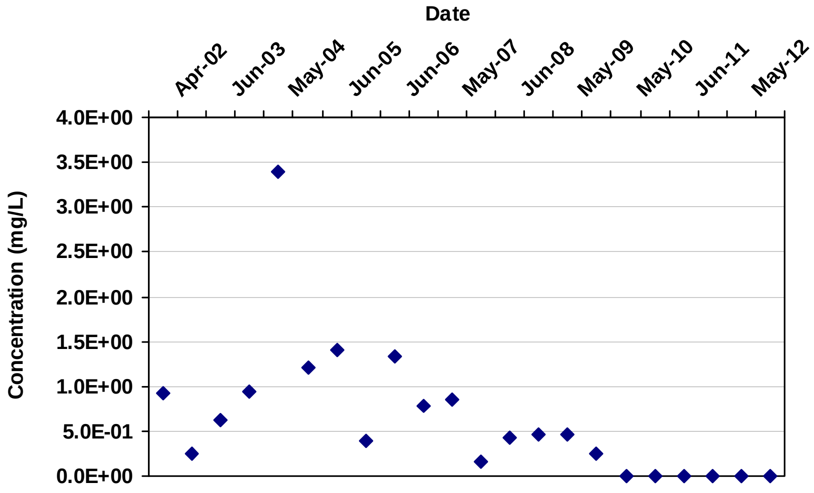
Consolidation Period: No Time Consolidation

Duplicate Consolidation: Median

Consolidation Type: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

-126

Confidence in Trend:

100.0%

Coefficient of Variation:

1.22

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	4/1/2002	C12-C16 PETROLEU	9.2E-01		1	1
32M-01-18XBR	S	10/1/2002	C12-C16 PETROLEU	2.4E-01		1	1
32M-01-18XBR	S	6/1/2003	C12-C16 PETROLEU	6.2E-01		1	1
32M-01-18XBR	S	12/1/2003	C12-C16 PETROLEU	9.4E-01		1	1
32M-01-18XBR	S	5/1/2004	C12-C16 PETROLEU	3.4E+00		1	1
32M-01-18XBR	S	10/1/2004	C12-C16 PETROLEU	1.2E+00		1	1
32M-01-18XBR	S	6/1/2005	C12-C16 PETROLEU	1.4E+00		1	1
32M-01-18XBR	S	10/1/2005	C12-C16 PETROLEU	4.0E-01		1	1
32M-01-18XBR	S	6/8/2006	C12-C16 PETROLEU	1.3E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	10/17/2006	C12-C16 PETROLEU	7.9E-01		1	1
32M-01-18XBR	S	5/7/2007	C12-C16 PETROLEU	8.5E-01		1	1
32M-01-18XBR	S	10/24/2007	C12-C16 PETROLEU	1.6E-01		1	1
32M-01-18XBR	S	6/1/2008	C12-C16 PETROLEU	4.3E-01		1	1
32M-01-18XBR	S	10/1/2008	C12-C16 PETROLEU	4.6E-01		1	1
32M-01-18XBR	S	5/1/2009	C12-C16 PETROLEU	4.7E-01		1	1
32M-01-18XBR	S	11/1/2009	C12-C16 PETROLEU	2.5E-01		1	1
32M-01-18XBR	S	5/1/2010	C12-C16 PETROLEU	5.0E-08	ND	1	0
32M-01-18XBR	S	10/1/2010	C12-C16 PETROLEU	5.0E-08	ND	1	0
32M-01-18XBR	S	6/1/2011	C12-C16 PETROLEU	5.0E-08	ND	1	0
32M-01-18XBR	S	10/1/2011	C12-C16 PETROLEU	5.0E-08	ND	1	0
32M-01-18XBR	S	5/1/2012	C12-C16 PETROLEU	5.0E-08	ND	1	0
32M-01-18XBR	S	10/1/2012	C12-C16 PETROLEU	5.0E-08	ND	1	0

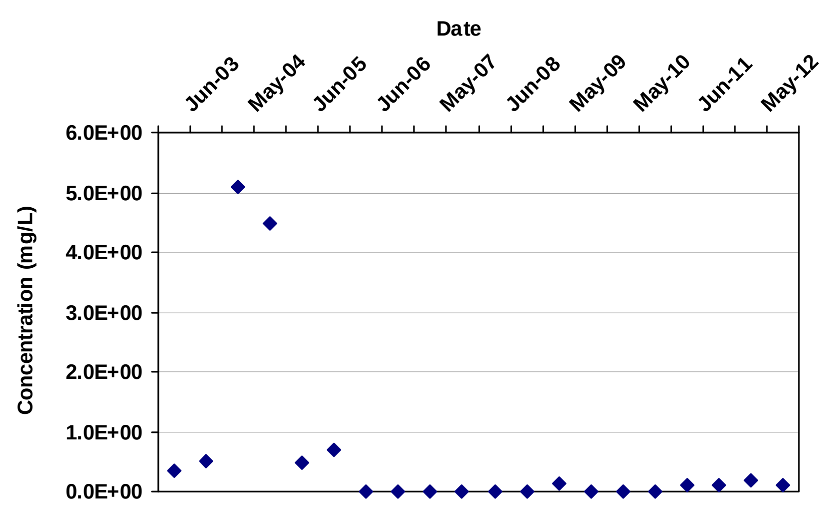
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Well: 32M-01-18XBR
Well Type: S
COC: C8-C10 PETROLEUM HYDROCARB

Time Period: 4/1/2002 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Duplicate Consolidation: Median
Consolidation Type: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

-44

Confidence in Trend:

91.8%

Coefficient of Variation:

2.37

Mann Kendall Concentration Trend: (See Note)

PD

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	6/1/2003	C8-C10 PETROLEUM	3.5E-01		1	1
32M-01-18XBR	S	12/1/2003	C8-C10 PETROLEUM	5.2E-01		1	1
32M-01-18XBR	S	5/1/2004	C8-C10 PETROLEUM	5.1E+00		1	1
32M-01-18XBR	S	10/1/2004	C8-C10 PETROLEUM	4.5E+00		1	1
32M-01-18XBR	S	6/1/2005	C8-C10 PETROLEUM	4.7E-01		1	1
32M-01-18XBR	S	10/1/2005	C8-C10 PETROLEUM	6.9E-01		1	1
32M-01-18XBR	S	6/8/2006	C8-C10 PETROLEUM	5.0E-08	ND	1	0
32M-01-18XBR	S	10/17/2006	C8-C10 PETROLEUM	5.0E-08	ND	1	0
32M-01-18XBR	S	5/7/2007	C8-C10 PETROLEUM	5.0E-08	ND	1	0

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

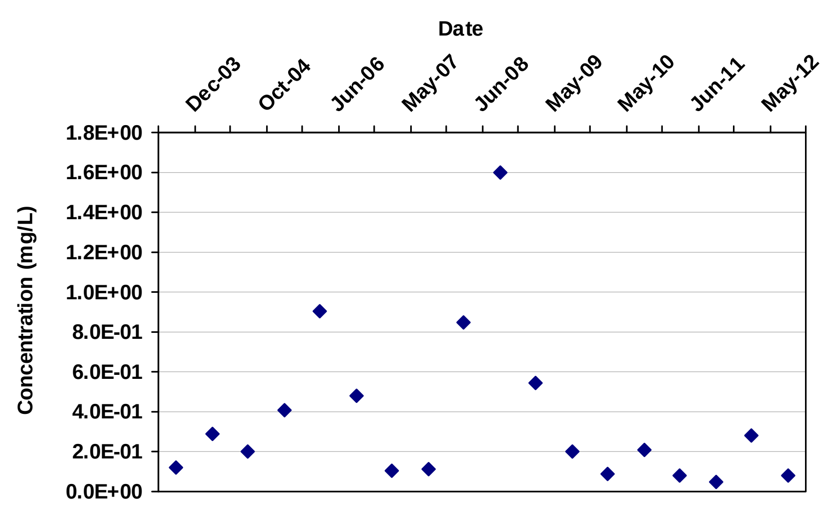
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	10/24/2007	C8-C10 PETROLEUM	5.0E-08	ND	1	0
32M-01-18XBR	S	6/1/2008	C8-C10 PETROLEUM	5.0E-08	ND	1	0
32M-01-18XBR	S	10/1/2008	C8-C10 PETROLEUM	5.0E-08	ND	1	0
32M-01-18XBR	S	5/1/2009	C8-C10 PETROLEUM	1.3E-01		1	1
32M-01-18XBR	S	11/1/2009	C8-C10 PETROLEUM	5.0E-08	ND	1	0
32M-01-18XBR	S	5/1/2010	C8-C10 PETROLEUM	5.0E-08	ND	1	0
32M-01-18XBR	S	10/1/2010	C8-C10 PETROLEUM	5.0E-08	ND	1	0
32M-01-18XBR	S	6/1/2011	C8-C10 PETROLEUM	1.0E-01		1	1
32M-01-18XBR	S	10/1/2011	C8-C10 PETROLEUM	1.1E-01		1	1
32M-01-18XBR	S	5/1/2012	C8-C10 PETROLEUM	1.8E-01		1	1
32M-01-18XBR	S	10/1/2012	C8-C10 PETROLEUM	1.0E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Well:	32M-01-18XBR	**Time Period:**	4/1/2002 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	CHLOROBENZENE	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-38

Confidence in Trend:

91.8%

Coefficient of Variation:

1.09

Mann Kendall Concentration Trend: (See Note)

PD

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	12/1/2003	CHLOROBENZENE	1.2E-01		1	1
32M-01-18XBR	S	5/1/2004	CHLOROBENZENE	2.9E-01		1	1
32M-01-18XBR	S	10/1/2004	CHLOROBENZENE	2.0E-01		1	1
32M-01-18XBR	S	6/1/2005	CHLOROBENZENE	4.1E-01		1	1
32M-01-18XBR	S	6/8/2006	CHLOROBENZENE	9.0E-01		1	1
32M-01-18XBR	S	10/17/2006	CHLOROBENZENE	4.8E-01		1	1
32M-01-18XBR	S	5/7/2007	CHLOROBENZENE	1.0E-01		1	1
32M-01-18XBR	S	10/24/2007	CHLOROBENZENE	1.1E-01		1	1
32M-01-18XBR	S	6/1/2008	CHLOROBENZENE	8.5E-01		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	10/1/2008	CHLOROBENZENE	1.6E+00		1	1
32M-01-18XBR	S	5/1/2009	CHLOROBENZENE	5.4E-01		1	1
32M-01-18XBR	S	11/1/2009	CHLOROBENZENE	2.0E-01		1	1
32M-01-18XBR	S	5/1/2010	CHLOROBENZENE	8.8E-02		1	1
32M-01-18XBR	S	10/1/2010	CHLOROBENZENE	2.1E-01		1	1
32M-01-18XBR	S	6/1/2011	CHLOROBENZENE	7.8E-02		1	1
32M-01-18XBR	S	10/1/2011	CHLOROBENZENE	4.9E-02		1	1
32M-01-18XBR	S	5/1/2012	CHLOROBENZENE	2.8E-01		1	1
32M-01-18XBR	S	10/1/2012	CHLOROBENZENE	8.2E-02		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well: 32M-01-18XBR

Well Type: S

COC: MANGANESE

Time Period: 4/1/2002 **to** 10/1/2012

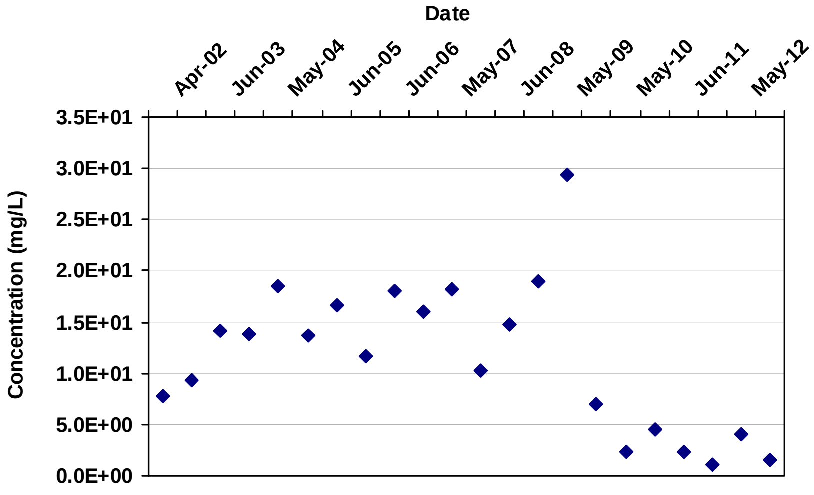
Consolidation Period: No Time Consolidation

Duplicate Consolidation: Median

Consolidation Type: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

-69

Confidence in Trend:

97.3%

Coefficient of Variation:

0.63

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	4/1/2002	MANGANESE	7.7E+00		1	1
32M-01-18XBR	S	10/1/2002	MANGANESE	9.3E+00		1	1
32M-01-18XBR	S	6/1/2003	MANGANESE	1.4E+01		1	1
32M-01-18XBR	S	12/1/2003	MANGANESE	1.4E+01		1	1
32M-01-18XBR	S	5/1/2004	MANGANESE	1.9E+01		1	1
32M-01-18XBR	S	10/1/2004	MANGANESE	1.4E+01		1	1
32M-01-18XBR	S	6/1/2005	MANGANESE	1.7E+01		1	1
32M-01-18XBR	S	10/1/2005	MANGANESE	1.2E+01		1	1
32M-01-18XBR	S	6/8/2006	MANGANESE	1.8E+01		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	10/17/2006	MANGANESE	1.6E+01		1	1
32M-01-18XBR	S	5/7/2007	MANGANESE	1.8E+01		1	1
32M-01-18XBR	S	10/24/2007	MANGANESE	1.0E+01		1	1
32M-01-18XBR	S	6/1/2008	MANGANESE	1.5E+01		1	1
32M-01-18XBR	S	10/1/2008	MANGANESE	1.9E+01		1	1
32M-01-18XBR	S	5/1/2009	MANGANESE	2.9E+01		1	1
32M-01-18XBR	S	11/1/2009	MANGANESE	7.0E+00		1	1
32M-01-18XBR	S	5/1/2010	MANGANESE	2.4E+00		1	1
32M-01-18XBR	S	10/1/2010	MANGANESE	4.5E+00		1	1
32M-01-18XBR	S	6/1/2011	MANGANESE	2.3E+00		1	1
32M-01-18XBR	S	10/1/2011	MANGANESE	1.2E+00		1	1
32M-01-18XBR	S	5/1/2012	MANGANESE	4.1E+00		1	1
32M-01-18XBR	S	10/1/2012	MANGANESE	1.5E+00		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

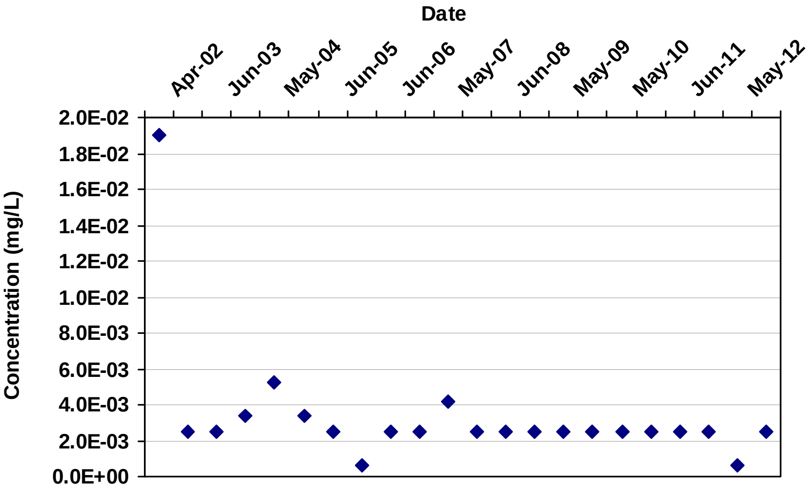
Project: AOC 32-43A, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well:	32M-01-18XBR	**Time Period:**	4/1/2002 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	TRICHLOROETHYLENE (TCE)	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-68

Confidence in Trend:

97.1%

Coefficient of Variation:

1.08

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	4/1/2002	TRICHLOROETHYLEN	1.9E-02		1	1
32M-01-18XBR	S	10/1/2002	TRICHLOROETHYLEN	2.5E-03	ND	1	0
32M-01-18XBR	S	6/1/2003	TRICHLOROETHYLEN	2.5E-03	ND	1	0
32M-01-18XBR	S	12/1/2003	TRICHLOROETHYLEN	3.4E-03		1	1
32M-01-18XBR	S	5/1/2004	TRICHLOROETHYLEN	5.2E-03		1	1
32M-01-18XBR	S	10/1/2004	TRICHLOROETHYLEN	3.4E-03		1	1
32M-01-18XBR	S	6/1/2005	TRICHLOROETHYLEN	2.5E-03	ND	1	0
32M-01-18XBR	S	10/1/2005	TRICHLOROETHYLEN	6.0E-04		1	1
32M-01-18XBR	S	6/8/2006	TRICHLOROETHYLEN	2.5E-03	ND	1	0

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	10/17/2006	TRICHLOROETHYLEN	2.5E-03	ND	1	0
32M-01-18XBR	S	5/7/2007	TRICHLOROETHYLEN	4.2E-03		1	1
32M-01-18XBR	S	10/24/2007	TRICHLOROETHYLEN	2.5E-03	ND	1	0
32M-01-18XBR	S	6/1/2008	TRICHLOROETHYLEN	2.5E-03	ND	1	0
32M-01-18XBR	S	10/1/2008	TRICHLOROETHYLEN	2.5E-03	ND	1	0
32M-01-18XBR	S	5/1/2009	TRICHLOROETHYLEN	2.5E-03	ND	1	0
32M-01-18XBR	S	11/1/2009	TRICHLOROETHYLEN	2.5E-03	ND	1	0
32M-01-18XBR	S	5/1/2010	TRICHLOROETHYLEN	2.5E-03	ND	1	0
32M-01-18XBR	S	10/1/2010	TRICHLOROETHYLEN	2.5E-03	ND	1	0
32M-01-18XBR	S	6/1/2011	TRICHLOROETHYLEN	2.5E-03	ND	1	0
32M-01-18XBR	S	10/1/2011	TRICHLOROETHYLEN	2.5E-03	ND	1	0
32M-01-18XBR	S	5/1/2012	TRICHLOROETHYLEN	6.0E-04		1	1
32M-01-18XBR	S	10/1/2012	TRICHLOROETHYLEN	2.5E-03	ND	1	0

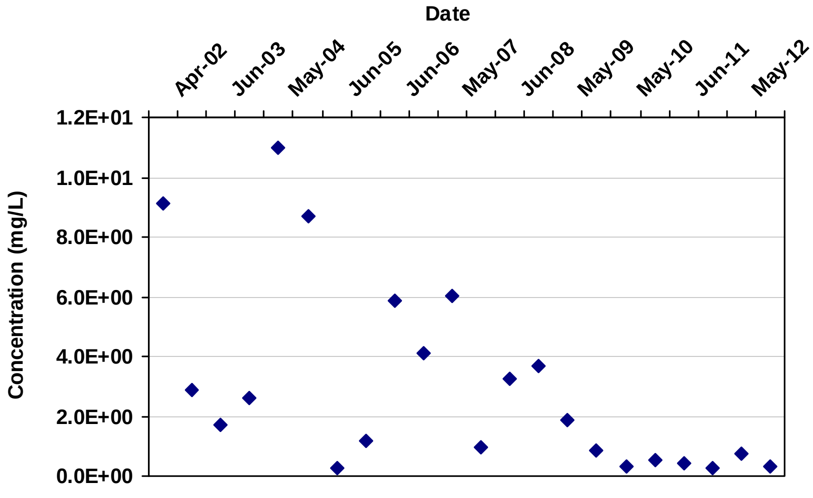
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Well: 32M-01-18XBR
Well Type: S
COC: VOLATILE PETROLEUM HYDROCAR

Time Period: 4/1/2002 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Duplicate Consolidation: Median
Consolidation Type: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

-113

Confidence in Trend:

99.9%

Coefficient of Variation:

1.06

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	4/1/2002	VOLATILE PETROLEU	9.1E+00		1	1
32M-01-18XBR	S	10/1/2002	VOLATILE PETROLEU	2.9E+00		1	1
32M-01-18XBR	S	6/1/2003	VOLATILE PETROLEU	1.7E+00		1	1
32M-01-18XBR	S	12/1/2003	VOLATILE PETROLEU	2.6E+00		1	1
32M-01-18XBR	S	5/1/2004	VOLATILE PETROLEU	1.1E+01		1	1
32M-01-18XBR	S	10/1/2004	VOLATILE PETROLEU	8.7E+00		1	1
32M-01-18XBR	S	6/1/2005	VOLATILE PETROLEU	2.6E-01		1	1
32M-01-18XBR	S	10/1/2005	VOLATILE PETROLEU	1.2E+00		1	1
32M-01-18XBR	S	6/8/2006	VOLATILE PETROLEU	5.9E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
32M-01-18XBR	S	10/17/2006	VOLATILE PETROLEU	4.1E+00		1	1
32M-01-18XBR	S	5/7/2007	VOLATILE PETROLEU	6.1E+00		1	1
32M-01-18XBR	S	10/24/2007	VOLATILE PETROLEU	9.5E-01		1	1
32M-01-18XBR	S	6/1/2008	VOLATILE PETROLEU	3.2E+00		1	1
32M-01-18XBR	S	10/1/2008	VOLATILE PETROLEU	3.7E+00		1	1
32M-01-18XBR	S	5/1/2009	VOLATILE PETROLEU	1.9E+00		1	1
32M-01-18XBR	S	11/1/2009	VOLATILE PETROLEU	8.4E-01		1	1
32M-01-18XBR	S	5/1/2010	VOLATILE PETROLEU	3.0E-01		1	1
32M-01-18XBR	S	10/1/2010	VOLATILE PETROLEU	5.4E-01		1	1
32M-01-18XBR	S	6/1/2011	VOLATILE PETROLEU	4.4E-01		1	1
32M-01-18XBR	S	10/1/2011	VOLATILE PETROLEU	2.7E-01		1	1
32M-01-18XBR	S	5/1/2012	VOLATILE PETROLEU	7.3E-01		1	1
32M-01-18XBR	S	10/1/2012	VOLATILE PETROLEU	3.2E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Linear Regression Statistics Summary

Project: AOC 32-43A, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Time Period: 4/1/2002 **to** 10/1/2012

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value

Well	Source/Tail	Average Conc (mg/L)	Median Conc (mg/L)	Standard Deviation	All Samples "ND" ?	Ln Slope	Coefficient of Variation	Confidence in Trend	Concentration Trend
1,2-DICHLOROBENZENE									
32M-01-18XBR	S	2.7E+00	2.6E+00	2.2E+00	No	-7.7E-04	0.79	100.0%	D
Dummy	T	1.2E+00	1.2E+00	0.0E+00	No	0.0E+00	0.00	0.0%	N/A
1,3-DICHLOROBENZENE									
32M-01-18XBR	S	3.6E-01	3.3E-01	2.6E-01	No	-5.7E-04	0.71	100.0%	D
Dummy	T	1.2E+00	1.2E+00	0.0E+00	No	0.0E+00	0.00	0.0%	N/A
1,4-DICHLOROBENZENE									
32M-01-18XBR	S	2.1E-01	1.9E-01	1.6E-01	No	-6.1E-04	0.74	100.0%	D
CHLOROBENZENE									
32M-01-18XBR	S	3.7E-01	2.1E-01	4.0E-01	No	-3.0E-04	1.09	89.9%	NT
Dummy	T	1.2E+00	1.2E+00	0.0E+00	No	0.0E+00	0.00	0.0%	N/A
TRICHLOROETHYLENE (TCE)									
32M-01-18XBR	S	3.4E-03	2.5E-03	3.6E-03	No	-2.4E-04	1.08	97.8%	D
Dummy	T	1.2E+00	1.2E+00	0.0E+00	No	0.0E+00	0.00	0.0%	N/A

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Non-detect (ND); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); COV = Coefficient of Variation

MAROS Linear Regression Statistics Summary

Project: AOC 32-43A, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Time Period: 4/1/2002 **to** 10/1/2012

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value

Well	Source/Tail	Average Conc (mg/L)	Median Conc (mg/L)	Standard Deviation	All Samples "ND" ?	Ln Slope	Coefficient of Variation	Confidence in Trend	Concentration Trend
C12-C16 PETROLEUM HYDROCARBO									
32M-01-18XBR	S	6.3E-01	4.4E-01	7.7E-01	No	-5.0E-03	1.22	100.0%	D
Dummy	T	1.2E+00	1.2E+00	0.0E+00	No	0.0E+00	0.00	0.0%	N/A
C8-C10 PETROLEUM HYDROCARBON									
32M-01-18XBR	S	6.1E-01	1.0E-01	1.4E+00	No	-1.7E-03	2.37	82.3%	NT
Dummy	T	1.2E+00	1.2E+00	0.0E+00	No	0.0E+00	0.00	0.0%	N/A
MANGANESE									
32M-01-18XBR	S	1.2E+01	1.3E+01	7.3E+00	No	-4.9E-04	0.63	99.9%	D
Dummy	T	1.2E+00	1.2E+00	0.0E+00	No	0.0E+00	0.00	0.0%	N/A
VOLATILE PETROLEUM HYDROCARB									
32M-01-18XBR	S	3.0E+00	1.8E+00	3.2E+00	No	-6.9E-04	1.06	100.0%	D
Dummy	T	1.2E+00	1.2E+00	0.0E+00	No	0.0E+00	0.00	0.0%	N/A

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Non-detect (ND); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); COV = Coefficient of Variation

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Time Period: 4/1/2002 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
1,2-DICHLOROBENZENE								
32M-01-18XBR	S	22	22	0.79	-127	100.0%	No	D
Dummy	T	2	2	0.00	0	0.0%	No	N/A
1,3-DICHLOROBENZENE								
32M-01-18XBR	S	22	22	0.71	-115	100.0%	No	D
Dummy	T	2	2	0.00	0	0.0%	No	N/A
1,4-DICHLOROBENZENE								
32M-01-18XBR	S	22	22	0.74	-126	100.0%	No	D
CHLOROBENZENE								
32M-01-18XBR	S	18	18	1.09	-38	91.8%	No	PD
Dummy	T	2	2	0.00	0	0.0%	No	N/A
TRICHLOROETHYLENE (TCE)								
32M-01-18XBR	S	22	7	1.08	-68	97.1%	No	D
Dummy	T	2	2	0.00	0	0.0%	No	N/A

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Mann-Kendall Statistics Summary

Project: AOC 32-43A, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Time Period: 4/1/2002 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
C12-C16 PETROLEUM HYDROCARBONS, ALI								
32M-01-18XBR	S	22	16	1.22	-126	100.0%	No	D
Dummy	T	1	1	0.00	0	0.0%	No	N/A
C8-C10 PETROLEUM HYDROCARBONS, ALIP								
32M-01-18XBR	S	20	11	2.37	-44	91.8%	No	PD
Dummy	T	2	2	0.00	0	0.0%	No	N/A
MANGANESE								
32M-01-18XBR	S	22	22	0.63	-69	97.3%	No	D
Dummy	T	1	1	0.00	0	0.0%	No	N/A
VOLATILE PETROLEUM HYDROCARBONS C9								
32M-01-18XBR	S	22	22	1.06	-113	99.9%	No	D
Dummy	T	2	2	0.00	0	0.0%	No	N/A

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Statistical Trend Analysis Summary

Project: AOC 32-43A, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Time Period:	4/1/2002	**to** 10/1/2012
Consolidation Period:	No Time Consolidation	
Consolidation Type:	Median	
Duplicate Consolidation:	Maximum	
ND Values:	1/2 Detection Limit	
J Flag Values :	Actual Value	

Well	Source / Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
1,2-DICHLOROBENZENE								
32M-01-18XBR	S	22	22	2.7E+00	2.6E+00	No	D	D
Dummy	T	2	2	1.2E+00	1.2E+00	No	N/A	N/A
1,3-DICHLOROBENZENE								
32M-01-18XBR	S	22	22	3.6E-01	3.3E-01	No	D	D
Dummy	T	2	2	1.2E+00	1.2E+00	No	N/A	N/A
1,4-DICHLOROBENZENE								
32M-01-18XBR	S	22	22	2.1E-01	1.9E-01	No	D	D
CHLOROBENZENE								
32M-01-18XBR	S	18	18	3.7E-01	2.1E-01	No	PD	NT
Dummy	T	2	2	1.2E+00	1.2E+00	No	N/A	N/A
TRICHLOROETHYLENE (TCE)								
32M-01-18XBR	S	22	7	3.4E-03	2.5E-03	No	D	D
Dummy	T	2	2	1.2E+00	1.2E+00	No	N/A	N/A

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); No Detectable Concentration (ND)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Statistical Trend Analysis Summary

Project: AOC 32-43A, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Time Period:	4/1/2002	**to** 10/1/2012
Consolidation Period:	No Time Consolidation	
Consolidation Type:	Median	
Duplicate Consolidation:	Maximum	
ND Values:	1/2 Detection Limit	
J Flag Values :	Actual Value	

Well	Source / Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
C12-C16 PETROLEUM HYDROCARBONS								
32M-01-18XBR	S	22	16	6.3E-01	4.4E-01	No	D	D
Dummy	T	1	1	1.2E+00	1.2E+00	No	N/A	N/A
C8-C10 PETROLEUM HYDROCARBONS,								
32M-01-18XBR	S	20	11	6.1E-01	1.0E-01	No	PD	NT
Dummy	T	2	2	1.2E+00	1.2E+00	No	N/A	N/A
MANGANESE								
32M-01-18XBR	S	22	22	1.2E+01	1.3E+01	No	D	D
Dummy	T	1	1	1.2E+00	1.2E+00	No	N/A	N/A
VOLATILE PETROLEUM HYDROCARBON								
32M-01-18XBR	S	22	22	3.0E+00	1.8E+00	No	D	D
Dummy	T	2	2	1.2E+00	1.2E+00	No	N/A	N/A

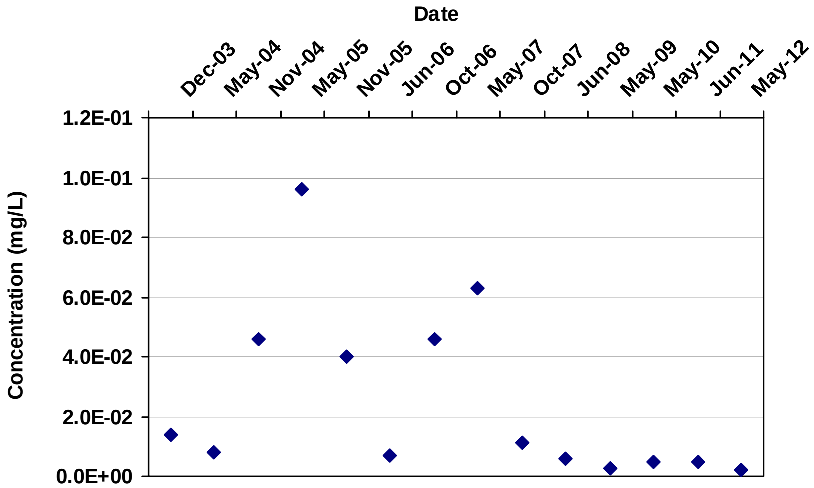
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); No Detectable Concentration (ND)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Mann-Kendall Statistics Summary

Project:	AOC 57, Area 2, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

Well:	57-AREA-2-SW3	**Time Period:**	12/1/2003 **to** 5/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	ARSENIC	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-46

Confidence in Trend:

99.4%

Coefficient of Variation:

1.14

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57-AREA-2-SW3	T	12/1/2003	ARSENIC	1.4E-02		1	1
57-AREA-2-SW3	T	5/1/2004	ARSENIC	8.1E-03		1	1
57-AREA-2-SW3	T	11/1/2004	ARSENIC	4.6E-02		1	1
57-AREA-2-SW3	T	5/1/2005	ARSENIC	9.6E-02		1	1
57-AREA-2-SW3	T	11/1/2005	ARSENIC	4.0E-02		1	1
57-AREA-2-SW3	T	6/1/2006	ARSENIC	7.0E-03		1	1
57-AREA-2-SW3	T	10/1/2006	ARSENIC	4.6E-02		1	1
57-AREA-2-SW3	T	5/1/2007	ARSENIC	6.3E-02		1	1
57-AREA-2-SW3	T	10/1/2007	ARSENIC	1.1E-02		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 2, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57-AREA-2-SW3	T	6/1/2008	ARSENIC	6.0E-03		1	1
57-AREA-2-SW3	T	5/1/2009	ARSENIC	2.6E-03		1	1
57-AREA-2-SW3	T	5/1/2010	ARSENIC	4.8E-03		1	1
57-AREA-2-SW3	T	6/1/2011	ARSENIC	5.0E-03		1	1
57-AREA-2-SW3	T	5/1/2012	ARSENIC	2.0E-03		1	1

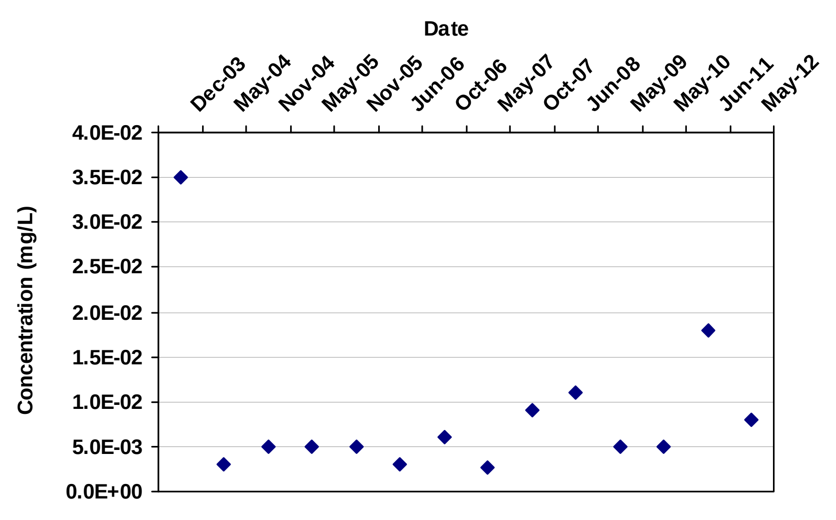
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 3, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well:	57-AREA-3-SW1	**Time Period:**	12/1/2003 **to** 5/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	ARSENIC	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

13

Confidence in Trend:

74.1%

Coefficient of Variation:

1.00

Mann Kendall Concentration Trend: (See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57-AREA-3-SW1	T	12/1/2003	ARSENIC	3.5E-02		1	1
57-AREA-3-SW1	T	5/1/2004	ARSENIC	3.1E-03		1	1
57-AREA-3-SW1	T	11/1/2004	ARSENIC	5.0E-03		1	1
57-AREA-3-SW1	T	5/1/2005	ARSENIC	5.0E-03	ND	1	0
57-AREA-3-SW1	T	11/1/2005	ARSENIC	5.0E-03		1	1
57-AREA-3-SW1	T	6/1/2006	ARSENIC	3.0E-03		1	1
57-AREA-3-SW1	T	10/1/2006	ARSENIC	6.0E-03		1	1
57-AREA-3-SW1	T	5/1/2007	ARSENIC	2.7E-03		1	1
57-AREA-3-SW1	T	10/1/2007	ARSENIC	9.0E-03		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 3, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

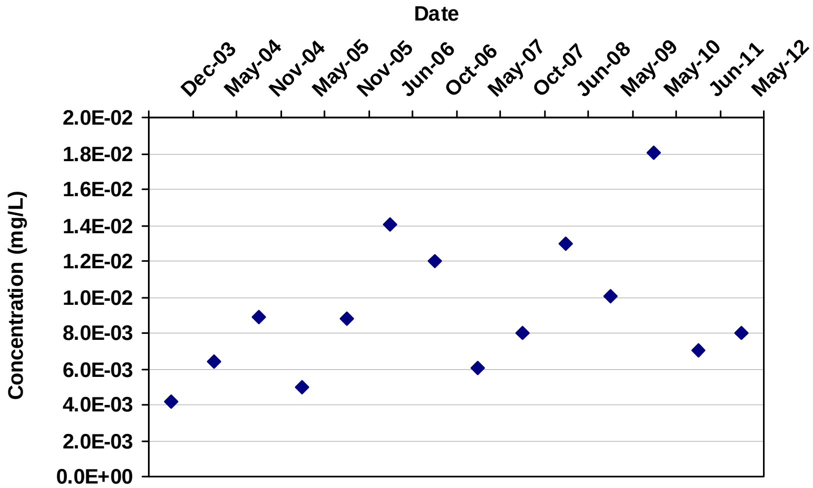
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57-AREA-3-SW1	T	6/1/2008	ARSENIC	1.1E-02		1	1
57-AREA-3-SW1	T	5/1/2009	ARSENIC	5.0E-03	ND	1	0
57-AREA-3-SW1	T	5/1/2010	ARSENIC	5.0E-03	ND	1	0
57-AREA-3-SW1	T	6/1/2011	ARSENIC	1.8E-02		1	1
57-AREA-3-SW1	T	5/1/2012	ARSENIC	8.0E-03		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project:	AOC 57, Area 2, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

Well:	57M-03-02X	**Time Period:**	12/1/2003 **to** 5/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	ARSENIC	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

26

Confidence in Trend:

91.3%

Coefficient of Variation:

0.42

Mann Kendall Concentration Trend: (See Note)

PI

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57M-03-02X	S	12/1/2003	ARSENIC	4.2E-03		1	1
57M-03-02X	S	5/1/2004	ARSENIC	6.4E-03		1	1
57M-03-02X	S	11/1/2004	ARSENIC	8.9E-03		1	1
57M-03-02X	S	5/1/2005	ARSENIC	5.0E-03	ND	1	0
57M-03-02X	S	11/1/2005	ARSENIC	8.8E-03		1	1
57M-03-02X	S	6/1/2006	ARSENIC	1.4E-02		1	1
57M-03-02X	S	10/1/2006	ARSENIC	1.2E-02		1	1
57M-03-02X	S	5/1/2007	ARSENIC	6.0E-03		1	1
57M-03-02X	S	10/1/2007	ARSENIC	8.0E-03		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 2, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57M-03-02X	S	6/1/2008	ARSENIC	1.3E-02		1	1
57M-03-02X	S	5/1/2009	ARSENIC	1.0E-02		1	1
57M-03-02X	S	5/1/2010	ARSENIC	1.8E-02		1	1
57M-03-02X	S	6/1/2011	ARSENIC	7.0E-03		1	1
57M-03-02X	S	5/1/2012	ARSENIC	8.0E-03		1	1

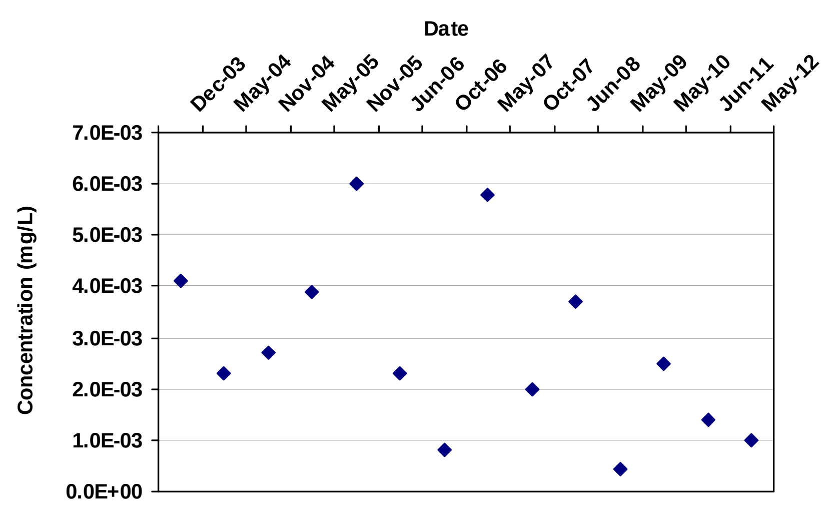
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 2, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Well: 57M-03-02X
Well Type: S
COC: TETRACHLOROETHYLENE(PCE)

Time Period: 12/1/2003 **to** 5/1/2012
Consolidation Period: No Time Consolidation
Duplicate Consolidation: Median
Consolidation Type: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

-34

Confidence in Trend:

96.5%

Coefficient of Variation:

0.62

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57M-03-02X	S	12/1/2003	TETRACHLOROETHY	4.1E-03		1	1
57M-03-02X	S	5/1/2004	TETRACHLOROETHY	2.3E-03		1	1
57M-03-02X	S	11/1/2004	TETRACHLOROETHY	2.7E-03		1	1
57M-03-02X	S	5/1/2005	TETRACHLOROETHY	3.9E-03		1	1
57M-03-02X	S	11/1/2005	TETRACHLOROETHY	6.0E-03		1	1
57M-03-02X	S	6/1/2006	TETRACHLOROETHY	2.3E-03		1	1
57M-03-02X	S	10/1/2006	TETRACHLOROETHY	8.0E-04		1	1
57M-03-02X	S	5/1/2007	TETRACHLOROETHY	5.8E-03		1	1
57M-03-02X	S	10/1/2007	TETRACHLOROETHY	2.0E-03		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 2, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57M-03-02X	S	6/1/2008	TETRACHLOROETHY	3.7E-03		1	1
57M-03-02X	S	5/1/2009	TETRACHLOROETHY	4.3E-04		1	1
57M-03-02X	S	5/1/2010	TETRACHLOROETHY	2.5E-03	ND	1	0
57M-03-02X	S	6/1/2011	TETRACHLOROETHY	1.4E-03		1	1
57M-03-02X	S	5/1/2012	TETRACHLOROETHY	9.8E-04		1	1

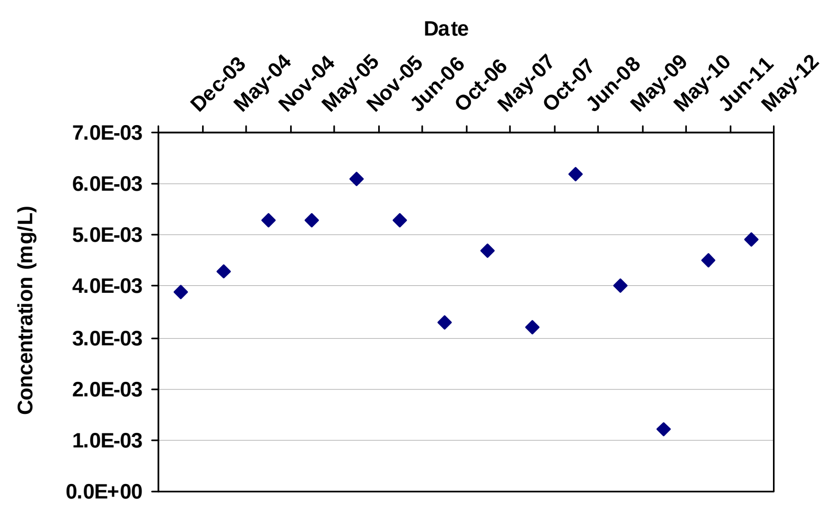
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 2, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well:	57M-03-02X	**Time Period:**	12/1/2003 **to** 5/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	TRICHLOROETHYLENE (TCE)	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-8

Confidence in Trend:

64.6%

Coefficient of Variation:

0.29

Mann Kendall Concentration Trend: (See Note)

S

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57M-03-02X	S	12/1/2003	TRICHLOROETHYLEN	3.9E-03		1	1
57M-03-02X	S	5/1/2004	TRICHLOROETHYLEN	4.3E-03		1	1
57M-03-02X	S	11/1/2004	TRICHLOROETHYLEN	5.3E-03		1	1
57M-03-02X	S	5/1/2005	TRICHLOROETHYLEN	5.3E-03		1	1
57M-03-02X	S	11/1/2005	TRICHLOROETHYLEN	6.1E-03		1	1
57M-03-02X	S	6/1/2006	TRICHLOROETHYLEN	5.3E-03		1	1
57M-03-02X	S	10/1/2006	TRICHLOROETHYLEN	3.3E-03		1	1
57M-03-02X	S	5/1/2007	TRICHLOROETHYLEN	4.7E-03		1	1
57M-03-02X	S	10/1/2007	TRICHLOROETHYLEN	3.2E-03		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 2, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57M-03-02X	S	6/1/2008	TRICHLOROETHYLEN	6.2E-03		1	1
57M-03-02X	S	5/1/2009	TRICHLOROETHYLEN	4.0E-03		1	1
57M-03-02X	S	5/1/2010	TRICHLOROETHYLEN	1.2E-03		1	1
57M-03-02X	S	6/1/2011	TRICHLOROETHYLEN	4.5E-03		1	1
57M-03-02X	S	5/1/2012	TRICHLOROETHYLEN	4.9E-03		1	1

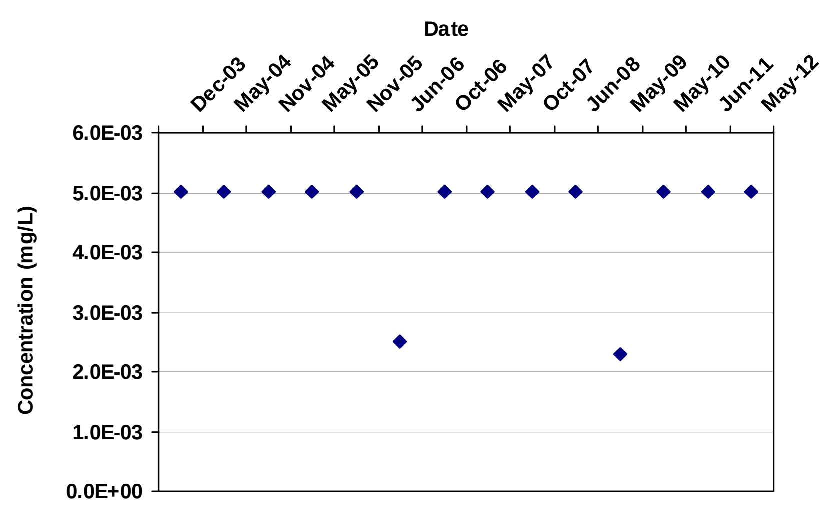
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 2, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well:	57M-03-03X	**Time Period:**	12/1/2003 **to** 5/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	ARSENIC	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-5

Confidence in Trend:

58.5%

Coefficient of Variation:

0.20

Mann Kendall Concentration Trend: (See Note)

S

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57M-03-03X	S	12/1/2003	ARSENIC	5.0E-03	ND	1	0
57M-03-03X	S	5/1/2004	ARSENIC	5.0E-03	ND	1	0
57M-03-03X	S	11/1/2004	ARSENIC	5.0E-03	ND	1	0
57M-03-03X	S	5/1/2005	ARSENIC	5.0E-03	ND	1	0
57M-03-03X	S	11/1/2005	ARSENIC	5.0E-03	ND	1	0
57M-03-03X	S	6/1/2006	ARSENIC	2.5E-03		1	1
57M-03-03X	S	10/1/2006	ARSENIC	5.0E-03	ND	1	0
57M-03-03X	S	5/1/2007	ARSENIC	5.0E-03	ND	1	0
57M-03-03X	S	10/1/2007	ARSENIC	5.0E-03	ND	1	0

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 2, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57M-03-03X	S	6/1/2008	ARSENIC	5.0E-03	ND	1	0
57M-03-03X	S	5/1/2009	ARSENIC	2.3E-03		1	1
57M-03-03X	S	5/1/2010	ARSENIC	5.0E-03	ND	1	0
57M-03-03X	S	6/1/2011	ARSENIC	5.0E-03	ND	1	0
57M-03-03X	S	5/1/2012	ARSENIC	5.0E-03	ND	1	0

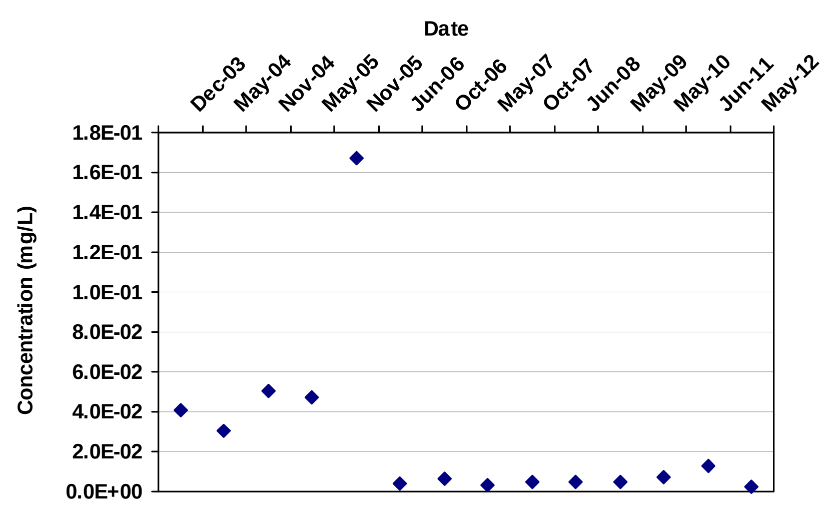
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 2, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well:	57M-03-04X	**Time Period:**	12/1/2003 **to** 5/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	ARSENIC	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-32

Confidence in Trend:

95.5%

Coefficient of Variation:

1.59

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57M-03-04X	T	12/1/2003	ARSENIC	4.1E-02		1	1
57M-03-04X	T	5/1/2004	ARSENIC	3.0E-02		1	1
57M-03-04X	T	11/1/2004	ARSENIC	5.0E-02		1	1
57M-03-04X	T	5/1/2005	ARSENIC	4.7E-02		1	1
57M-03-04X	T	11/1/2005	ARSENIC	1.7E-01		1	1
57M-03-04X	T	6/1/2006	ARSENIC	3.7E-03		1	1
57M-03-04X	T	10/1/2006	ARSENIC	6.0E-03		1	1
57M-03-04X	T	5/1/2007	ARSENIC	3.0E-03		1	1
57M-03-04X	T	10/1/2007	ARSENIC	5.0E-03	ND	1	0

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 2, Former Ft. Devens
User Name: T Lillys

Location: Devens
State: Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57M-03-04X	T	6/1/2008	ARSENIC	5.0E-03	ND	1	0
57M-03-04X	T	5/1/2009	ARSENIC	5.0E-03	ND	1	0
57M-03-04X	T	5/1/2010	ARSENIC	7.0E-03		1	1
57M-03-04X	T	6/1/2011	ARSENIC	1.3E-02		1	1
57M-03-04X	T	5/1/2012	ARSENIC	2.5E-03	ND	1	0

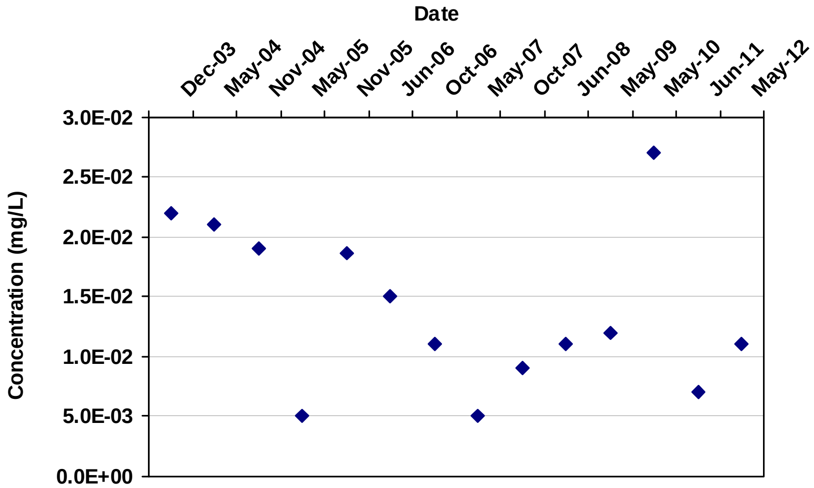
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 2, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well:	57M-03-05X	**Time Period:**	12/1/2003 **to** 5/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	ARSENIC	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-26

Confidence in Trend:

91.3%

Coefficient of Variation:

0.49

Mann Kendall Concentration Trend: (See Note)

PD

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57M-03-05X	T	12/1/2003	ARSENIC	2.2E-02		1	1
57M-03-05X	T	5/1/2004	ARSENIC	2.1E-02		1	1
57M-03-05X	T	11/1/2004	ARSENIC	1.9E-02		1	1
57M-03-05X	T	5/1/2005	ARSENIC	5.0E-03	ND	1	0
57M-03-05X	T	11/1/2005	ARSENIC	1.9E-02		1	1
57M-03-05X	T	6/1/2006	ARSENIC	1.5E-02		1	1
57M-03-05X	T	10/1/2006	ARSENIC	1.1E-02		1	1
57M-03-05X	T	5/1/2007	ARSENIC	5.0E-03		1	1
57M-03-05X	T	10/1/2007	ARSENIC	9.0E-03		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 2, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57M-03-05X	T	6/1/2008	ARSENIC	1.1E-02		1	1
57M-03-05X	T	5/1/2009	ARSENIC	1.2E-02		1	1
57M-03-05X	T	5/1/2010	ARSENIC	2.7E-02		1	1
57M-03-05X	T	6/1/2011	ARSENIC	7.0E-03		1	1
57M-03-05X	T	5/1/2012	ARSENIC	1.1E-02		1	1

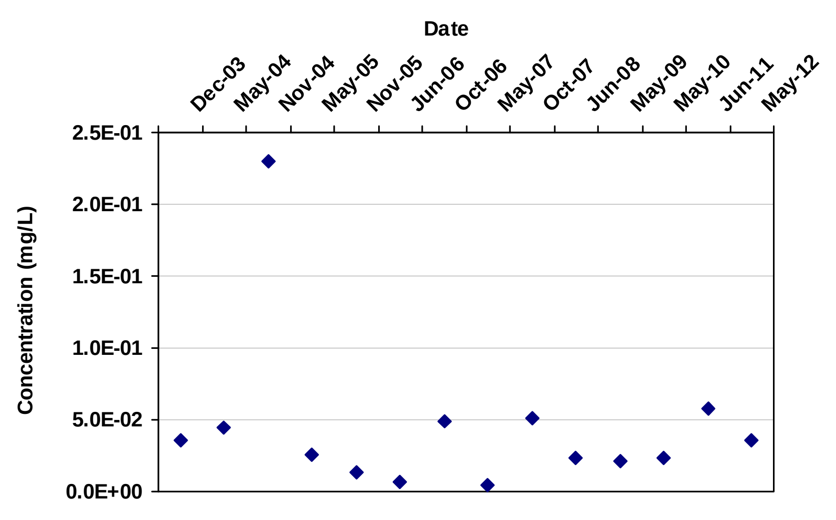
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 3, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well:	57M-95-03X	**Time Period:**	12/1/2003 **to** 5/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	ARSENIC	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-3

Confidence in Trend:

54.3%

Coefficient of Variation:

1.26

Mann Kendall Concentration Trend: (See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57M-95-03X	S	12/1/2003	ARSENIC	3.6E-02		1	1
57M-95-03X	S	5/1/2004	ARSENIC	4.4E-02		1	1
57M-95-03X	S	11/1/2004	ARSENIC	2.3E-01		1	1
57M-95-03X	S	5/1/2005	ARSENIC	2.5E-02		1	1
57M-95-03X	S	11/1/2005	ARSENIC	1.4E-02		1	1
57M-95-03X	S	6/1/2006	ARSENIC	7.0E-03		1	1
57M-95-03X	S	10/1/2006	ARSENIC	4.9E-02		1	1
57M-95-03X	S	5/1/2007	ARSENIC	4.8E-03		1	1
57M-95-03X	S	10/1/2007	ARSENIC	5.1E-02		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 3, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

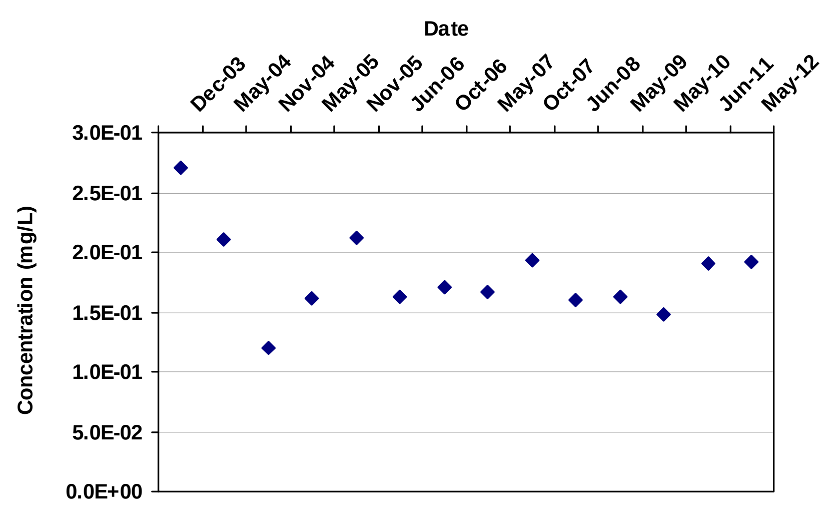
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57M-95-03X	S	6/1/2008	ARSENIC	2.3E-02		1	1
57M-95-03X	S	5/1/2009	ARSENIC	2.1E-02		1	1
57M-95-03X	S	5/1/2010	ARSENIC	2.3E-02		1	1
57M-95-03X	S	6/1/2011	ARSENIC	5.8E-02		1	1
57M-95-03X	S	5/1/2012	ARSENIC	3.6E-02		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 3, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Well:	57M-96-11X	**Time Period:**	12/1/2003 **to** 5/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	ARSENIC	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-12

Confidence in Trend:

72.3%

Coefficient of Variation:

0.20

Mann Kendall Concentration Trend: (See Note)

S

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57M-96-11X	T	12/1/2003	ARSENIC	2.7E-01		1	1
57M-96-11X	T	5/1/2004	ARSENIC	2.1E-01		1	1
57M-96-11X	T	11/1/2004	ARSENIC	1.2E-01		1	1
57M-96-11X	T	5/1/2005	ARSENIC	1.6E-01		1	1
57M-96-11X	T	11/1/2005	ARSENIC	2.1E-01		1	1
57M-96-11X	T	6/1/2006	ARSENIC	1.6E-01		1	1
57M-96-11X	T	10/1/2006	ARSENIC	1.7E-01		1	1
57M-96-11X	T	5/1/2007	ARSENIC	1.7E-01		1	1
57M-96-11X	T	10/1/2007	ARSENIC	1.9E-01		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 3, Former Ft. Devens
User Name: T Lillys

Location: Devens
State: Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
57M-96-11X	T	6/1/2008	ARSENIC	1.6E-01		1	1
57M-96-11X	T	5/1/2009	ARSENIC	1.6E-01		1	1
57M-96-11X	T	5/1/2010	ARSENIC	1.5E-01		1	1
57M-96-11X	T	6/1/2011	ARSENIC	1.9E-01		1	1
57M-96-11X	T	5/1/2012	ARSENIC	1.9E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Linear Regression Statistics Summary

Project: AOC 57, Area 2, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Time Period:	12/1/2003	**to** 5/1/2012
Consolidation Period:	No Time Consolidation	
Consolidation Type:	Median	
Duplicate Consolidation:	Maximum	
ND Values:	1/2 Detection Limit	
J Flag Values :	Actual Value	

Well	Source/Tail	Average Conc (mg/L)	Median Conc (mg/L)	Standard Deviation	All Samples "ND" ?	Ln Slope	Coefficient of Variation	Confidence in Trend	Concentration Trend
ARSENIC									
57-AREA-2-SW3	T	2.5E-02	9.6E-03	2.9E-02	No	-8.6E-04	1.14	99.5%	D
57M-03-02X	S	9.2E-03	8.4E-03	3.8E-03	No	1.6E-04	0.42	91.4%	PI
57M-03-03X	S	4.6E-03	5.0E-03	9.4E-04	No	-2.3E-05	0.20	60.9%	S
57M-03-04X	T	2.8E-02	6.5E-03	4.4E-02	No	-8.5E-04	1.59	99.2%	D
57M-03-05X	T	1.4E-02	1.2E-02	6.8E-03	No	-1.3E-04	0.49	79.6%	S
TETRACHLOROETHYLENE(PCE)									
57M-03-02X	S	2.8E-03	2.4E-03	1.7E-03	No	-4.0E-04	0.62	96.7%	D
TRICHLOROETHYLENE (TCE)									
57M-03-02X	S	4.4E-03	4.6E-03	1.3E-03	No	-1.2E-04	0.29	83.6%	S

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Non-detect (ND); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); COV = Coefficient of Variation

MAROS Statistical Trend Analysis Summary

Project: AOC 57, Area 2, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Time Period: 12/1/2003 **to** 5/1/2012

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value

Well	Source / Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
ARSENIC								
57-AREA-2-SW3	T	14	14	2.5E-02	9.6E-03	No	D	D
57M-03-02X	S	14	13	9.2E-03	8.4E-03	No	PI	PI
57M-03-03X	S	14	2	4.6E-03	5.0E-03	No	S	S
57M-03-04X	T	14	10	2.8E-02	6.5E-03	No	D	D
57M-03-05X	T	14	13	1.4E-02	1.2E-02	No	PD	S
TETRACHLOROETHYLENE(PCE)								
57M-03-02X	S	14	13	2.8E-03	2.4E-03	No	D	D
TRICHLOROETHYLENE (TCE)								
57M-03-02X	S	14	14	4.4E-03	4.6E-03	No	S	S

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); No Detectable Concentration (ND)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Linear Regression Statistics Summary

Project: AOC 57, Area 3, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Time Period:	12/1/2003	**to** 5/1/2012
Consolidation Period:	No Time Consolidation	
Consolidation Type:	Median	
Duplicate Consolidation:	Maximum	
ND Values:	1/2 Detection Limit	
J Flag Values :	Actual Value	

Well	Source/Tail	Average Conc (mg/L)	Median Conc (mg/L)	Standard Deviation	All Samples "ND" ?	Ln Slope	Coefficient of Variation	Confidence in Trend	Concentration Trend
ARSENIC									
57-AREA-3-SW1	T	8.6E-03	5.0E-03	8.6E-03	No	1.0E-04	1.00	68.3%	NT
57M-95-03X	S	4.4E-02	3.1E-02	5.6E-02	No	-6.5E-05	1.26	58.9%	NT
57M-96-11X	T	1.8E-01	1.7E-01	3.6E-02	No	-3.2E-05	0.20	70.7%	S

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Non-detect (ND); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); COV = Coefficient of Variation

MAROS Mann-Kendall Statistics Summary

Project: AOC 57, Area 3, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Time Period: 12/1/2003 **to** 5/1/2012
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
ARSENIC								
57-AREA-3-SW1	T	14	11	1.00	13	74.1%	No	NT
57M-95-03X	S	14	14	1.26	-3	54.3%	No	NT
57M-96-11X	T	14	14	0.20	-12	72.3%	No	S

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Statistical Trend Analysis Summary

Project: AOC 57, Area 3, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Time Period:	12/1/2003	**to** 5/1/2012
Consolidation Period:	No Time Consolidation	
Consolidation Type:	Median	
Duplicate Consolidation:	Maximum	
ND Values:	1/2 Detection Limit	
J Flag Values :	Actual Value	

Well	Source / Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
ARSENIC								
57-AREA-3-SW1	T	14	11	8.6E-03	5.0E-03	No	NT	NT
57M-95-03X	S	14	14	4.4E-02	3.1E-02	No	NT	NT
57M-96-11X	T	14	14	1.8E-01	1.7E-01	No	S	S

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); No Detectable Concentration (ND)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Mann-Kendall Statistics Summary

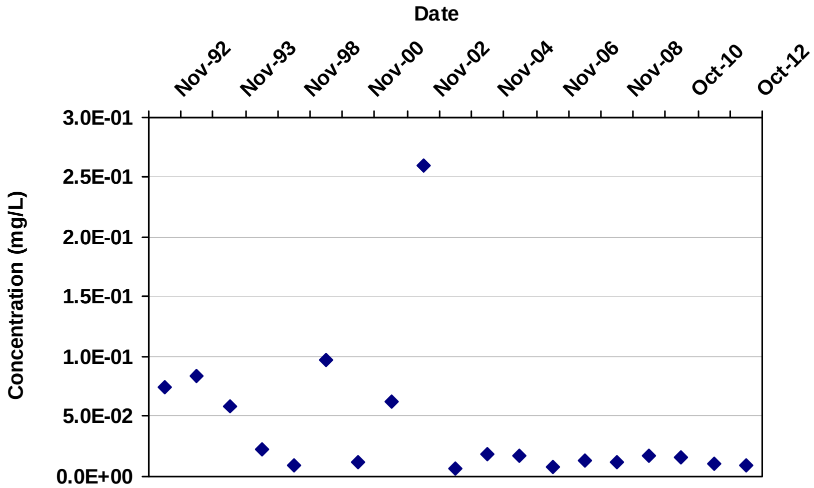
Project: AOC 26, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well:	26M-92-03X	**Time Period:**	11/1/1992 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	HEXAHYDRO-1,3,5-TRINITRO-1,3,5	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-65

Confidence in Trend:

98.8%

Coefficient of Variation:

1.41

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
26M-92-03X	S	11/1/1992	HEXAHYDRO-1,3,5-T	7.5E-02		1	1
26M-92-03X	S	5/1/1993	HEXAHYDRO-1,3,5-T	8.3E-02		1	1
26M-92-03X	S	11/1/1993	HEXAHYDRO-1,3,5-T	5.8E-02		1	1
26M-92-03X	S	11/1/1997	HEXAHYDRO-1,3,5-T	2.3E-02		1	1
26M-92-03X	S	11/1/1998	HEXAHYDRO-1,3,5-T	8.9E-03		1	1
26M-92-03X	S	11/1/1999	HEXAHYDRO-1,3,5-T	9.7E-02		1	1
26M-92-03X	S	11/1/2000	HEXAHYDRO-1,3,5-T	1.2E-02		1	1
26M-92-03X	S	11/1/2001	HEXAHYDRO-1,3,5-T	6.2E-02		1	1
26M-92-03X	S	11/1/2002	HEXAHYDRO-1,3,5-T	2.6E-01		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 26, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
26M-92-03X	S	11/1/2003	HEXAHYDRO-1,3,5-T	6.7E-03		1	1
26M-92-03X	S	11/1/2004	HEXAHYDRO-1,3,5-T	1.8E-02		1	1
26M-92-03X	S	11/1/2005	HEXAHYDRO-1,3,5-T	1.7E-02		1	1
26M-92-03X	S	11/1/2006	HEXAHYDRO-1,3,5-T	7.8E-03		1	1
26M-92-03X	S	11/1/2007	HEXAHYDRO-1,3,5-T	1.3E-02		1	1
26M-92-03X	S	11/1/2008	HEXAHYDRO-1,3,5-T	1.3E-02		1	1
26M-92-03X	S	11/1/2009	HEXAHYDRO-1,3,5-T	1.7E-02		1	1
26M-92-03X	S	10/1/2010	HEXAHYDRO-1,3,5-T	1.6E-02		1	1
26M-92-03X	S	10/1/2011	HEXAHYDRO-1,3,5-T	1.1E-02		1	1
26M-92-03X	S	10/1/2012	HEXAHYDRO-1,3,5-T	9.7E-03		1	1

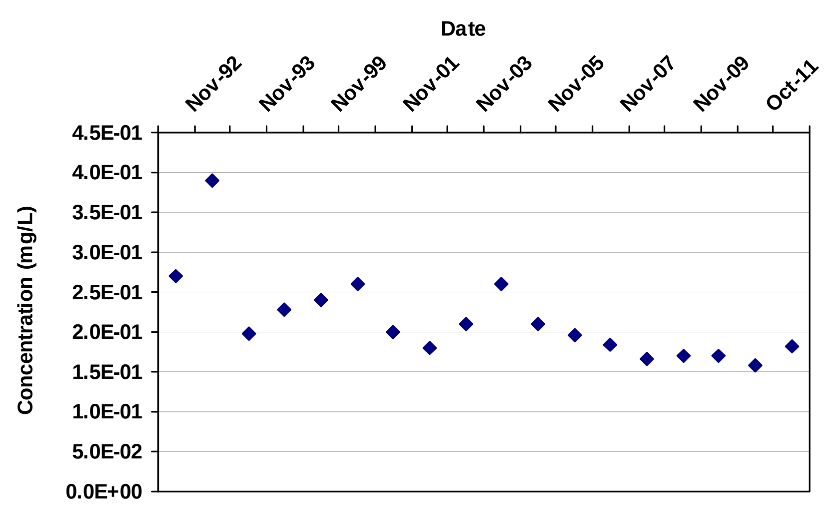
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 26, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well:	26M-92-04X	**Time Period:**	11/1/1992 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	HEXAHYDRO-1,3,5-TRINITRO-1,3,5	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-92

Confidence in Trend:

100.0%

Coefficient of Variation:

0.26

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
26M-92-04X	S	11/1/1992	HEXAHYDRO-1,3,5-T	2.7E-01		1	1
26M-92-04X	S	5/1/1993	HEXAHYDRO-1,3,5-T	3.9E-01		1	1
26M-92-04X	S	11/1/1993	HEXAHYDRO-1,3,5-T	2.0E-01		1	1
26M-92-04X	S	11/1/1998	HEXAHYDRO-1,3,5-T	2.3E-01		1	1
26M-92-04X	S	11/1/1999	HEXAHYDRO-1,3,5-T	2.4E-01		1	1
26M-92-04X	S	11/1/2000	HEXAHYDRO-1,3,5-T	2.6E-01		1	1
26M-92-04X	S	11/1/2001	HEXAHYDRO-1,3,5-T	2.0E-01		1	1
26M-92-04X	S	11/1/2002	HEXAHYDRO-1,3,5-T	1.8E-01		1	1
26M-92-04X	S	11/1/2003	HEXAHYDRO-1,3,5-T	2.1E-01		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 26, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
26M-92-04X	S	11/1/2004	HEXAHYDRO-1,3,5-T	2.6E-01		1	1
26M-92-04X	S	11/1/2005	HEXAHYDRO-1,3,5-T	2.1E-01		1	1
26M-92-04X	S	11/1/2006	HEXAHYDRO-1,3,5-T	2.0E-01		1	1
26M-92-04X	S	11/1/2007	HEXAHYDRO-1,3,5-T	1.8E-01		1	1
26M-92-04X	S	11/1/2008	HEXAHYDRO-1,3,5-T	1.7E-01		1	1
26M-92-04X	S	11/1/2009	HEXAHYDRO-1,3,5-T	1.7E-01		1	1
26M-92-04X	S	10/1/2010	HEXAHYDRO-1,3,5-T	1.7E-01		1	1
26M-92-04X	S	10/1/2011	HEXAHYDRO-1,3,5-T	1.6E-01		1	1
26M-92-04X	S	10/1/2012	HEXAHYDRO-1,3,5-T	1.8E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 26, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well: 26M-92-04X

Well Type: S

COC: PERCHLORATE

Time Period: 11/1/1992 **to** 10/1/2012

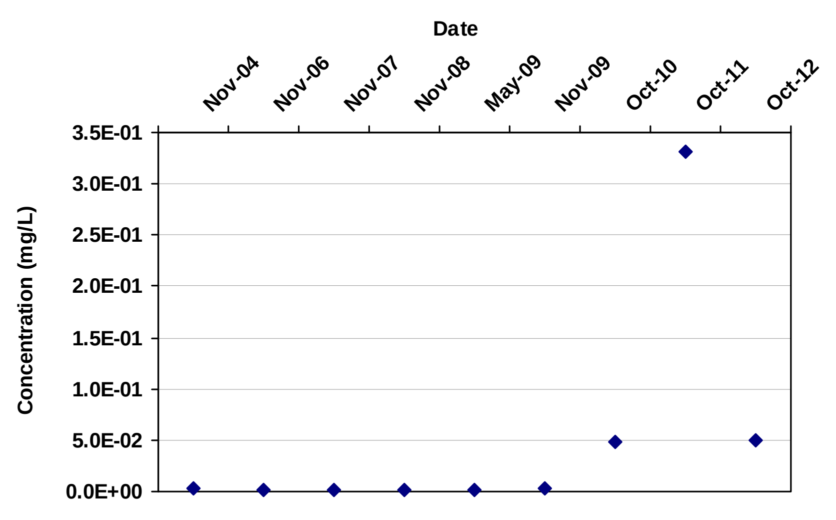
Consolidation Period: No Time Consolidation

Duplicate Consolidation: Median

Consolidation Type: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

12

Confidence in Trend:

87.0%

Coefficient of Variation:

2.20

Mann Kendall Concentration Trend: (See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
26M-92-04X	S	11/1/2004	PERCHLORATE	3.1E-03		1	1
26M-92-04X	S	11/1/2006	PERCHLORATE	2.3E-03		1	1
26M-92-04X	S	11/1/2007	PERCHLORATE	1.8E-03		1	1
26M-92-04X	S	11/1/2008	PERCHLORATE	1.7E-03		1	1
26M-92-04X	S	5/1/2009	PERCHLORATE	1.5E-03		1	1
26M-92-04X	S	11/1/2009	PERCHLORATE	3.0E-03		1	1
26M-92-04X	S	10/1/2010	PERCHLORATE	4.8E-02		1	1
26M-92-04X	S	10/1/2011	PERCHLORATE	3.3E-01		1	1
26M-92-04X	S	10/1/2012	PERCHLORATE	4.9E-02		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 26, Former Ft. Devens　**User Name:** T Lillys

Location: Devens　**State:** Massachusetts

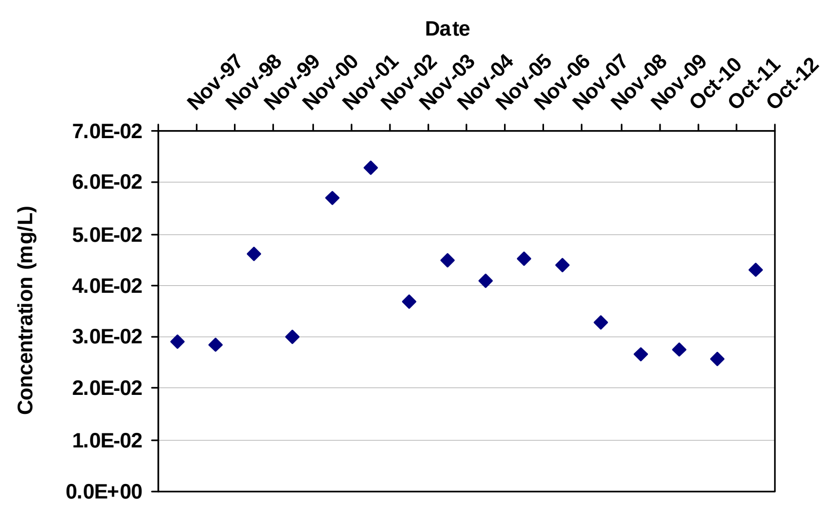
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 26, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Well:	26M-97-08X	**Time Period:**	11/1/1992 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	HEXAHYDRO-1,3,5-TRINITRO-1,3,5	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-24

Confidence in Trend:

84.7%

Coefficient of Variation:

0.29

Mann Kendall Concentration Trend: (See Note)

S

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
26M-97-08X	S	11/1/1997	HEXAHYDRO-1,3,5-T	2.9E-02		1	1
26M-97-08X	S	11/1/1998	HEXAHYDRO-1,3,5-T	2.9E-02		1	1
26M-97-08X	S	11/1/1999	HEXAHYDRO-1,3,5-T	4.6E-02		1	1
26M-97-08X	S	11/1/2000	HEXAHYDRO-1,3,5-T	3.0E-02		1	1
26M-97-08X	S	11/1/2001	HEXAHYDRO-1,3,5-T	5.7E-02		1	1
26M-97-08X	S	11/1/2002	HEXAHYDRO-1,3,5-T	6.3E-02		1	1
26M-97-08X	S	11/1/2003	HEXAHYDRO-1,3,5-T	3.7E-02		1	1
26M-97-08X	S	11/1/2004	HEXAHYDRO-1,3,5-T	4.5E-02		1	1
26M-97-08X	S	11/1/2005	HEXAHYDRO-1,3,5-T	4.1E-02		1	1

MAROS Mann-Kendall Statistics Summary

Project:	AOC 26, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

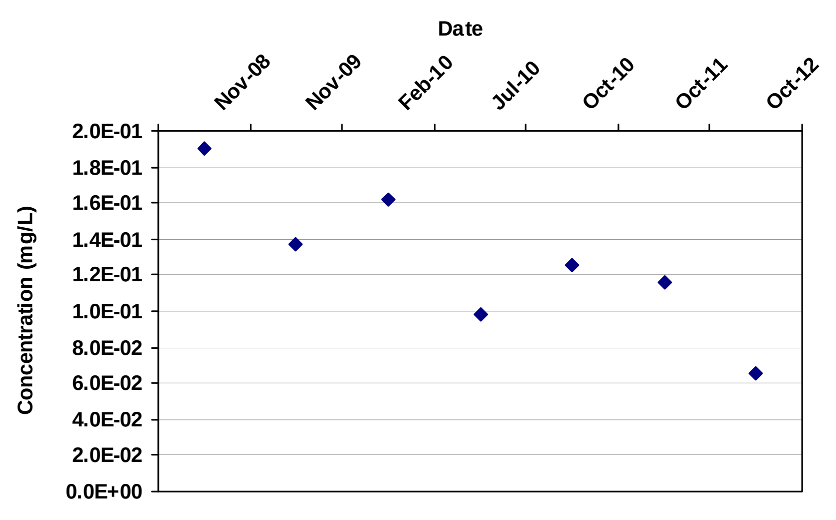
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
26M-97-08X	S	11/1/2006	HEXAHYDRO-1,3,5-T	4.5E-02		1	1
26M-97-08X	S	11/1/2007	HEXAHYDRO-1,3,5-T	4.4E-02		1	1
26M-97-08X	S	11/1/2008	HEXAHYDRO-1,3,5-T	3.3E-02		1	1
26M-97-08X	S	11/1/2009	HEXAHYDRO-1,3,5-T	2.7E-02		1	1
26M-97-08X	S	10/1/2010	HEXAHYDRO-1,3,5-T	2.8E-02		1	1
26M-97-08X	S	10/1/2011	HEXAHYDRO-1,3,5-T	2.6E-02		1	1
26M-97-08X	S	10/1/2012	HEXAHYDRO-1,3,5-T	4.3E-02		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project:	AOC 26, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

Well:	26WP-06-01	**Time Period:**	11/1/1992 **to** 10/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	HEXAHYDRO-1,3,5-TRINITRO-1,3,5	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-15

Confidence in Trend:

98.5%

Coefficient of Variation:

0.32

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
26WP-06-01	T	11/1/2008	HEXAHYDRO-1,3,5-T	1.9E-01		1	1
26WP-06-01	T	11/1/2009	HEXAHYDRO-1,3,5-T	1.4E-01		1	1
26WP-06-01	T	2/1/2010	HEXAHYDRO-1,3,5-T	1.6E-01		1	1
26WP-06-01	T	7/1/2010	HEXAHYDRO-1,3,5-T	9.8E-02		1	1
26WP-06-01	T	10/1/2010	HEXAHYDRO-1,3,5-T	1.3E-01		1	1
26WP-06-01	T	10/1/2011	HEXAHYDRO-1,3,5-T	1.2E-01		1	1
26WP-06-01	T	10/1/2012	HEXAHYDRO-1,3,5-T	6.5E-02		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 26, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

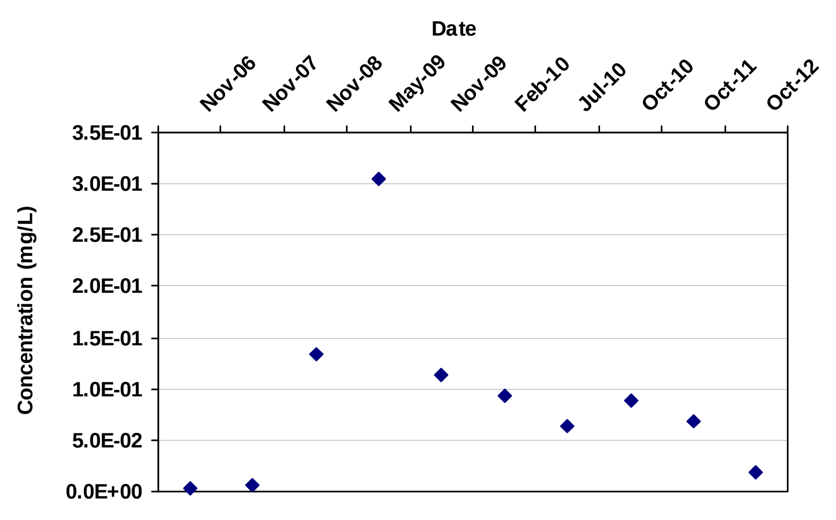
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 26, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Well:	26WP-06-01	**Time Period:**	11/1/1992 **to** 10/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	PERCHLORATE	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-5

Confidence in Trend:

63.6%

Coefficient of Variation:

0.98

Mann Kendall Concentration Trend: (See Note)

S

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
26WP-06-01	T	11/1/2006	PERCHLORATE	3.1E-03		1	1
26WP-06-01	T	11/1/2007	PERCHLORATE	5.6E-03		1	1
26WP-06-01	T	11/1/2008	PERCHLORATE	1.3E-01		1	1
26WP-06-01	T	5/1/2009	PERCHLORATE	3.1E-01		1	1
26WP-06-01	T	11/1/2009	PERCHLORATE	1.1E-01		1	1
26WP-06-01	T	2/1/2010	PERCHLORATE	9.4E-02		1	1
26WP-06-01	T	7/1/2010	PERCHLORATE	6.4E-02		1	1
26WP-06-01	T	10/1/2010	PERCHLORATE	8.9E-02		1	1
26WP-06-01	T	10/1/2011	PERCHLORATE	6.8E-02		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 26, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
26WP-06-01	T	10/1/2012	PERCHLORATE	1.9E-02		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Linear Regression Statistics Summary

Project: AOC 26, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Time Period: 11/1/1992 **to** 10/1/2012

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value

Well	Source/Tail	Average Conc (mg/L)	Median Conc (mg/L)	Standard Deviation	All Samples "ND" ?	Ln Slope	Coefficient of Variation	Confidence in Trend	Concentration Trend
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-T									
26M-92-03X	S	4.3E-02	1.7E-02	6.0E-02	No	-2.6E-04	1.41	99.5%	D
26M-92-04X	S	2.1E-01	2.0E-01	5.6E-02	No	-7.4E-05	0.26	100.0%	D
26M-97-08X	S	3.9E-02	3.9E-02	1.1E-02	No	-2.9E-05	0.29	74.5%	S
26WP-06-01	T	1.3E-01	1.3E-01	4.1E-02	No	-6.6E-04	0.32	99.6%	D
PERCHLORATE									
26M-92-04X	S	4.9E-02	3.0E-03	1.1E-01	No	1.6E-03	2.20	98.4%	I
26WP-06-01	T	9.0E-02	7.9E-02	8.8E-02	No	9.4E-04	0.98	88.1%	NT

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Non-detect (ND); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); COV = Coefficient of Variation

MAROS Mann-Kendall Statistics Summary

Project: AOC 26, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Time Period: 11/1/1992 **to** 10/1/2012

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZIN								
26M-92-03X	S	19	19	1.41	-65	98.8%	No	D
26M-92-04X	S	18	18	0.26	-92	100.0%	No	D
26M-97-08X	S	16	16	0.29	-24	84.7%	No	S
26WP-06-01	T	7	7	0.32	-15	98.5%	No	D
PERCHLORATE								
26M-92-04X	S	9	9	2.20	12	87.0%	No	NT
26WP-06-01	T	10	10	0.98	-5	63.6%	No	S

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Statistical Trend Analysis Summary

Project: AOC 26, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Time Period:	11/1/1992	**to** 10/1/2012
Consolidation Period:	No Time Consolidation	
Consolidation Type:	Median	
Duplicate Consolidation:	Maximum	
ND Values:	1/2 Detection Limit	
J Flag Values :	Actual Value	

Well	Source / Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRI								
26M-92-03X	S	19	19	4.3E-02	1.7E-02	No	D	D
26M-92-04X	S	18	18	2.1E-01	2.0E-01	No	D	D
26M-97-08X	S	16	16	3.9E-02	3.9E-02	No	S	S
26WP-06-01	T	7	7	1.3E-01	1.3E-01	No	D	D
PERCHLORATE								
26M-92-04X	S	9	9	4.9E-02	3.0E-03	No	NT	I
26WP-06-01	T	10	10	9.0E-02	7.9E-02	No	S	NT

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); No Detectable Concentration (ND)

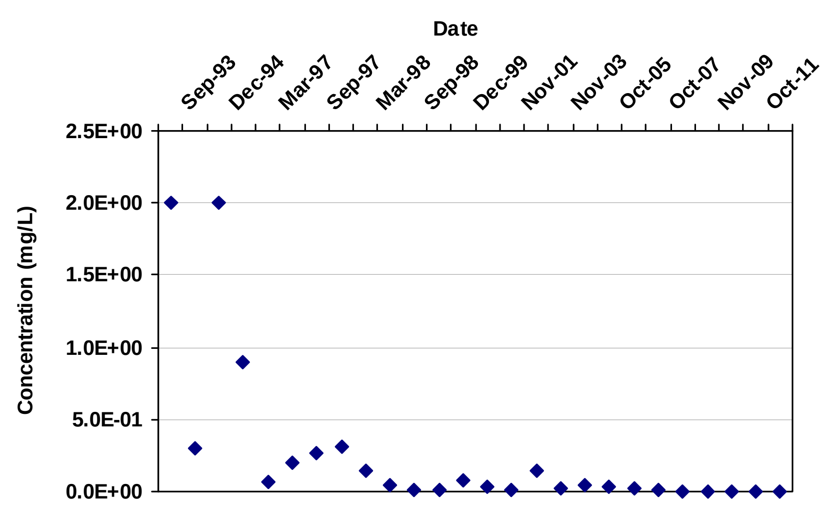
The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Well: XGM-93-02X
Well Type: S
COC: BENZENE

Time Period: 9/1/1993 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Duplicate Consolidation: Median
Consolidation Type: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

-242

Confidence in Trend:

100.0%

Coefficient of Variation:

2.14

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-93-02X	S	9/1/1993	BENZENE	2.0E+00		1	1
XGM-93-02X	S	1/1/1994	BENZENE	3.0E-01		1	1
XGM-93-02X	S	12/1/1994	BENZENE	2.0E+00		1	1
XGM-93-02X	S	3/1/1995	BENZENE	9.0E-01		1	1
XGM-93-02X	S	3/1/1997	BENZENE	6.8E-02		1	1
XGM-93-02X	S	6/1/1997	BENZENE	2.0E-01		1	1
XGM-93-02X	S	9/1/1997	BENZENE	2.6E-01		1	1
XGM-93-02X	S	12/1/1997	BENZENE	3.1E-01		1	1
XGM-93-02X	S	3/1/1998	BENZENE	1.4E-01		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

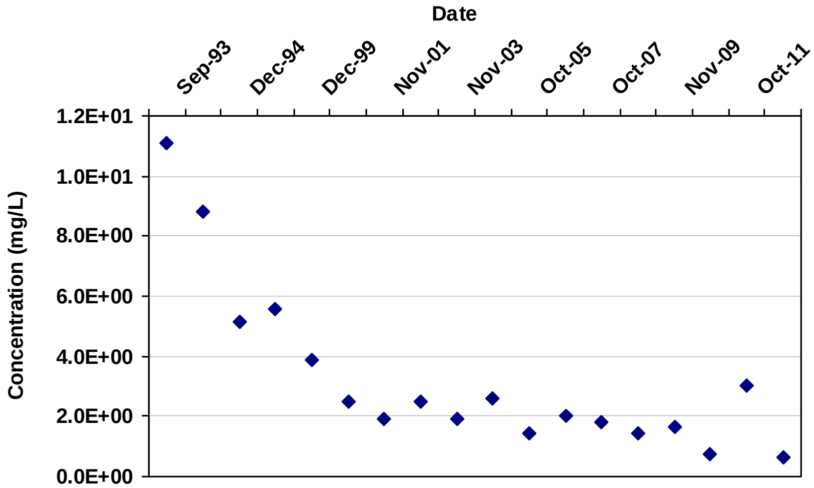
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-93-02X	S	6/1/1998	BENZENE	4.4E-02		1	1
XGM-93-02X	S	9/1/1998	BENZENE	1.6E-02		1	1
XGM-93-02X	S	12/1/1998	BENZENE	1.4E-02		1	1
XGM-93-02X	S	12/1/1999	BENZENE	8.1E-02		1	1
XGM-93-02X	S	11/1/2000	BENZENE	3.2E-02		1	1
XGM-93-02X	S	11/1/2001	BENZENE	1.2E-02		1	1
XGM-93-02X	S	11/1/2002	BENZENE	1.4E-01		1	1
XGM-93-02X	S	11/1/2003	BENZENE	2.4E-02		1	1
XGM-93-02X	S	10/1/2004	BENZENE	3.9E-02		1	1
XGM-93-02X	S	10/5/2005	BENZENE	2.9E-02		1	1
XGM-93-02X	S	10/1/2006	BENZENE	1.9E-02		1	1
XGM-93-02X	S	10/1/2007	BENZENE	8.8E-03		1	1
XGM-93-02X	S	10/1/2008	BENZENE	2.6E-03		1	1
XGM-93-02X	S	11/1/2009	BENZENE	1.0E-03		1	1
XGM-93-02X	S	10/1/2010	BENZENE	2.5E-03	ND	1	0
XGM-93-02X	S	10/1/2011	BENZENE	2.5E-03	ND	1	0
XGM-93-02X	S	10/1/2012	BENZENE	5.0E-08	ND	1	0

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project:	AOC 43G, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

Well:	XGM-93-02X	**Time Period:**	9/1/1993 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	MANGANESE	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-105

Confidence in Trend:

100.0%

Coefficient of Variation:

0.86

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-93-02X	S	9/1/1993	MANGANESE	1.1E+01		1	1
XGM-93-02X	S	1/1/1994	MANGANESE	8.8E+00		1	1
XGM-93-02X	S	12/1/1994	MANGANESE	5.2E+00		1	1
XGM-93-02X	S	3/1/1995	MANGANESE	5.6E+00		1	1
XGM-93-02X	S	12/1/1999	MANGANESE	3.9E+00		1	1
XGM-93-02X	S	11/1/2000	MANGANESE	2.5E+00		1	1
XGM-93-02X	S	11/1/2001	MANGANESE	1.9E+00		1	1
XGM-93-02X	S	11/1/2002	MANGANESE	2.5E+00		1	1
XGM-93-02X	S	11/1/2003	MANGANESE	1.9E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-93-02X	S	10/1/2004	MANGANESE	2.6E+00		1	1
XGM-93-02X	S	10/5/2005	MANGANESE	1.5E+00		1	1
XGM-93-02X	S	10/1/2006	MANGANESE	2.0E+00		1	1
XGM-93-02X	S	10/1/2007	MANGANESE	1.8E+00		1	1
XGM-93-02X	S	10/1/2008	MANGANESE	1.4E+00		1	1
XGM-93-02X	S	11/1/2009	MANGANESE	1.6E+00		1	1
XGM-93-02X	S	10/1/2010	MANGANESE	7.4E-01		1	1
XGM-93-02X	S	10/1/2011	MANGANESE	3.0E+00		1	1
XGM-93-02X	S	10/1/2012	MANGANESE	6.1E-01		1	1

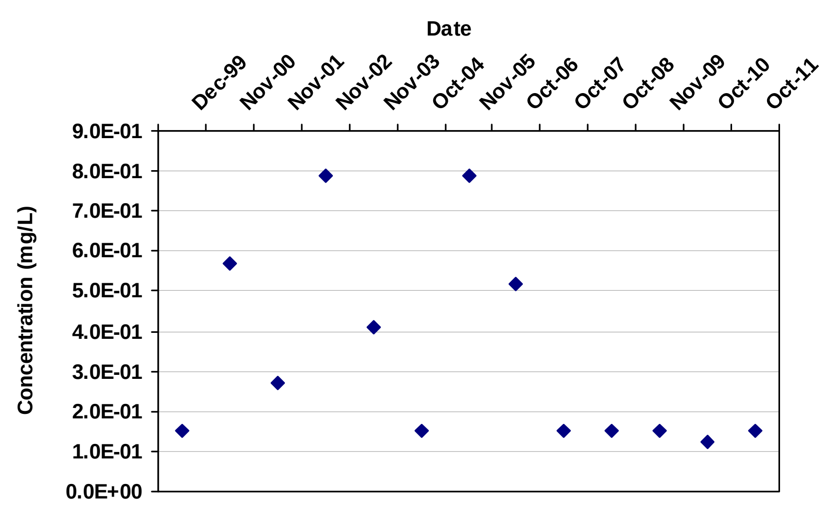
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Well: XGM-93-02X
Well Type: S
COC: VOLATILE PETROLEUM HYDROCAR

Time Period: 9/1/1993 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Duplicate Consolidation: Median
Consolidation Type: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

-29

Confidence in Trend:

95.6%

Coefficient of Variation:

0.75

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-93-02X	S	12/1/1999	VOLATILE PETROLEU	1.5E-01	ND	1	0
XGM-93-02X	S	11/1/2000	VOLATILE PETROLEU	5.7E-01		1	1
XGM-93-02X	S	11/1/2001	VOLATILE PETROLEU	2.7E-01		1	1
XGM-93-02X	S	11/1/2002	VOLATILE PETROLEU	7.9E-01		1	1
XGM-93-02X	S	11/1/2003	VOLATILE PETROLEU	4.1E-01		1	1
XGM-93-02X	S	10/1/2004	VOLATILE PETROLEU	1.5E-01	ND	1	0
XGM-93-02X	S	11/5/2005	VOLATILE PETROLEU	7.9E-01		1	1
XGM-93-02X	S	10/1/2006	VOLATILE PETROLEU	5.2E-01		1	1
XGM-93-02X	S	10/1/2007	VOLATILE PETROLEU	1.5E-01	ND	1	0

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-93-02X	S	10/1/2008	VOLATILE PETROLEU	1.5E-01	ND	1	0
XGM-93-02X	S	11/1/2009	VOLATILE PETROLEU	1.5E-01	ND	1	0
XGM-93-02X	S	10/1/2010	VOLATILE PETROLEU	1.2E-01		1	1
XGM-93-02X	S	10/1/2011	VOLATILE PETROLEU	1.5E-01	ND	1	0

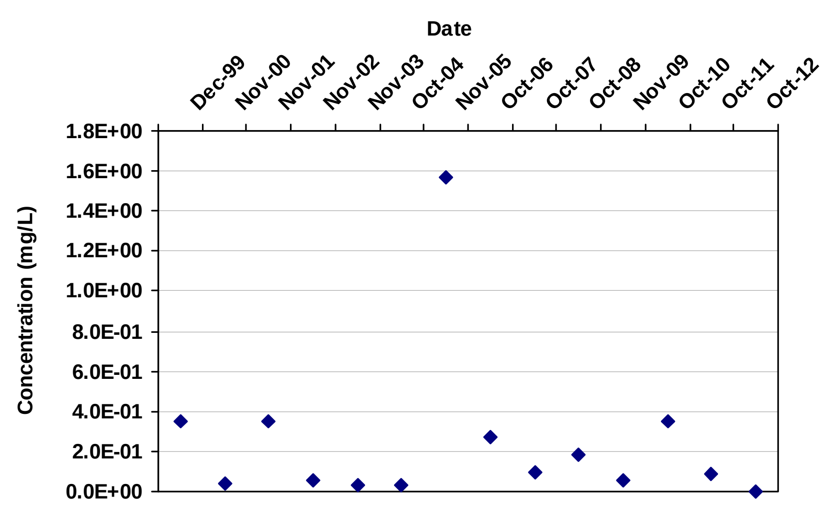
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Well: XGM-93-02X
Well Type: S
COC: VOLATILE PETROLEUM HYDROCAR

Time Period: 9/1/1993 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Duplicate Consolidation: Median
Consolidation Type: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

-12

Confidence in Trend:

72.3%

Coefficient of Variation:

1.62

Mann Kendall Concentration Trend: (See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-93-02X	S	12/1/1999	VOLATILE PETROLEU	3.5E-01	ND	1	0
XGM-93-02X	S	11/1/2000	VOLATILE PETROLEU	3.9E-02		1	1
XGM-93-02X	S	11/1/2001	VOLATILE PETROLEU	3.5E-01	ND	1	0
XGM-93-02X	S	11/1/2002	VOLATILE PETROLEU	5.8E-02		1	1
XGM-93-02X	S	11/1/2003	VOLATILE PETROLEU	3.3E-02		1	1
XGM-93-02X	S	10/1/2004	VOLATILE PETROLEU	3.4E-02		1	1
XGM-93-02X	S	11/5/2005	VOLATILE PETROLEU	1.6E+00		1	1
XGM-93-02X	S	10/1/2006	VOLATILE PETROLEU	2.7E-01		1	1
XGM-93-02X	S	10/1/2007	VOLATILE PETROLEU	9.4E-02		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-93-02X	S	10/1/2008	VOLATILE PETROLEU	1.8E-01		1	1
XGM-93-02X	S	11/1/2009	VOLATILE PETROLEU	5.6E-02		1	1
XGM-93-02X	S	10/1/2010	VOLATILE PETROLEU	3.5E-01	ND	1	0
XGM-93-02X	S	10/1/2011	VOLATILE PETROLEU	8.5E-02		1	1
XGM-93-02X	S	10/1/2012	VOLATILE PETROLEU	5.0E-08	ND	1	0

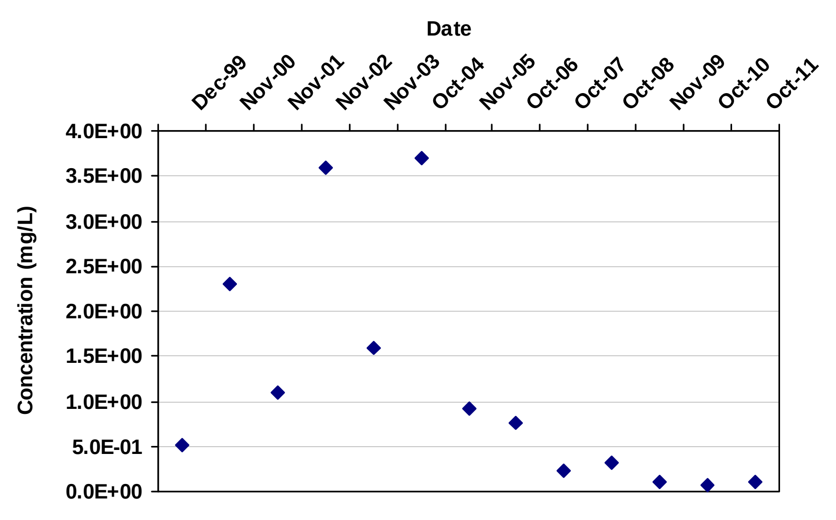
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well:	XGM-93-02X	**Time Period:**	9/1/1993 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	VOLATILE PETROLEUM HYDROCAR	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-46

Confidence in Trend:

99.8%

Coefficient of Variation:

1.08

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-93-02X	S	12/1/1999	VOLATILE PETROLEU	5.1E-01		1	1
XGM-93-02X	S	11/1/2000	VOLATILE PETROLEU	2.3E+00		1	1
XGM-93-02X	S	11/1/2001	VOLATILE PETROLEU	1.1E+00		1	1
XGM-93-02X	S	11/1/2002	VOLATILE PETROLEU	3.6E+00		1	1
XGM-93-02X	S	11/1/2003	VOLATILE PETROLEU	1.6E+00		1	1
XGM-93-02X	S	10/1/2004	VOLATILE PETROLEU	3.7E+00		1	1
XGM-93-02X	S	11/5/2005	VOLATILE PETROLEU	9.2E-01		1	1
XGM-93-02X	S	10/1/2006	VOLATILE PETROLEU	7.7E-01		1	1
XGM-93-02X	S	10/1/2007	VOLATILE PETROLEU	2.3E-01		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-93-02X	S	10/1/2008	VOLATILE PETROLEU	3.3E-01		1	1
XGM-93-02X	S	11/1/2009	VOLATILE PETROLEU	1.1E-01		1	1
XGM-93-02X	S	10/1/2010	VOLATILE PETROLEU	7.3E-02		1	1
XGM-93-02X	S	10/1/2011	VOLATILE PETROLEU	1.0E-01	ND	1	0

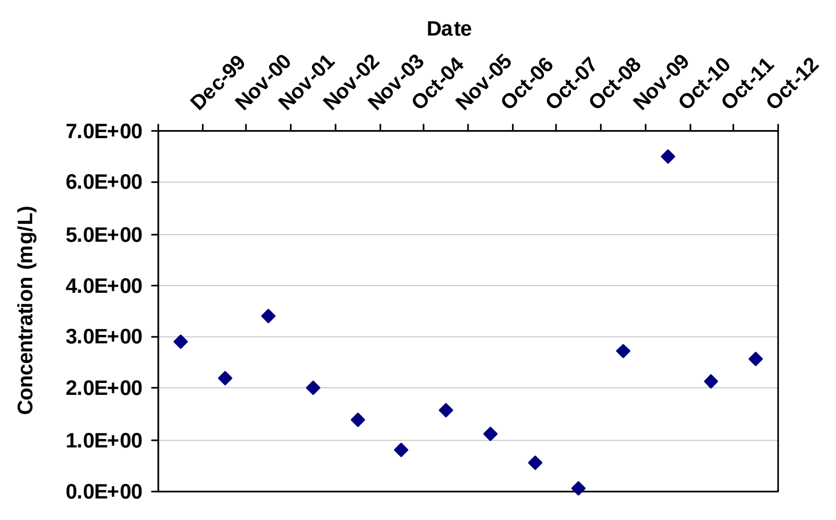
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Well: XGM-94-04X
Well Type: T
COC: MANGANESE

Time Period: 9/1/1993 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Duplicate Consolidation: Median
Consolidation Type: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

-11

Confidence in Trend:

70.5%

Coefficient of Variation:

0.74

Mann Kendall Concentration Trend: (See Note)

S

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-94-04X	T	12/1/1999	MANGANESE	2.9E+00		1	1
XGM-94-04X	T	11/1/2000	MANGANESE	2.2E+00		1	1
XGM-94-04X	T	11/1/2001	MANGANESE	3.4E+00		1	1
XGM-94-04X	T	11/1/2002	MANGANESE	2.0E+00		1	1
XGM-94-04X	T	11/1/2003	MANGANESE	1.4E+00		1	1
XGM-94-04X	T	10/1/2004	MANGANESE	7.9E-01		1	1
XGM-94-04X	T	11/1/2005	MANGANESE	1.6E+00		1	1
XGM-94-04X	T	10/1/2006	MANGANESE	1.1E+00		1	1
XGM-94-04X	T	10/1/2007	MANGANESE	5.6E-01		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-94-04X	T	10/1/2008	MANGANESE	6.8E-02		1	1
XGM-94-04X	T	11/1/2009	MANGANESE	2.7E+00		1	1
XGM-94-04X	T	10/1/2010	MANGANESE	6.5E+00		1	1
XGM-94-04X	T	10/1/2011	MANGANESE	2.1E+00		1	1
XGM-94-04X	T	10/1/2012	MANGANESE	2.6E+00		1	1

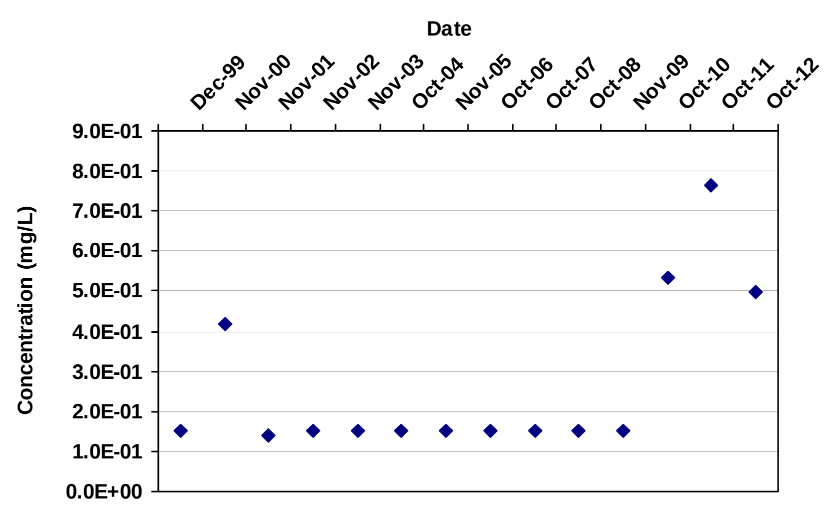
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens　**User Name:** T Lillys

Location: Devens　**State:** Massachusetts

Well:	XGM-94-04X	**Time Period:**	9/1/1993 **to** 10/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	VOLATILE PETROLEUM HYDROCAR	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

27

Confidence in Trend:

92.1%

Coefficient of Variation:

0.77

Mann Kendall Concentration Trend: (See Note)

PI

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-94-04X	T	12/1/1999	VOLATILE PETROLEU	1.5E-01	ND	1	0
XGM-94-04X	T	11/1/2000	VOLATILE PETROLEU	4.2E-01		1	1
XGM-94-04X	T	11/1/2001	VOLATILE PETROLEU	1.4E-01		1	1
XGM-94-04X	T	11/1/2002	VOLATILE PETROLEU	1.5E-01	ND	1	0
XGM-94-04X	T	11/1/2003	VOLATILE PETROLEU	1.5E-01	ND	1	0
XGM-94-04X	T	10/1/2004	VOLATILE PETROLEU	1.5E-01	ND	1	0
XGM-94-04X	T	11/5/2005	VOLATILE PETROLEU	1.5E-01	ND	1	0
XGM-94-04X	T	10/1/2006	VOLATILE PETROLEU	1.5E-01	ND	1	0
XGM-94-04X	T	10/1/2007	VOLATILE PETROLEU	1.5E-01	ND	1	0

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

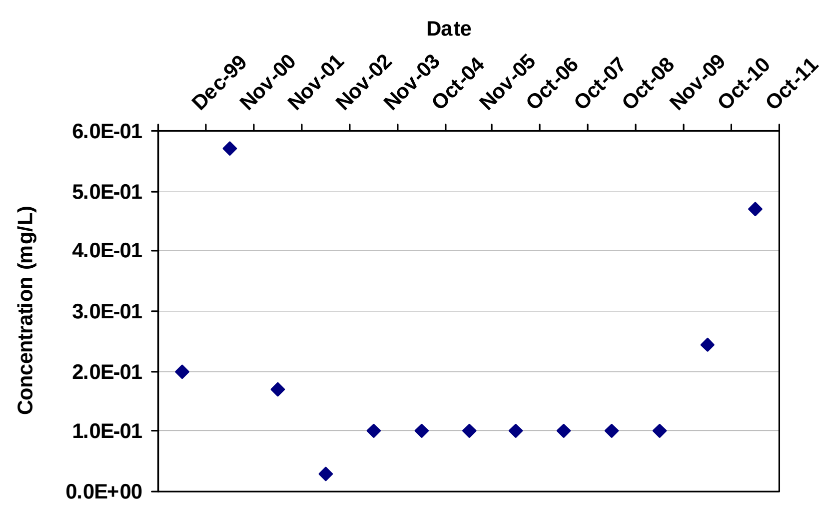
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-94-04X	T	10/1/2008	VOLATILE PETROLEU	1.5E-01	ND	1	0
XGM-94-04X	T	11/1/2009	VOLATILE PETROLEU	1.5E-01	ND	1	0
XGM-94-04X	T	10/1/2010	VOLATILE PETROLEU	5.3E-01		1	1
XGM-94-04X	T	10/1/2011	VOLATILE PETROLEU	7.7E-01		1	1
XGM-94-04X	T	10/1/2012	VOLATILE PETROLEU	5.0E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project:	AOC 43G, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

Well:	XGM-94-04X	**Time Period:**	9/1/1993 **to** 10/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	VOLATILE PETROLEUM HYDROCAR	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

1

Confidence in Trend:

50.0%

Coefficient of Variation:

0.87

Mann Kendall Concentration Trend: (See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-94-04X	T	12/1/1999	VOLATILE PETROLEU	2.0E-01		1	1
XGM-94-04X	T	11/1/2000	VOLATILE PETROLEU	5.7E-01		1	1
XGM-94-04X	T	11/1/2001	VOLATILE PETROLEU	1.7E-01		1	1
XGM-94-04X	T	11/1/2002	VOLATILE PETROLEU	2.8E-02		1	1
XGM-94-04X	T	11/1/2003	VOLATILE PETROLEU	1.0E-01	ND	1	0
XGM-94-04X	T	10/1/2004	VOLATILE PETROLEU	1.0E-01	ND	1	0
XGM-94-04X	T	11/5/2005	VOLATILE PETROLEU	1.0E-01	ND	1	0
XGM-94-04X	T	10/1/2006	VOLATILE PETROLEU	1.0E-01	ND	1	0
XGM-94-04X	T	10/1/2007	VOLATILE PETROLEU	1.0E-01	ND	1	0

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-94-04X	T	10/1/2008	VOLATILE PETROLEU	1.0E-01	ND	1	0
XGM-94-04X	T	11/1/2009	VOLATILE PETROLEU	1.0E-01	ND	1	0
XGM-94-04X	T	10/1/2010	VOLATILE PETROLEU	2.4E-01		1	1
XGM-94-04X	T	10/1/2011	VOLATILE PETROLEU	4.7E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

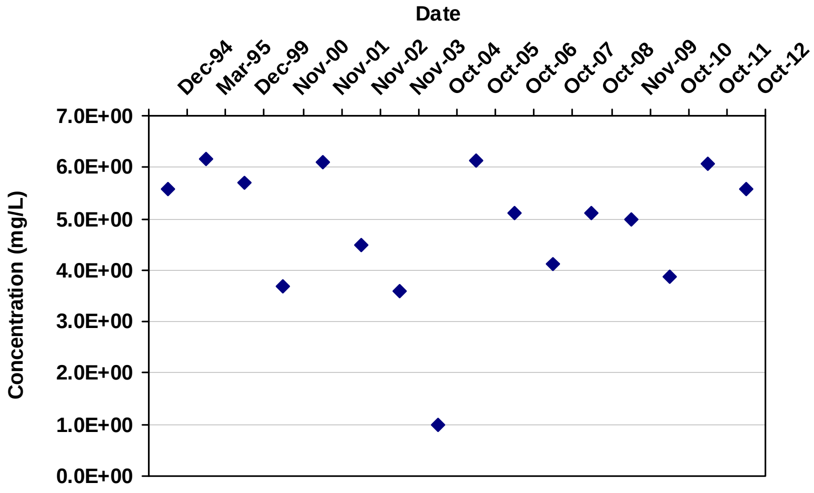
MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens
User Name: T Lillys

Location: Devens
State: Massachusetts

Well: XGM-94-07X
Well Type: T
COC: MANGANESE

Time Period: 9/1/1993 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Duplicate Consolidation: Median
Consolidation Type: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

-12

Confidence in Trend:

68.7%

Coefficient of Variation:

0.28

Mann Kendall Concentration Trend: (See Note)

S

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-94-07X	T	12/1/1994	MANGANESE	5.6E+00		1	1
XGM-94-07X	T	3/1/1995	MANGANESE	6.2E+00		1	1
XGM-94-07X	T	12/1/1999	MANGANESE	5.7E+00		1	1
XGM-94-07X	T	11/1/2000	MANGANESE	3.7E+00		1	1
XGM-94-07X	T	11/1/2001	MANGANESE	6.1E+00		1	1
XGM-94-07X	T	11/1/2002	MANGANESE	4.5E+00		1	1
XGM-94-07X	T	11/1/2003	MANGANESE	3.6E+00		1	1
XGM-94-07X	T	10/1/2004	MANGANESE	1.0E+00		1	1
XGM-94-07X	T	10/5/2005	MANGANESE	6.1E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

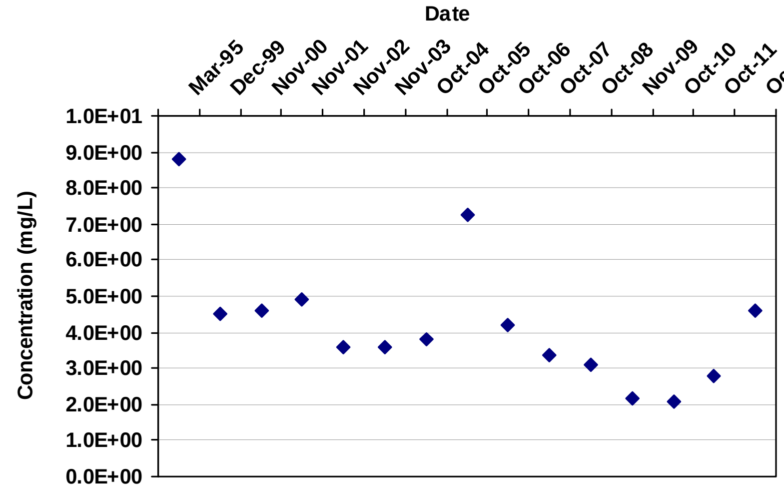
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-94-07X	T	10/1/2006	MANGANESE	5.1E+00		1	1
XGM-94-07X	T	10/1/2007	MANGANESE	4.1E+00		1	1
XGM-94-07X	T	10/1/2008	MANGANESE	5.1E+00		1	1
XGM-94-07X	T	11/1/2009	MANGANESE	5.0E+00		1	1
XGM-94-07X	T	10/1/2010	MANGANESE	3.9E+00		1	1
XGM-94-07X	T	10/1/2011	MANGANESE	6.1E+00		1	1
XGM-94-07X	T	10/1/2012	MANGANESE	5.6E+00		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project:	AOC 43G, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

Well:	XGM-94-08X	**Time Period:**	9/1/1993 **to** 10/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	MANGANESE	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-50

Confidence in Trend:

99.3%

Coefficient of Variation:

0.42

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-94-08X	T	3/1/1995	MANGANESE	8.8E+00		1	1
XGM-94-08X	T	12/1/1999	MANGANESE	4.5E+00		1	1
XGM-94-08X	T	11/1/2000	MANGANESE	4.6E+00		1	1
XGM-94-08X	T	11/1/2001	MANGANESE	4.9E+00		1	1
XGM-94-08X	T	11/1/2002	MANGANESE	3.6E+00		1	1
XGM-94-08X	T	11/1/2003	MANGANESE	3.6E+00		1	1
XGM-94-08X	T	10/1/2004	MANGANESE	3.8E+00		1	1
XGM-94-08X	T	10/5/2005	MANGANESE	7.3E+00		1	1
XGM-94-08X	T	10/1/2006	MANGANESE	4.2E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

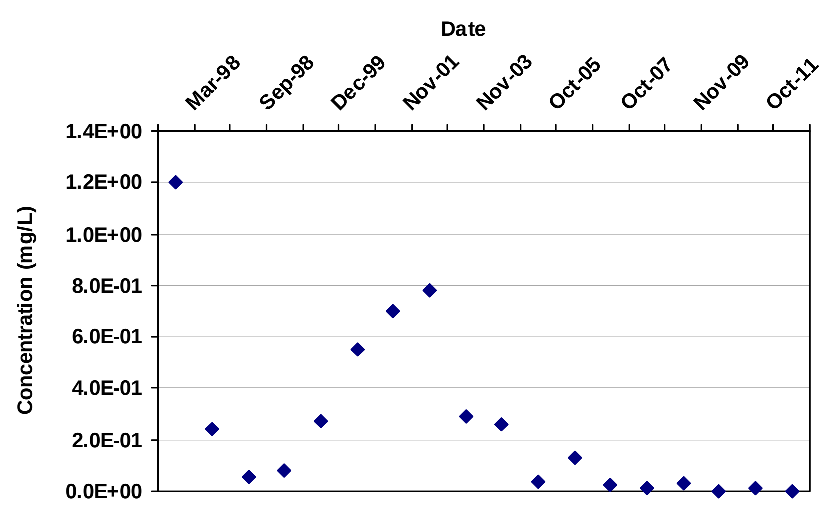
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-94-08X	T	10/1/2007	MANGANESE	3.4E+00		1	1
XGM-94-08X	T	10/1/2008	MANGANESE	3.1E+00		1	1
XGM-94-08X	T	11/1/2009	MANGANESE	2.2E+00		1	1
XGM-94-08X	T	10/1/2010	MANGANESE	2.1E+00		1	1
XGM-94-08X	T	10/1/2011	MANGANESE	2.8E+00		1	1
XGM-94-08X	T	10/1/2012	MANGANESE	4.6E+00		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project:	AOC 43G, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

Well:	XGM-97-12X	**Time Period:**	9/1/1993 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	BENZENE	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-85

Confidence in Trend:

100.0%

Coefficient of Variation:

1.30

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-97-12X	S	3/1/1998	BENZENE	1.2E+00		1	1
XGM-97-12X	S	6/1/1998	BENZENE	2.4E-01		1	1
XGM-97-12X	S	9/1/1998	BENZENE	5.4E-02		1	1
XGM-97-12X	S	12/1/1998	BENZENE	7.9E-02		1	1
XGM-97-12X	S	12/1/1999	BENZENE	2.7E-01		1	1
XGM-97-12X	S	11/1/2000	BENZENE	5.5E-01		1	1
XGM-97-12X	S	11/1/2001	BENZENE	7.0E-01		1	1
XGM-97-12X	S	11/1/2002	BENZENE	7.8E-01		1	1
XGM-97-12X	S	11/1/2003	BENZENE	2.9E-01		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-97-12X	S	10/1/2004	BENZENE	2.6E-01		1	1
XGM-97-12X	S	10/5/2005	BENZENE	3.6E-02		1	1
XGM-97-12X	S	10/1/2006	BENZENE	1.3E-01		1	1
XGM-97-12X	S	10/1/2007	BENZENE	2.3E-02		1	1
XGM-97-12X	S	10/1/2008	BENZENE	1.4E-02		1	1
XGM-97-12X	S	11/1/2009	BENZENE	2.8E-02		1	1
XGM-97-12X	S	10/1/2010	BENZENE	2.5E-03	ND	1	0
XGM-97-12X	S	10/1/2011	BENZENE	1.4E-02		1	1
XGM-97-12X	S	10/1/2012	BENZENE	3.0E-03		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

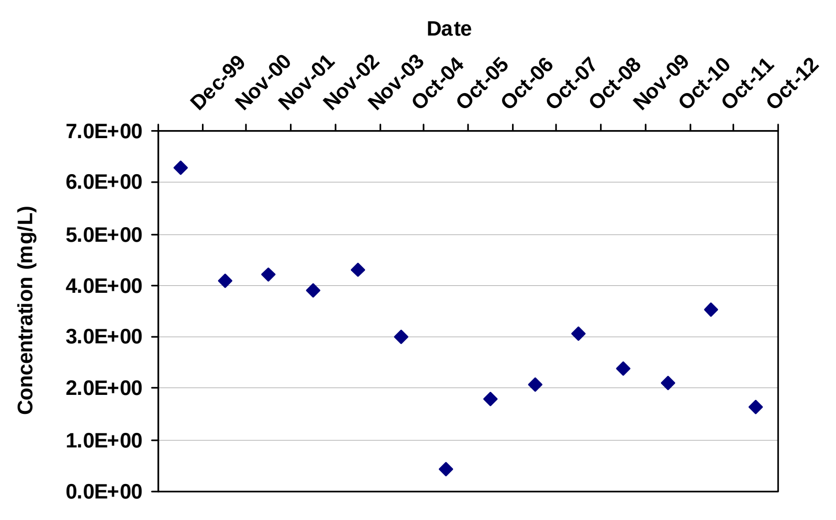
Project: AOC 43G, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well:	XGM-97-12X	**Time Period:**	9/1/1993 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	MANGANESE	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-41

Confidence in Trend:

98.7%

Coefficient of Variation:

0.48

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-97-12X	S	12/1/1999	MANGANESE	6.3E+00		1	1
XGM-97-12X	S	11/1/2000	MANGANESE	4.1E+00		1	1
XGM-97-12X	S	11/1/2001	MANGANESE	4.2E+00		1	1
XGM-97-12X	S	11/1/2002	MANGANESE	3.9E+00		1	1
XGM-97-12X	S	11/1/2003	MANGANESE	4.3E+00		1	1
XGM-97-12X	S	10/1/2004	MANGANESE	3.0E+00		1	1
XGM-97-12X	S	10/5/2005	MANGANESE	4.4E-01		1	1
XGM-97-12X	S	10/1/2006	MANGANESE	1.8E+00		1	1
XGM-97-12X	S	10/1/2007	MANGANESE	2.1E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens　　**User Name:** T Lillys

Location: Devens　　**State:** Massachusetts

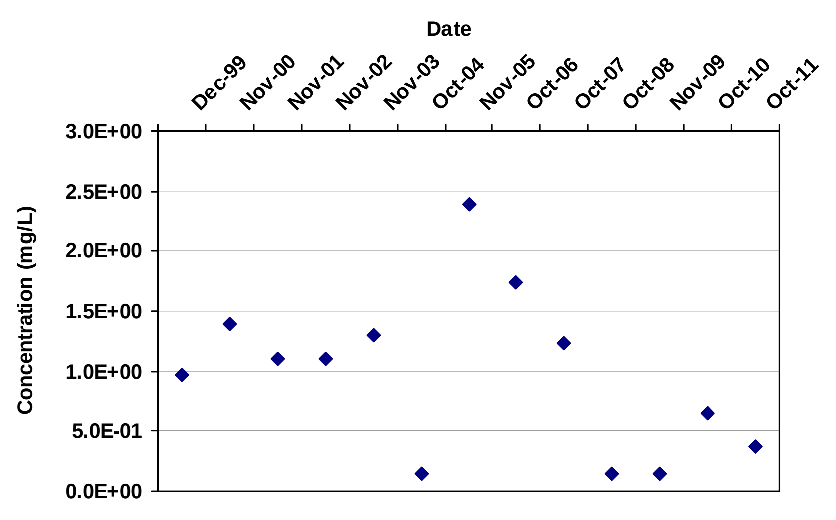
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-97-12X	S	10/1/2008	MANGANESE	3.1E+00		1	1
XGM-97-12X	S	11/1/2009	MANGANESE	2.4E+00		1	1
XGM-97-12X	S	10/1/2010	MANGANESE	2.1E+00		1	1
XGM-97-12X	S	10/1/2011	MANGANESE	3.5E+00		1	1
XGM-97-12X	S	10/1/2012	MANGANESE	1.6E+00		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project:	AOC 43G, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

Well:	XGM-97-12X	**Time Period:**	9/1/1993 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	VOLATILE PETROLEUM HYDROCAR	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-18

Confidence in Trend:

84.7%

Coefficient of Variation:

0.69

Mann Kendall Concentration Trend: (See Note)

S

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-97-12X	S	12/1/1999	VOLATILE PETROLEU	9.7E-01		1	1
XGM-97-12X	S	11/1/2000	VOLATILE PETROLEU	1.4E+00		1	1
XGM-97-12X	S	11/1/2001	VOLATILE PETROLEU	1.1E+00		1	1
XGM-97-12X	S	11/1/2002	VOLATILE PETROLEU	1.1E+00		1	1
XGM-97-12X	S	11/1/2003	VOLATILE PETROLEU	1.3E+00		1	1
XGM-97-12X	S	10/1/2004	VOLATILE PETROLEU	1.5E-01	ND	1	0
XGM-97-12X	S	11/5/2005	VOLATILE PETROLEU	2.4E+00		1	1
XGM-97-12X	S	10/1/2006	VOLATILE PETROLEU	1.7E+00		1	1
XGM-97-12X	S	10/1/2007	VOLATILE PETROLEU	1.2E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-97-12X	S	10/1/2008	VOLATILE PETROLEU	1.5E-01	ND	1	0
XGM-97-12X	S	11/1/2009	VOLATILE PETROLEU	1.5E-01	ND	1	0
XGM-97-12X	S	10/1/2010	VOLATILE PETROLEU	6.4E-01		1	1
XGM-97-12X	S	10/1/2011	VOLATILE PETROLEU	3.7E-01		1	1

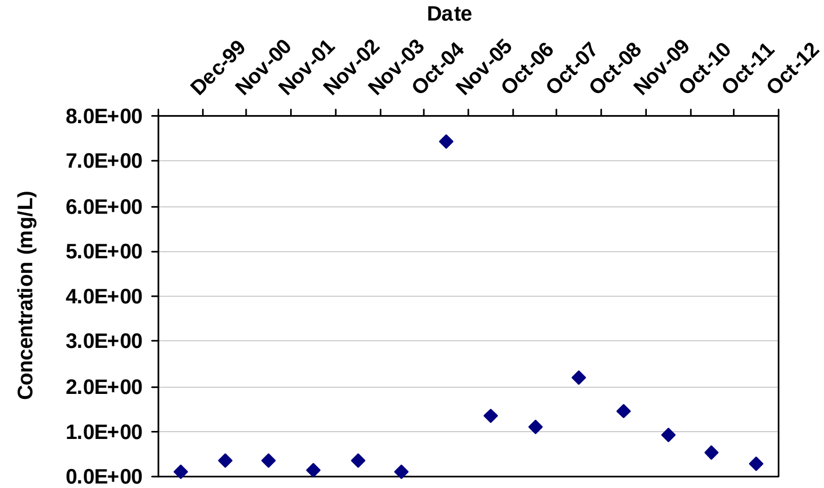
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Well: XGM-97-12X
Well Type: S
COC: VOLATILE PETROLEUM HYDROCAR

Time Period: 9/1/1993 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Duplicate Consolidation: Median
Consolidation Type: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

20

Confidence in Trend:

84.8%

Coefficient of Variation:

1.60

Mann Kendall Concentration Trend: (See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-97-12X	S	12/1/1999	VOLATILE PETROLEU	9.6E-02		1	1
XGM-97-12X	S	11/1/2000	VOLATILE PETROLEU	3.5E-01	ND	1	0
XGM-97-12X	S	11/1/2001	VOLATILE PETROLEU	3.5E-01	ND	1	0
XGM-97-12X	S	11/1/2002	VOLATILE PETROLEU	1.3E-01		1	1
XGM-97-12X	S	11/1/2003	VOLATILE PETROLEU	3.5E-01	ND	1	0
XGM-97-12X	S	10/1/2004	VOLATILE PETROLEU	9.4E-02		1	1
XGM-97-12X	S	11/5/2005	VOLATILE PETROLEU	7.4E+00		1	1
XGM-97-12X	S	10/1/2006	VOLATILE PETROLEU	1.3E+00		1	1
XGM-97-12X	S	10/1/2007	VOLATILE PETROLEU	1.1E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-97-12X	S	10/1/2008	VOLATILE PETROLEU	2.2E+00		1	1
XGM-97-12X	S	11/1/2009	VOLATILE PETROLEU	1.4E+00		1	1
XGM-97-12X	S	10/1/2010	VOLATILE PETROLEU	9.2E-01		1	1
XGM-97-12X	S	10/1/2011	VOLATILE PETROLEU	5.4E-01		1	1
XGM-97-12X	S	10/1/2012	VOLATILE PETROLEU	2.8E-01		1	1

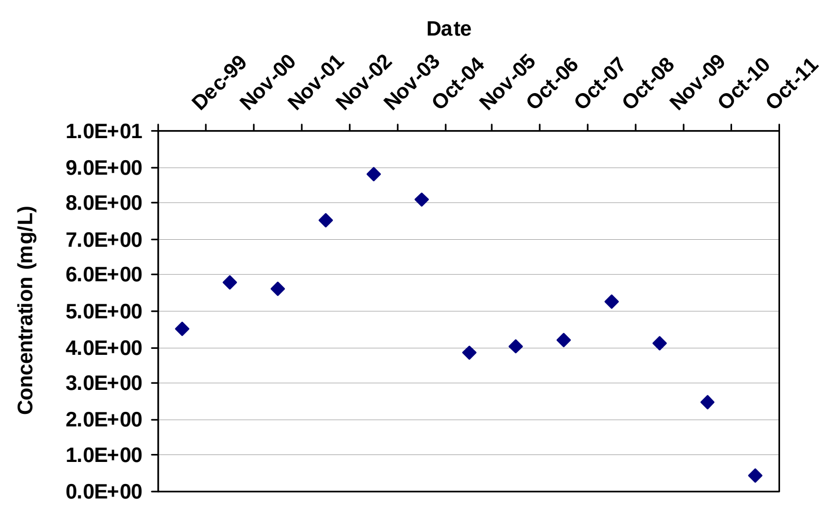
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Well: XGM-97-12X
Well Type: S
COC: VOLATILE PETROLEUM HYDROCAR

Time Period: 9/1/1993 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Duplicate Consolidation: Median
Consolidation Type: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

-34

Confidence in Trend:

97.9%

Coefficient of Variation:

0.46

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-97-12X	S	12/1/1999	VOLATILE PETROLEU	4.5E+00		1	1
XGM-97-12X	S	11/1/2000	VOLATILE PETROLEU	5.8E+00		1	1
XGM-97-12X	S	11/1/2001	VOLATILE PETROLEU	5.6E+00		1	1
XGM-97-12X	S	11/1/2002	VOLATILE PETROLEU	7.5E+00		1	1
XGM-97-12X	S	11/1/2003	VOLATILE PETROLEU	8.8E+00		1	1
XGM-97-12X	S	10/1/2004	VOLATILE PETROLEU	8.1E+00		1	1
XGM-97-12X	S	11/5/2005	VOLATILE PETROLEU	3.8E+00		1	1
XGM-97-12X	S	10/1/2006	VOLATILE PETROLEU	4.0E+00		1	1
XGM-97-12X	S	10/1/2007	VOLATILE PETROLEU	4.2E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

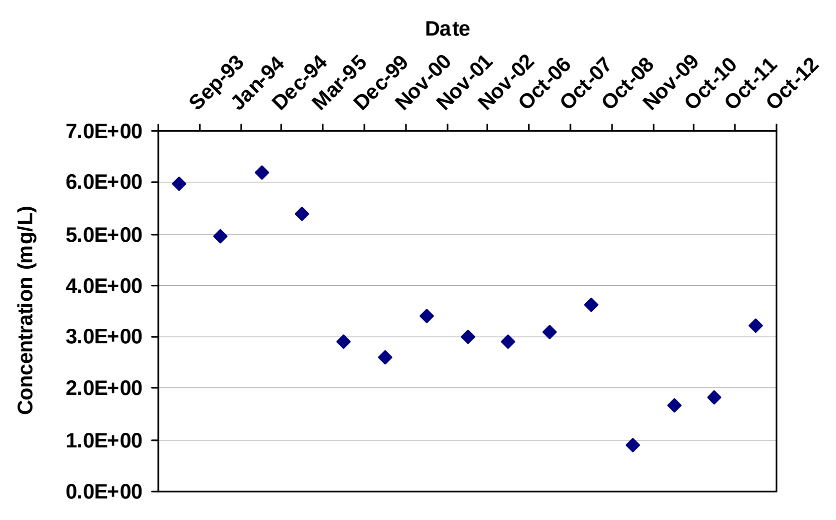
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
XGM-97-12X	S	10/1/2008	VOLATILE PETROLEU	5.3E+00		1	1
XGM-97-12X	S	11/1/2009	VOLATILE PETROLEU	4.1E+00		1	1
XGM-97-12X	S	10/1/2010	VOLATILE PETROLEU	2.5E+00		1	1
XGM-97-12X	S	10/1/2011	VOLATILE PETROLEU	4.6E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project:	AOC 43G, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

Well:	AAFES-06/6R	**Time Period:**	9/1/1993 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	MANGANESE	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-46

Confidence in Trend:

98.8%

Coefficient of Variation:

0.45

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
AAFES-06/6R	S	9/1/1993	MANGANESE	6.0E+00		1	1
AAFES-06/6R	S	1/1/1994	MANGANESE	5.0E+00		1	1
AAFES-06/6R	S	12/1/1994	MANGANESE	6.2E+00		1	1
AAFES-06/6R	S	3/1/1995	MANGANESE	5.4E+00		1	1
AAFES-06/6R	S	12/1/1999	MANGANESE	2.9E+00		1	1
AAFES-06/6R	S	11/1/2000	MANGANESE	2.6E+00		1	1
AAFES-06/6R	S	11/1/2001	MANGANESE	3.4E+00		1	1
AAFES-06/6R	S	11/1/2002	MANGANESE	3.0E+00		1	1
AAFES-06/6R	S	10/1/2006	MANGANESE	2.9E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project:	AOC 43G, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
AAFES-06/6R	S	10/1/2007	MANGANESE	3.1E+00		1	1
AAFES-06/6R	S	10/1/2008	MANGANESE	3.6E+00		1	1
AAFES-06/6R	S	11/1/2009	MANGANESE	9.1E-01		1	1
AAFES-06/6R	S	10/1/2010	MANGANESE	1.7E+00		1	1
AAFES-06/6R	S	10/1/2011	MANGANESE	1.8E+00		1	1
AAFES-06/6R	S	10/1/2012	MANGANESE	3.2E+00		1	1

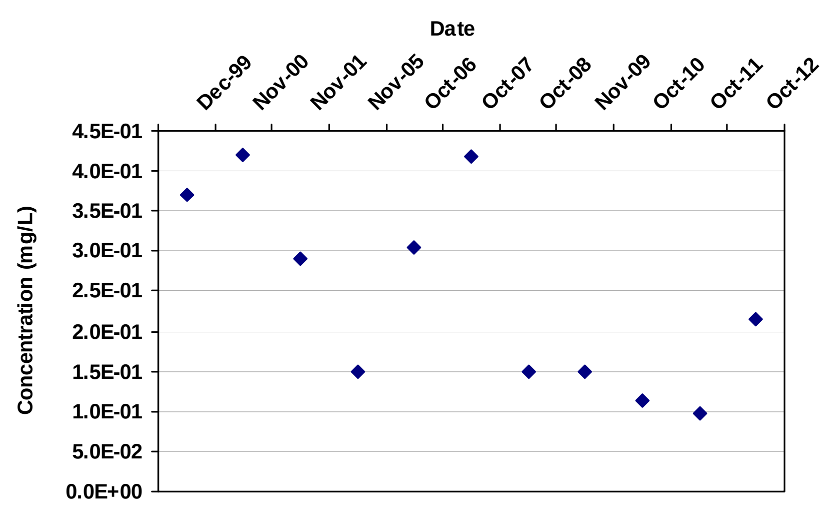
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well:	AAFES-06/6R	**Time Period:**	9/1/1993 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	VOLATILE PETROLEUM HYDROCAR	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-28

Confidence in Trend:

98.4%

Coefficient of Variation:

0.50

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
AAFES-06/6R	S	12/1/1999	VOLATILE PETROLEU	3.7E-01		1	1
AAFES-06/6R	S	11/1/2000	VOLATILE PETROLEU	4.2E-01		1	1
AAFES-06/6R	S	11/1/2001	VOLATILE PETROLEU	2.9E-01		1	1
AAFES-06/6R	S	11/5/2005	VOLATILE PETROLEU	1.5E-01	ND	1	0
AAFES-06/6R	S	10/1/2006	VOLATILE PETROLEU	3.1E-01		1	1
AAFES-06/6R	S	10/1/2007	VOLATILE PETROLEU	4.2E-01		1	1
AAFES-06/6R	S	10/1/2008	VOLATILE PETROLEU	1.5E-01	ND	1	0
AAFES-06/6R	S	11/1/2009	VOLATILE PETROLEU	1.5E-01	ND	1	0
AAFES-06/6R	S	10/1/2010	VOLATILE PETROLEU	1.1E-01		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
AAFES-06/6R	S	10/1/2011	VOLATILE PETROLEU	9.8E-02		1	1
AAFES-06/6R	S	10/1/2012	VOLATILE PETROLEU	2.2E-01		1	1

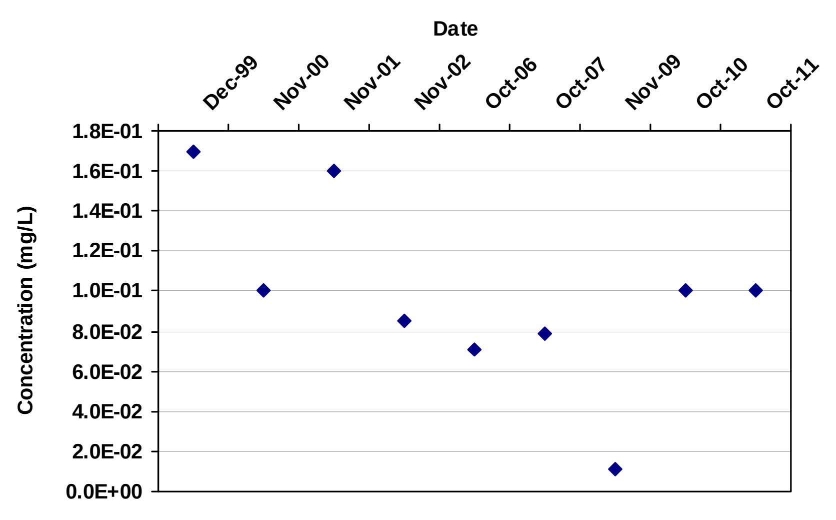
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well:	AAFES-06/6R	**Time Period:**	9/1/1993 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	VOLATILE PETROLEUM HYDROCAR	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-11

Confidence in Trend:

84.6%

Coefficient of Variation:

0.49

Mann Kendall Concentration Trend: (See Note)

S

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
AAFES-06/6R	S	12/1/1999	VOLATILE PETROLEU	1.7E-01		1	1
AAFES-06/6R	S	11/1/2000	VOLATILE PETROLEU	1.0E-01		1	1
AAFES-06/6R	S	11/1/2001	VOLATILE PETROLEU	1.6E-01		1	1
AAFES-06/6R	S	11/1/2002	VOLATILE PETROLEU	8.5E-02		1	1
AAFES-06/6R	S	10/1/2006	VOLATILE PETROLEU	7.1E-02		1	1
AAFES-06/6R	S	10/1/2007	VOLATILE PETROLEU	7.9E-02		1	1
AAFES-06/6R	S	11/1/2009	VOLATILE PETROLEU	1.1E-02		1	1
AAFES-06/6R	S	10/1/2010	VOLATILE PETROLEU	1.0E-01	ND	1	0
AAFES-06/6R	S	10/1/2011	VOLATILE PETROLEU	1.0E-01	ND	1	0

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects

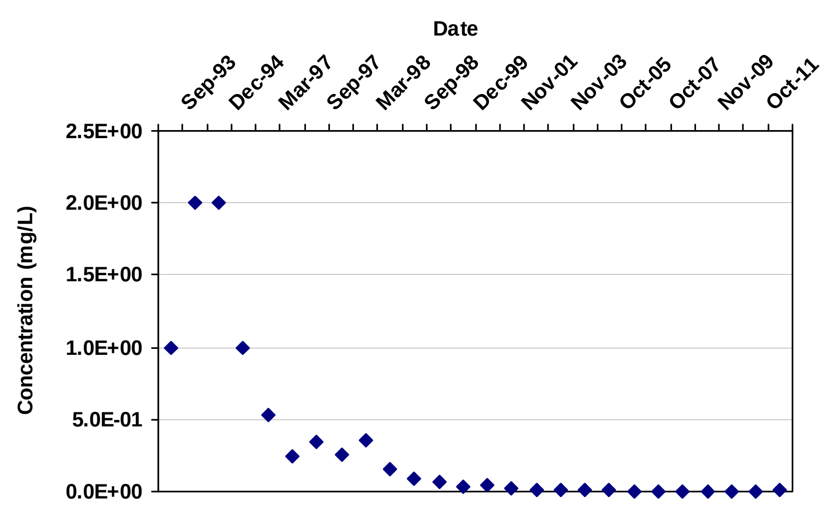
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well:	AAFES-2	**Time Period:**	9/1/1993 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	BENZENE	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-271

Confidence in Trend:

100.0%

Coefficient of Variation:

1.81

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
AAFES-2	S	9/1/1993	BENZENE	1.0E+00		1	1
AAFES-2	S	1/1/1994	BENZENE	2.0E+00		1	1
AAFES-2	S	12/1/1994	BENZENE	2.0E+00		1	1
AAFES-2	S	3/1/1995	BENZENE	1.0E+00		1	1
AAFES-2	S	3/1/1997	BENZENE	5.3E-01		1	1
AAFES-2	S	6/1/1997	BENZENE	2.4E-01		1	1
AAFES-2	S	9/1/1997	BENZENE	3.4E-01		1	1
AAFES-2	S	12/1/1997	BENZENE	2.5E-01		1	1
AAFES-2	S	3/1/1998	BENZENE	3.5E-01		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
AAFES-2	S	6/1/1998	BENZENE	1.6E-01		2	2
AAFES-2	S	9/1/1998	BENZENE	8.7E-02		1	1
AAFES-2	S	12/1/1998	BENZENE	6.2E-02		1	1
AAFES-2	S	12/1/1999	BENZENE	3.6E-02		1	1
AAFES-2	S	11/1/2000	BENZENE	4.3E-02		1	1
AAFES-2	S	11/1/2001	BENZENE	2.6E-02		1	1
AAFES-2	S	11/1/2002	BENZENE	9.0E-03		1	1
AAFES-2	S	11/1/2003	BENZENE	9.0E-03		1	1
AAFES-2	S	10/1/2004	BENZENE	6.6E-03		1	1
AAFES-2	S	10/5/2005	BENZENE	6.1E-03		1	1
AAFES-2	S	10/1/2006	BENZENE	1.0E-03		1	1
AAFES-2	S	10/1/2007	BENZENE	2.5E-03	ND	1	0
AAFES-2	S	10/1/2008	BENZENE	2.5E-03	ND	1	0
AAFES-2	S	11/1/2009	BENZENE	3.9E-03		1	1
AAFES-2	S	10/1/2010	BENZENE	2.5E-03	ND	1	0
AAFES-2	S	10/1/2011	BENZENE	2.5E-03	ND	1	0
AAFES-2	S	10/1/2012	BENZENE	6.6E-03		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

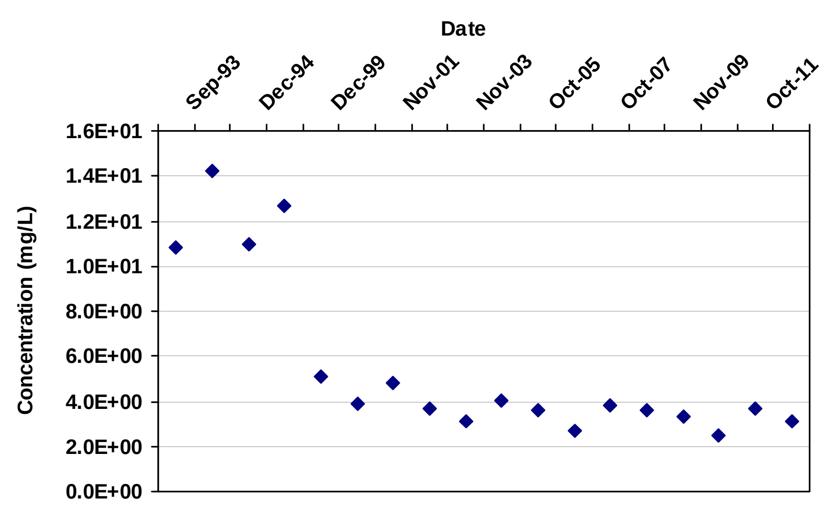
Project: AOC 43G, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well:	AAFES-2	**Time Period:**	9/1/1993 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	MANGANESE	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-99

Confidence in Trend:

100.0%

Coefficient of Variation:

0.68

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
AAFES-2	S	9/1/1993	MANGANESE	1.1E+01		1	1
AAFES-2	S	1/1/1994	MANGANESE	1.4E+01		1	1
AAFES-2	S	12/1/1994	MANGANESE	1.1E+01		1	1
AAFES-2	S	3/1/1995	MANGANESE	1.3E+01		1	1
AAFES-2	S	12/1/1999	MANGANESE	5.1E+00		1	1
AAFES-2	S	11/1/2000	MANGANESE	3.9E+00		1	1
AAFES-2	S	11/1/2001	MANGANESE	4.8E+00		1	1
AAFES-2	S	11/1/2002	MANGANESE	3.7E+00		1	1
AAFES-2	S	11/1/2003	MANGANESE	3.1E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
AAFES-2	S	10/1/2004	MANGANESE	4.0E+00		1	1
AAFES-2	S	10/5/2005	MANGANESE	3.6E+00		1	1
AAFES-2	S	10/1/2006	MANGANESE	2.7E+00		1	1
AAFES-2	S	10/1/2007	MANGANESE	3.8E+00		1	1
AAFES-2	S	10/1/2008	MANGANESE	3.6E+00		1	1
AAFES-2	S	11/1/2009	MANGANESE	3.3E+00		1	1
AAFES-2	S	10/1/2010	MANGANESE	2.5E+00		1	1
AAFES-2	S	10/1/2011	MANGANESE	3.7E+00		1	1
AAFES-2	S	10/1/2012	MANGANESE	3.1E+00		1	1

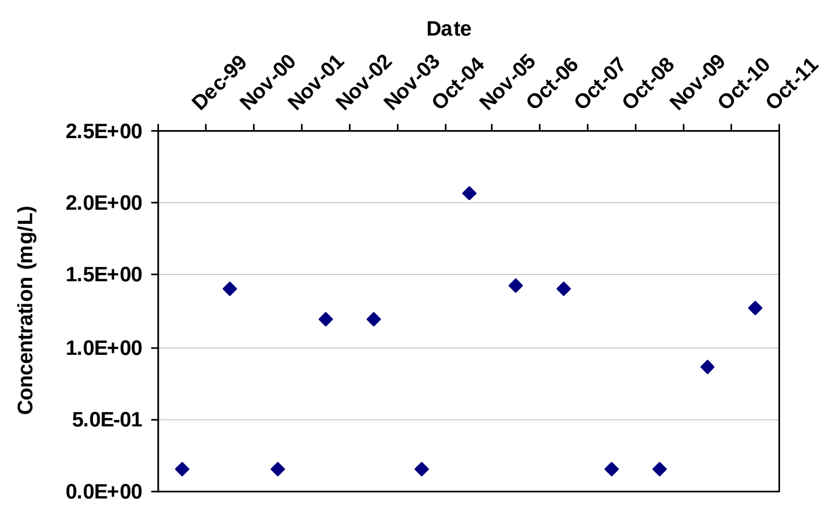
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Well: AAFES-2
Well Type: S
COC: VOLATILE PETROLEUM HYDROCAR

Time Period: 9/1/1993 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Duplicate Consolidation: Median
Consolidation Type: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

4

Confidence in Trend:

57.1%

Coefficient of Variation:

0.74

Mann Kendall Concentration Trend: (See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
AAFES-2	S	12/1/1999	VOLATILE PETROLEU	1.5E-01	ND	1	0
AAFES-2	S	11/1/2000	VOLATILE PETROLEU	1.4E+00		1	1
AAFES-2	S	11/1/2001	VOLATILE PETROLEU	1.5E-01	ND	1	0
AAFES-2	S	11/1/2002	VOLATILE PETROLEU	1.2E+00		1	1
AAFES-2	S	11/1/2003	VOLATILE PETROLEU	1.2E+00		1	1
AAFES-2	S	10/1/2004	VOLATILE PETROLEU	1.5E-01	ND	1	0
AAFES-2	S	11/5/2005	VOLATILE PETROLEU	2.1E+00		1	1
AAFES-2	S	10/1/2006	VOLATILE PETROLEU	1.4E+00		1	1
AAFES-2	S	10/1/2007	VOLATILE PETROLEU	1.4E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
AAFES-2	S	10/1/2008	VOLATILE PETROLEU	1.5E-01	ND	1	0
AAFES-2	S	11/1/2009	VOLATILE PETROLEU	1.5E-01	ND	1	0
AAFES-2	S	10/1/2010	VOLATILE PETROLEU	8.6E-01		1	1
AAFES-2	S	10/1/2011	VOLATILE PETROLEU	1.3E+00		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

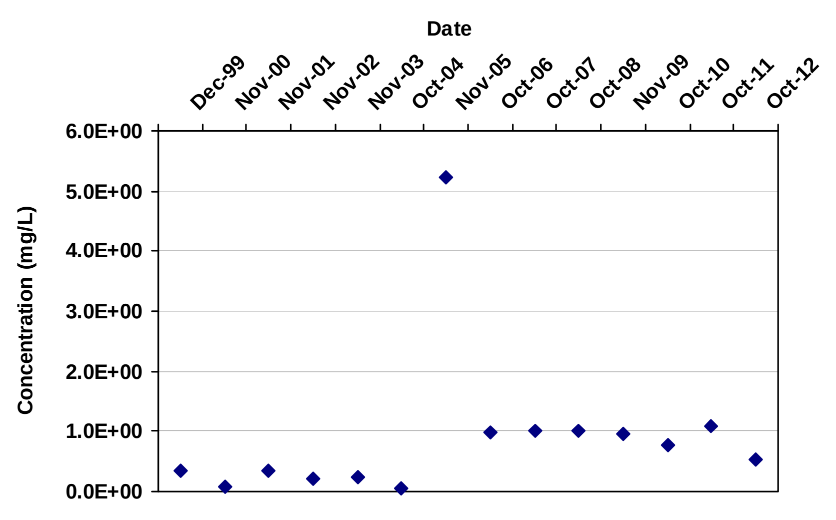
Project: AOC 43G, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well:	AAFES-2	**Time Period:**	9/1/1993 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	VOLATILE PETROLEUM HYDROCAR	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

30

Confidence in Trend:

94.4%

Coefficient of Variation:

1.41

Mann Kendall Concentration Trend: (See Note)

PI

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
AAFES-2	S	12/1/1999	VOLATILE PETROLEU	3.5E-01	ND	1	0
AAFES-2	S	11/1/2000	VOLATILE PETROLEU	8.1E-02		1	1
AAFES-2	S	11/1/2001	VOLATILE PETROLEU	3.5E-01	ND	1	0
AAFES-2	S	11/1/2002	VOLATILE PETROLEU	2.0E-01		1	1
AAFES-2	S	11/1/2003	VOLATILE PETROLEU	2.5E-01		1	1
AAFES-2	S	10/1/2004	VOLATILE PETROLEU	5.7E-02		1	1
AAFES-2	S	11/5/2005	VOLATILE PETROLEU	5.2E+00		1	1
AAFES-2	S	10/1/2006	VOLATILE PETROLEU	9.9E-01		1	1
AAFES-2	S	10/1/2007	VOLATILE PETROLEU	1.0E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
AAFES-2	S	10/1/2008	VOLATILE PETROLEU	1.0E+00		1	1
AAFES-2	S	11/1/2009	VOLATILE PETROLEU	9.5E-01		1	1
AAFES-2	S	10/1/2010	VOLATILE PETROLEU	7.7E-01		1	1
AAFES-2	S	10/1/2011	VOLATILE PETROLEU	1.1E+00		1	1
AAFES-2	S	10/1/2012	VOLATILE PETROLEU	5.4E-01		1	1

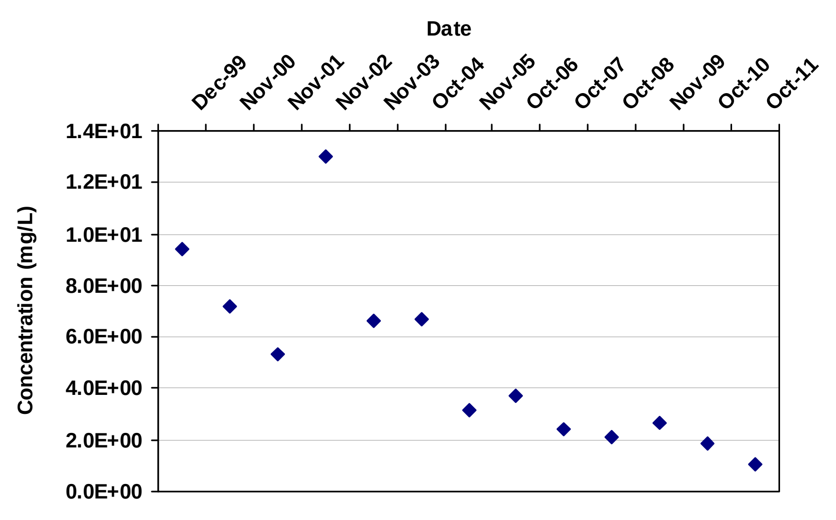
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well:	AAFES-2	**Time Period:**	9/1/1993 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	VOLATILE PETROLEUM HYDROCAR	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-60

Confidence in Trend:

100.0%

Coefficient of Variation:

0.69

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
AAFES-2	S	12/1/1999	VOLATILE PETROLEU	9.4E+00		1	1
AAFES-2	S	11/1/2000	VOLATILE PETROLEU	7.2E+00		1	1
AAFES-2	S	11/1/2001	VOLATILE PETROLEU	5.3E+00		1	1
AAFES-2	S	11/1/2002	VOLATILE PETROLEU	1.3E+01		1	1
AAFES-2	S	11/1/2003	VOLATILE PETROLEU	6.6E+00		1	1
AAFES-2	S	10/1/2004	VOLATILE PETROLEU	6.7E+00		1	1
AAFES-2	S	11/5/2005	VOLATILE PETROLEU	3.1E+00		1	1
AAFES-2	S	10/1/2006	VOLATILE PETROLEU	3.7E+00		1	1
AAFES-2	S	10/1/2007	VOLATILE PETROLEU	2.4E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
AAFES-2	S	10/1/2008	VOLATILE PETROLEU	2.1E+00		1	1
AAFES-2	S	11/1/2009	VOLATILE PETROLEU	2.7E+00		1	1
AAFES-2	S	10/1/2010	VOLATILE PETROLEU	1.9E+00		1	1
AAFES-2	S	10/1/2011	VOLATILE PETROLEU	1.1E+00		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Linear Regression Statistics Summary

Project: AOC 43G, Former Ft. Devens
User Name: T Lillys

Location: Devens
State: Massachusetts

Time Period: 9/1/1993 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value

Well	Source/Tail	Average Conc (mg/L)	Median Conc (mg/L)	Standard Deviation	All Samples "ND" ?	Ln Slope	Coefficient of Variation	Confidence in Trend	Concentration Trend
BENZENE									
AAFES-2	S	3.1E-01	4.0E-02	5.7E-01	No	-1.0E-03	1.81	100.0%	D
XGM-93-02X	S	2.6E-01	3.6E-02	5.5E-01	No	-1.2E-03	2.14	100.0%	D
XGM-97-12X	S	2.6E-01	1.0E-01	3.4E-01	No	-8.2E-04	1.30	100.0%	D
MANGANESE									
AAFES-06/6R	S	3.4E+00	3.1E+00	1.6E+00	No	-1.5E-04	0.45	99.9%	D
AAFES-2	S	5.5E+00	3.7E+00	3.8E+00	No	-2.1E-04	0.68	100.0%	D
XGM-93-02X	S	3.3E+00	2.3E+00	2.8E+00	No	-2.9E-04	0.86	100.0%	D
XGM-94-04X	T	2.1E+00	2.1E+00	1.6E+00	No	-6.0E-05	0.74	61.2%	S
XGM-94-07X	T	4.8E+00	5.1E+00	1.4E+00	No	-1.2E-05	0.28	57.9%	S
XGM-94-08X	T	4.2E+00	3.8E+00	1.8E+00	No	-1.5E-04	0.42	99.7%	D
XGM-97-12X	S	3.1E+00	3.0E+00	1.5E+00	No	-1.8E-04	0.48	93.6%	PD
VOLATILE PETROLEUM HYDROCARB									
AAFES-06/6R	S	2.4E-01	2.2E-01	1.2E-01	No	-2.3E-04	0.50	99.2%	D
AAFES-2	S	8.9E-01	1.2E+00	6.6E-01	No	1.0E-04	0.74	66.1%	NT
XGM-93-02X	S	3.4E-01	1.5E-01	2.5E-01	No	-2.4E-04	0.75	94.8%	PD
XGM-94-04X	T	2.6E-01	1.5E-01	2.0E-01	No	2.1E-04	0.77	96.9%	I
XGM-97-12X	S	9.8E-01	1.1E+00	6.8E-01	No	-3.2E-04	0.69	94.5%	PD
VOLATILE PETROLEUM HYDROCARB									
AAFES-2	S	9.2E-01	6.6E-01	1.3E+00	No	4.0E-04	1.41	97.3%	I

MAROS Linear Regression Statistics Summary

AOC 43G, Former Ft. Devens

Devens

User Name: T Lillys

State: Massachusetts

Well	Source/Tail	Average Conc (mg/L)	Median Conc (mg/L)	Standard Deviation	All Samples "ND" ?	Ln Slope	Coefficient of Variation	Confidence in Trend	Concentration Trend
VOLATILE PETROLEUM HYDROCARB									
XGM-93-02X	S	2.5E-01	9.0E-02	4.0E-01	No	-1.1E-03	1.62	93.2%	PD
XGM-97-12X	S	1.2E+00	4.4E-01	1.9E+00	No	3.6E-04	1.60	93.8%	PI
VOLATILE PETROLEUM HYDROCARB									
AAFES-06/6R	S	9.7E-02	1.0E-01	4.7E-02	No	-2.3E-04	0.49	90.9%	PD
AAFES-2	S	5.0E+00	3.7E+00	3.5E+00	No	-4.7E-04	0.69	100.0%	D
XGM-93-02X	S	1.2E+00	7.7E-01	1.3E+00	No	-7.5E-04	1.08	99.9%	D
XGM-94-04X	T	1.8E-01	1.0E-01	1.6E-01	No	3.9E-05	0.87	59.0%	NT
XGM-97-12X	S	5.0E+00	4.5E+00	2.3E+00	No	-3.4E-04	0.46	99.1%	D

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Non-detect (ND); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); COV = Coefficient of Variation

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Time Period: 9/1/1993 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
BENZENE								
AAFES-2	S	26	22	1.81	-271	100.0%	No	D
XGM-93-02X	S	26	23	2.14	-242	100.0%	No	D
XGM-97-12X	S	18	17	1.30	-85	100.0%	No	D
MANGANESE								
AAFES-06/6R	S	15	15	0.45	-46	98.8%	No	D
AAFES-2	S	18	18	0.68	-99	100.0%	No	D
XGM-93-02X	S	18	18	0.86	-105	100.0%	No	D
XGM-94-04X	T	14	14	0.74	-11	70.5%	No	S
XGM-94-07X	T	16	16	0.28	-12	68.7%	No	S
XGM-94-08X	T	15	15	0.42	-50	99.3%	No	D
XGM-97-12X	S	14	14	0.48	-41	98.7%	No	D
VOLATILE PETROLEUM HYDROCARBONS C5								
AAFES-06/6R	S	11	8	0.50	-28	98.4%	No	D
AAFES-2	S	13	8	0.74	4	57.1%	No	NT
XGM-93-02X	S	13	7	0.75	-29	95.6%	No	D
XGM-94-04X	T	14	5	0.77	27	92.1%	No	PI
XGM-97-12X	S	13	10	0.69	-18	84.7%	No	S
VOLATILE PETROLEUM HYDROCARBONS C8								
AAFES-2	S	14	12	1.41	30	94.4%	No	PI
XGM-93-02X	S	14	10	1.62	-12	72.3%	No	NT
XGM-97-12X	S	14	11	1.60	20	84.8%	No	NT
VOLATILE PETROLEUM HYDROCARBONS C9								
AAFES-06/6R	S	9	7	0.49	-11	84.6%	No	S
AAFES-2	S	13	13	0.69	-60	100.0%	No	D
XGM-93-02X	S	13	12	1.08	-46	99.8%	No	D

MAROS Mann-Kendall Statistics Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

VOLATILE PETROLEUM HYDROCARBONS C9

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
XGM-94-04X	T	13	6	0.87	1	50.0%	No	NT
XGM-97-12X	S	13	13	0.46	-34	97.9%	No	D

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Statistical Trend Analysis Summary

Project: AOC 43G, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Time Period:	9/1/1993	**to** 10/1/2012
Consolidation Period:	No Time Consolidation	
Consolidation Type:	Median	
Duplicate Consolidation:	Maximum	
ND Values:	1/2 Detection Limit	
J Flag Values :	Actual Value	

Well	Source / Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
BENZENE								
AAFES-2	S	26	22	3.1E-01	4.0E-02	No	D	D
XGM-93-02X	S	26	23	2.6E-01	3.6E-02	No	D	D
XGM-97-12X	S	18	17	2.6E-01	1.0E-01	No	D	D
MANGANESE								
AAFES-06/6R	S	15	15	3.4E+00	3.1E+00	No	D	D
AAFES-2	S	18	18	5.5E+00	3.7E+00	No	D	D
XGM-93-02X	S	18	18	3.3E+00	2.3E+00	No	D	D
XGM-94-04X	T	14	14	2.1E+00	2.1E+00	No	S	S
XGM-94-07X	T	16	16	4.8E+00	5.1E+00	No	S	S
XGM-94-08X	T	15	15	4.2E+00	3.8E+00	No	D	D
XGM-97-12X	S	14	14	3.1E+00	3.0E+00	No	D	PD
VOLATILE PETROLEUM HYDROCARBON								
AAFES-06/6R	S	11	8	2.4E-01	2.2E-01	No	D	D
AAFES-2	S	13	8	8.9E-01	1.2E+00	No	NT	NT
XGM-93-02X	S	13	7	3.4E-01	1.5E-01	No	D	PD
XGM-94-04X	T	14	5	2.6E-01	1.5E-01	No	PI	I
XGM-97-12X	S	13	10	9.8E-01	1.1E+00	No	S	PD
VOLATILE PETROLEUM HYDROCARBON								
AAFES-2	S	14	12	9.2E-01	6.6E-01	No	PI	I
XGM-93-02X	S	14	10	2.5E-01	9.0E-02	No	NT	PD
XGM-97-12X	S	14	11	1.2E+00	4.4E-01	No	NT	PI
VOLATILE PETROLEUM HYDROCARBON								
AAFES-06/6R	S	9	7	9.7E-02	1.0E-01	No	S	PD
AAFES-2	S	13	13	5.0E+00	3.7E+00	No	D	D
XGM-93-02X	S	13	12	1.2E+00	7.7E-01	No	D	D

MAROS Statistical Trend Analysis Summary

Project: AOC 43G, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well Name	Source / Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
VOLATILE PETROLEUM HYDROCARBON								
XGM-94-04X	T	13	6	1.8E-01	1.0E-01	No	NT	NT
XGM-97-12X	S	13	13	5.0E+00	4.5E+00	No	D	D

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); No Detectable Concentration (ND)

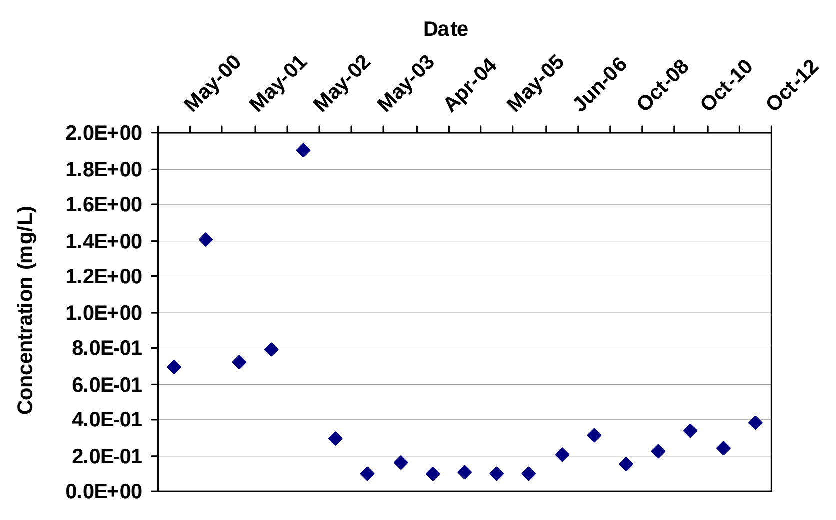
The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well:	69W-94-13	**Time Period:**	5/1/2000 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	C10-C12 PETROLEUM HYDROCARB	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-23

Confidence in Trend:

77.7%

Coefficient of Variation:

1.11

Mann Kendall Concentration Trend: (See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
69W-94-13	S	5/1/2000	C10-C12 PETROLEU	6.9E-01		1	1
69W-94-13	S	11/1/2000	C10-C12 PETROLEU	1.4E+00		1	1
69W-94-13	S	5/1/2001	C10-C12 PETROLEU	7.2E-01		1	1
69W-94-13	S	11/1/2001	C10-C12 PETROLEU	7.9E-01		1	1
69W-94-13	S	5/1/2002	C10-C12 PETROLEU	1.9E+00		1	1
69W-94-13	S	11/1/2002	C10-C12 PETROLEU	2.9E-01		1	1
69W-94-13	S	5/1/2003	C10-C12 PETROLEU	1.0E-01	ND	1	0
69W-94-13	S	11/1/2003	C10-C12 PETROLEU	1.6E-01		1	1
69W-94-13	S	4/1/2004	C10-C12 PETROLEU	1.0E-01	ND	1	0

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

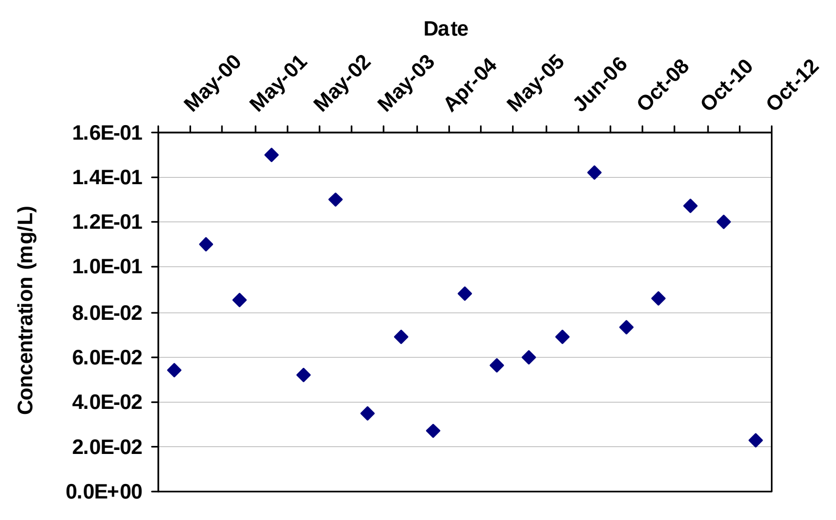
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
69W-94-13	S	11/1/2004	C10-C12 PETROLEU	1.1E-01		1	1
69W-94-13	S	5/1/2005	C10-C12 PETROLEU	1.0E-01	ND	1	0
69W-94-13	S	11/1/2005	C10-C12 PETROLEU	1.0E-01	ND	1	0
69W-94-13	S	6/1/2006	C10-C12 PETROLEU	2.0E-01		1	1
69W-94-13	S	10/1/2007	C10-C12 PETROLEU	3.1E-01		1	1
69W-94-13	S	10/1/2008	C10-C12 PETROLEU	1.5E-01		1	1
69W-94-13	S	11/1/2009	C10-C12 PETROLEU	2.3E-01		1	1
69W-94-13	S	10/1/2010	C10-C12 PETROLEU	3.4E-01		1	1
69W-94-13	S	10/1/2011	C10-C12 PETROLEU	2.4E-01		1	1
69W-94-13	S	10/1/2012	C10-C12 PETROLEU	3.8E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project:	AOC 69W, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

Well:	69W-94-13	**Time Period:**	5/1/2000 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	ARSENIC	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

8

Confidence in Trend:

59.6%

Coefficient of Variation:

0.47

Mann Kendall Concentration Trend: (See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
69W-94-13	S	5/1/2000	ARSENIC	5.4E-02		1	1
69W-94-13	S	11/1/2000	ARSENIC	1.1E-01		1	1
69W-94-13	S	5/1/2001	ARSENIC	8.5E-02		1	1
69W-94-13	S	11/1/2001	ARSENIC	1.5E-01		1	1
69W-94-13	S	5/1/2002	ARSENIC	5.2E-02		1	1
69W-94-13	S	11/1/2002	ARSENIC	1.3E-01		1	1
69W-94-13	S	5/1/2003	ARSENIC	3.5E-02		1	1
69W-94-13	S	11/1/2003	ARSENIC	6.9E-02		1	1
69W-94-13	S	4/1/2004	ARSENIC	2.7E-02		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
69W-94-13	S	11/1/2004	ARSENIC	8.8E-02		1	1
69W-94-13	S	5/1/2005	ARSENIC	5.6E-02		1	1
69W-94-13	S	11/1/2005	ARSENIC	6.0E-02		1	1
69W-94-13	S	6/1/2006	ARSENIC	6.9E-02		1	1
69W-94-13	S	10/1/2007	ARSENIC	1.4E-01		1	1
69W-94-13	S	10/1/2008	ARSENIC	7.3E-02		1	1
69W-94-13	S	11/1/2009	ARSENIC	8.6E-02		1	1
69W-94-13	S	10/1/2010	ARSENIC	1.3E-01		1	1
69W-94-13	S	10/1/2011	ARSENIC	1.2E-01		1	1
69W-94-13	S	10/1/2012	ARSENIC	2.3E-02		1	1

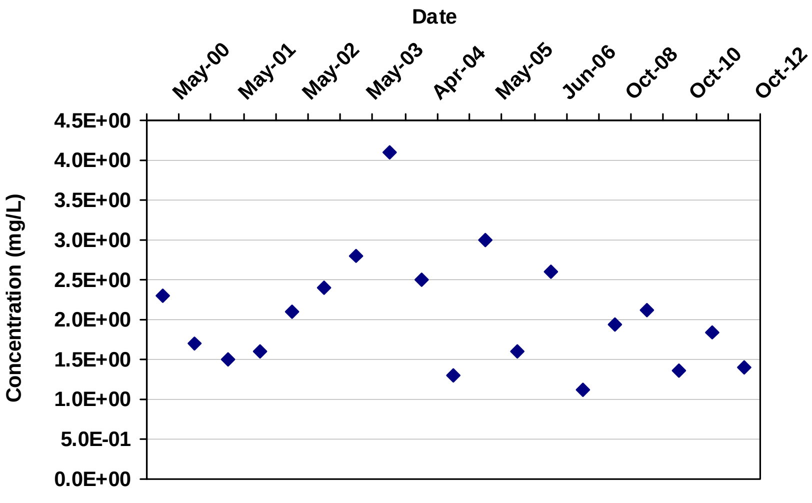
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Well: 69W-94-13
Well Type: S
COC: MANGANESE

Time Period: 5/1/2000 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Duplicate Consolidation: Median
Consolidation Type: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

-22

Confidence in Trend:

76.6%

Coefficient of Variation:

0.35

Mann Kendall Concentration Trend: (See Note)

S

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
69W-94-13	S	5/1/2000	MANGANESE	2.3E+00		1	1
69W-94-13	S	11/1/2000	MANGANESE	1.7E+00		1	1
69W-94-13	S	5/1/2001	MANGANESE	1.5E+00		1	1
69W-94-13	S	11/1/2001	MANGANESE	1.6E+00		1	1
69W-94-13	S	5/1/2002	MANGANESE	2.1E+00		1	1
69W-94-13	S	11/1/2002	MANGANESE	2.4E+00		1	1
69W-94-13	S	5/1/2003	MANGANESE	2.8E+00		1	1
69W-94-13	S	11/1/2003	MANGANESE	4.1E+00		1	1
69W-94-13	S	4/1/2004	MANGANESE	2.5E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

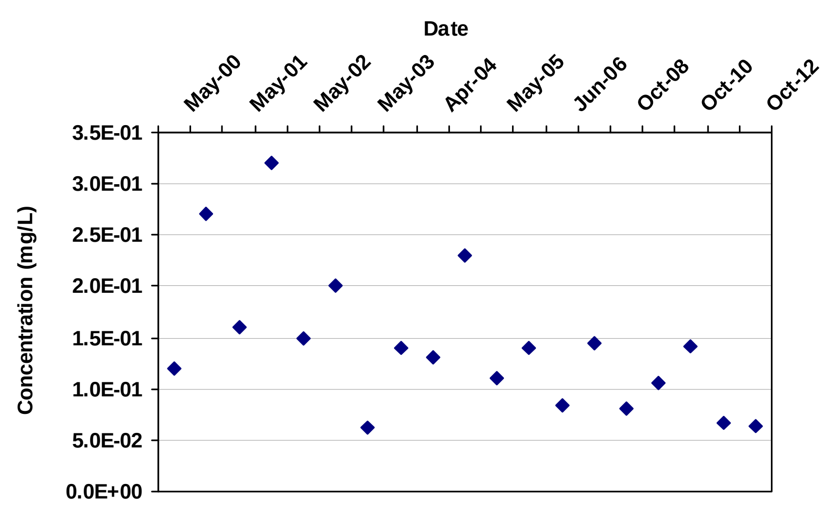
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
69W-94-13	S	11/1/2004	MANGANESE	1.3E+00		1	1
69W-94-13	S	5/1/2005	MANGANESE	3.0E+00		1	1
69W-94-13	S	11/1/2005	MANGANESE	1.6E+00		1	1
69W-94-13	S	6/1/2006	MANGANESE	2.6E+00		1	1
69W-94-13	S	10/1/2007	MANGANESE	1.1E+00		1	1
69W-94-13	S	10/1/2008	MANGANESE	1.9E+00		1	1
69W-94-13	S	11/1/2009	MANGANESE	2.1E+00		1	1
69W-94-13	S	10/1/2010	MANGANESE	1.4E+00		1	1
69W-94-13	S	10/1/2011	MANGANESE	1.8E+00		1	1
69W-94-13	S	10/1/2012	MANGANESE	1.4E+00		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project:	AOC 69W, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

Well:	69W-94-13	**Time Period:**	5/1/2000 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	VOLATILE PETROLEUM HYDROCAR	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-74

Confidence in Trend:

99.6%

Coefficient of Variation:

0.49

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
69W-94-13	S	5/1/2000	VOLATILE PETROLEU	1.2E-01		1	1
69W-94-13	S	11/1/2000	VOLATILE PETROLEU	2.7E-01		1	1
69W-94-13	S	5/1/2001	VOLATILE PETROLEU	1.6E-01		1	1
69W-94-13	S	11/1/2001	VOLATILE PETROLEU	3.2E-01		1	1
69W-94-13	S	5/1/2002	VOLATILE PETROLEU	1.5E-01		1	1
69W-94-13	S	11/1/2002	VOLATILE PETROLEU	2.0E-01		1	1
69W-94-13	S	5/1/2003	VOLATILE PETROLEU	6.2E-02		1	1
69W-94-13	S	11/1/2003	VOLATILE PETROLEU	1.4E-01		1	1
69W-94-13	S	4/1/2004	VOLATILE PETROLEU	1.3E-01		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

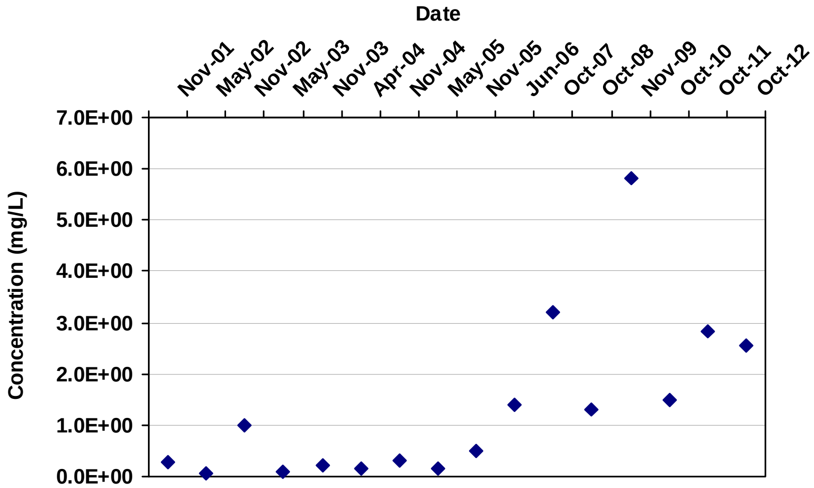
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
69W-94-13	S	11/1/2004	VOLATILE PETROLEU	2.3E-01		1	1
69W-94-13	S	5/1/2005	VOLATILE PETROLEU	1.1E-01		1	1
69W-94-13	S	11/1/2005	VOLATILE PETROLEU	1.4E-01		1	1
69W-94-13	S	6/1/2006	VOLATILE PETROLEU	8.4E-02		1	1
69W-94-13	S	10/1/2007	VOLATILE PETROLEU	1.4E-01		1	1
69W-94-13	S	10/1/2008	VOLATILE PETROLEU	8.1E-02		1	1
69W-94-13	S	11/1/2009	VOLATILE PETROLEU	1.1E-01		1	1
69W-94-13	S	10/1/2010	VOLATILE PETROLEU	1.4E-01		1	1
69W-94-13	S	10/1/2011	VOLATILE PETROLEU	6.7E-02		1	1
69W-94-13	S	10/1/2012	VOLATILE PETROLEU	6.3E-02		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project:	AOC 69W, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

Well:	ZWM-01-25X	**Time Period:**	5/1/2000 **to** 10/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	MANGANESE	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

73

Confidence in Trend:

100.0%

Coefficient of Variation:

1.19

Mann Kendall Concentration Trend: (See Note)

I

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-01-25X	T	11/1/2001	MANGANESE	2.8E-01		1	1
ZWM-01-25X	T	5/1/2002	MANGANESE	6.1E-02		1	1
ZWM-01-25X	T	11/1/2002	MANGANESE	1.0E+00		1	1
ZWM-01-25X	T	5/1/2003	MANGANESE	8.9E-02		1	1
ZWM-01-25X	T	11/1/2003	MANGANESE	2.3E-01		1	1
ZWM-01-25X	T	4/1/2004	MANGANESE	1.4E-01		1	1
ZWM-01-25X	T	11/1/2004	MANGANESE	3.0E-01		1	1
ZWM-01-25X	T	5/1/2005	MANGANESE	1.4E-01		1	1
ZWM-01-25X	T	11/1/2005	MANGANESE	4.9E-01		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-01-25X	T	6/1/2006	MANGANESE	1.4E+00		1	1
ZWM-01-25X	T	10/1/2007	MANGANESE	3.2E+00		1	1
ZWM-01-25X	T	10/1/2008	MANGANESE	1.3E+00		1	1
ZWM-01-25X	T	11/1/2009	MANGANESE	5.8E+00		1	1
ZWM-01-25X	T	10/1/2010	MANGANESE	1.5E+00		1	1
ZWM-01-25X	T	10/1/2011	MANGANESE	2.8E+00		1	1
ZWM-01-25X	T	10/1/2012	MANGANESE	2.5E+00		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

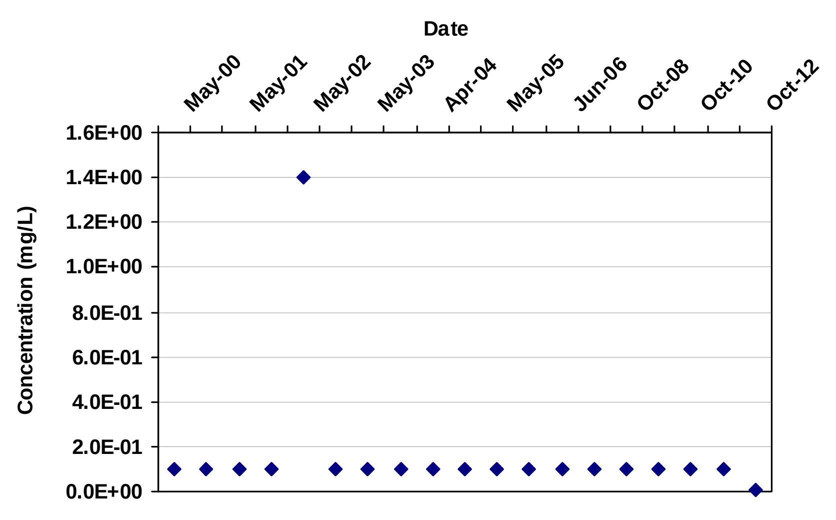
Project: AOC 69W, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well:	ZWM-95-15X	**Time Period:**	5/1/2000 **to** 10/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	C10-C12 PETROLEUM HYDROCARB	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-27

Confidence in Trend:

81.6%

Coefficient of Variation:

1.84

Mann Kendall Concentration Trend: (See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-95-15X	T	5/1/2000	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-95-15X	T	11/1/2000	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-95-15X	T	5/1/2001	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-95-15X	T	11/1/2001	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-95-15X	T	5/1/2002	C10-C12 PETROLEU	1.4E+00		1	1
ZWM-95-15X	T	11/1/2002	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-95-15X	T	5/1/2003	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-95-15X	T	11/1/2003	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-95-15X	T	4/1/2004	C10-C12 PETROLEU	1.0E-01	ND	1	0

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-95-15X	T	11/1/2004	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-95-15X	T	5/1/2005	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-95-15X	T	11/1/2005	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-95-15X	T	6/1/2006	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-95-15X	T	10/1/2007	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-95-15X	T	10/1/2008	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-95-15X	T	11/1/2009	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-95-15X	T	10/1/2010	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-95-15X	T	10/1/2011	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-95-15X	T	10/1/2012	C10-C12 PETROLEU	5.0E-03	ND	1	0

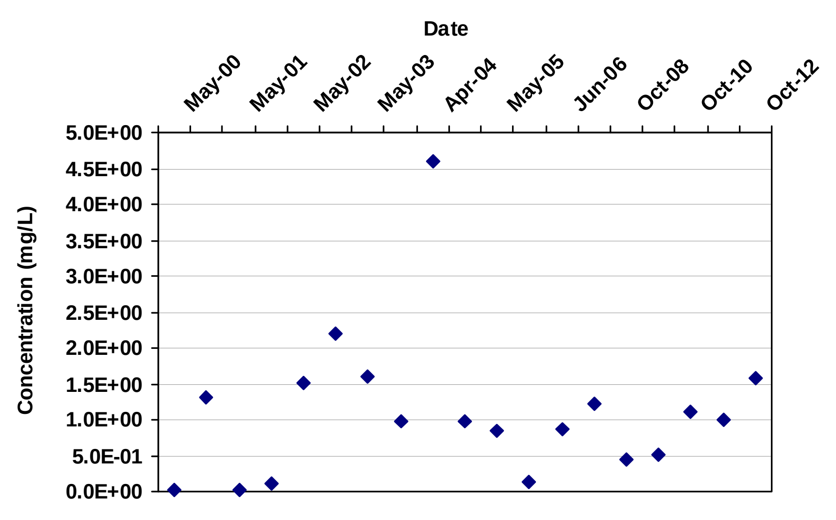
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well:	ZWM-95-15X	**Time Period:**	5/1/2000 **to** 10/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	MANGANESE	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

19

Confidence in Trend:

73.3%

Coefficient of Variation:

0.94

Mann Kendall Concentration Trend: (See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-95-15X	T	5/1/2000	MANGANESE	2.8E-02		1	1
ZWM-95-15X	T	11/1/2000	MANGANESE	1.3E+00		1	1
ZWM-95-15X	T	5/1/2001	MANGANESE	2.5E-02		1	1
ZWM-95-15X	T	11/1/2001	MANGANESE	1.0E-01		1	1
ZWM-95-15X	T	5/1/2002	MANGANESE	1.5E+00		1	1
ZWM-95-15X	T	11/1/2002	MANGANESE	2.2E+00		1	1
ZWM-95-15X	T	5/1/2003	MANGANESE	1.6E+00		1	1
ZWM-95-15X	T	11/1/2003	MANGANESE	9.7E-01		1	1
ZWM-95-15X	T	4/1/2004	MANGANESE	4.6E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-95-15X	T	11/1/2004	MANGANESE	9.8E-01		1	1
ZWM-95-15X	T	5/1/2005	MANGANESE	8.5E-01		1	1
ZWM-95-15X	T	11/1/2005	MANGANESE	1.3E-01		1	1
ZWM-95-15X	T	6/1/2006	MANGANESE	8.6E-01		1	1
ZWM-95-15X	T	10/1/2007	MANGANESE	1.2E+00		1	1
ZWM-95-15X	T	10/1/2008	MANGANESE	4.4E-01		1	1
ZWM-95-15X	T	11/1/2009	MANGANESE	5.0E-01		1	1
ZWM-95-15X	T	10/1/2010	MANGANESE	1.1E+00		1	1
ZWM-95-15X	T	10/1/2011	MANGANESE	1.0E+00		1	1
ZWM-95-15X	T	10/1/2012	MANGANESE	1.6E+00		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

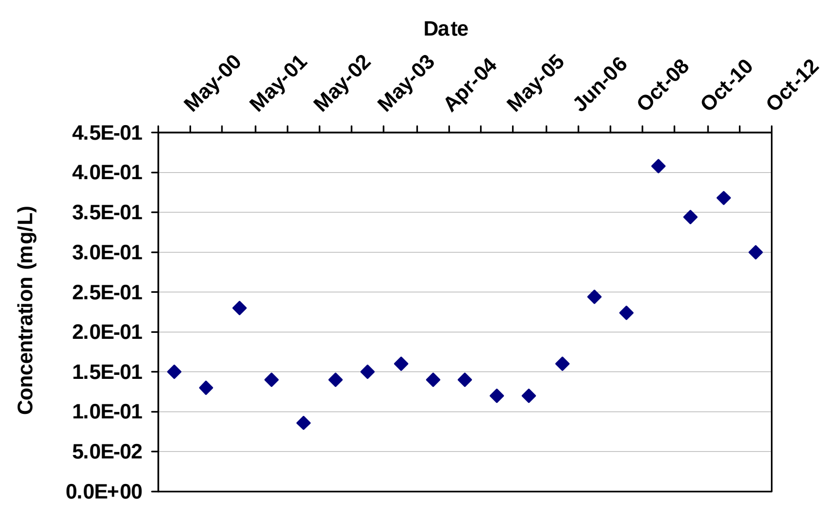
Project: AOC 69W, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well:	ZWM-99-22X	**Time Period:**	5/1/2000 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	ARSENIC	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

71

Confidence in Trend:

99.4%

Coefficient of Variation:

0.47

Mann Kendall Concentration Trend: (See Note)

I

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-99-22X	S	5/1/2000	ARSENIC	1.5E-01		1	1
ZWM-99-22X	S	11/1/2000	ARSENIC	1.3E-01		1	1
ZWM-99-22X	S	5/1/2001	ARSENIC	2.3E-01		1	1
ZWM-99-22X	S	11/1/2001	ARSENIC	1.4E-01		1	1
ZWM-99-22X	S	5/1/2002	ARSENIC	8.6E-02		1	1
ZWM-99-22X	S	11/1/2002	ARSENIC	1.4E-01		1	1
ZWM-99-22X	S	5/1/2003	ARSENIC	1.5E-01		1	1
ZWM-99-22X	S	11/1/2003	ARSENIC	1.6E-01		1	1
ZWM-99-22X	S	4/1/2004	ARSENIC	1.4E-01		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

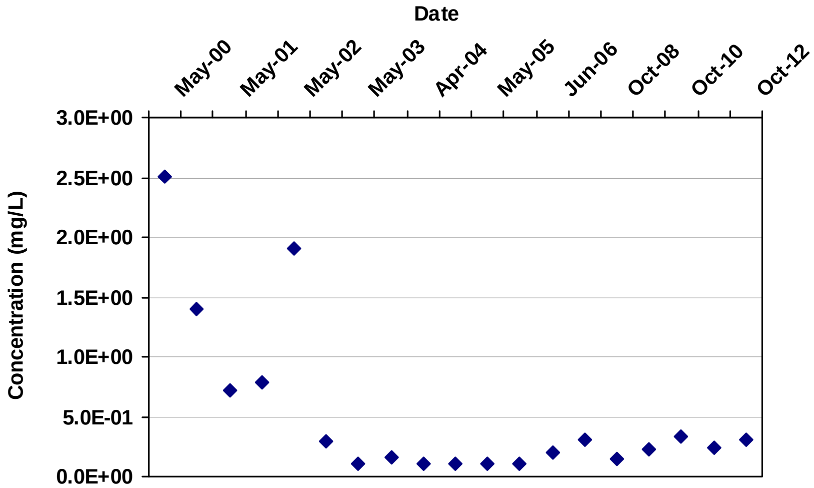
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-99-22X	S	11/1/2004	ARSENIC	1.4E-01		1	1
ZWM-99-22X	S	5/1/2005	ARSENIC	1.2E-01		1	1
ZWM-99-22X	S	11/1/2005	ARSENIC	1.2E-01		1	1
ZWM-99-22X	S	6/1/2006	ARSENIC	1.6E-01		1	1
ZWM-99-22X	S	10/1/2007	ARSENIC	2.4E-01		1	1
ZWM-99-22X	S	10/1/2008	ARSENIC	2.2E-01		1	1
ZWM-99-22X	S	11/1/2009	ARSENIC	4.1E-01		1	1
ZWM-99-22X	S	10/1/2010	ARSENIC	3.4E-01		1	1
ZWM-99-22X	S	10/1/2011	ARSENIC	3.7E-01		1	1
ZWM-99-22X	S	10/1/2012	ARSENIC	3.0E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project:	AOC 69W, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

Well:	ZWM-99-22X	**Time Period:**	5/1/2000 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	C10-C12 PETROLEUM HYDROCARB	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-35

Confidence in Trend:

88.1%

Coefficient of Variation:

1.28

Mann Kendall Concentration Trend: (See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-99-22X	S	5/1/2000	C10-C12 PETROLEU	2.5E+00		1	1
ZWM-99-22X	S	11/1/2000	C10-C12 PETROLEU	1.4E+00		1	1
ZWM-99-22X	S	5/1/2001	C10-C12 PETROLEU	7.2E-01		1	1
ZWM-99-22X	S	11/1/2001	C10-C12 PETROLEU	7.9E-01		1	1
ZWM-99-22X	S	5/1/2002	C10-C12 PETROLEU	1.9E+00		1	1
ZWM-99-22X	S	11/1/2002	C10-C12 PETROLEU	2.9E-01		1	1
ZWM-99-22X	S	5/1/2003	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-99-22X	S	11/1/2003	C10-C12 PETROLEU	1.6E-01		1	1
ZWM-99-22X	S	4/1/2004	C10-C12 PETROLEU	1.0E-01	ND	1	0

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-99-22X	S	11/1/2004	C10-C12 PETROLEU	1.1E-01		1	1
ZWM-99-22X	S	5/1/2005	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-99-22X	S	11/1/2005	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-99-22X	S	6/1/2006	C10-C12 PETROLEU	2.0E-01		1	1
ZWM-99-22X	S	10/1/2007	C10-C12 PETROLEU	3.1E-01		1	1
ZWM-99-22X	S	10/1/2008	C10-C12 PETROLEU	1.5E-01		1	1
ZWM-99-22X	S	11/1/2009	C10-C12 PETROLEU	2.3E-01		1	1
ZWM-99-22X	S	10/1/2010	C10-C12 PETROLEU	3.4E-01		1	1
ZWM-99-22X	S	10/1/2011	C10-C12 PETROLEU	2.4E-01		1	1
ZWM-99-22X	S	10/1/2012	C10-C12 PETROLEU	3.1E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Well: ZWM-99-22X

Well Type: S

COC: MANGANESE

Time Period: 5/1/2000 **to** 10/1/2012

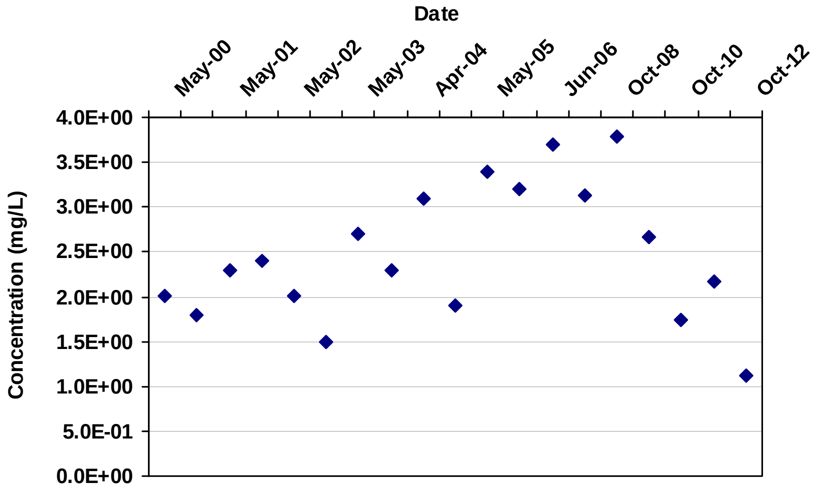
Consolidation Period: No Time Consolidation

Duplicate Consolidation: Median

Consolidation Type: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

25

Confidence in Trend:

79.7%

Coefficient of Variation:

0.31

Mann Kendall Concentration Trend: (See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-99-22X	S	5/1/2000	MANGANESE	2.0E+00		1	1
ZWM-99-22X	S	11/1/2000	MANGANESE	1.8E+00		1	1
ZWM-99-22X	S	5/1/2001	MANGANESE	2.3E+00		1	1
ZWM-99-22X	S	11/1/2001	MANGANESE	2.4E+00		1	1
ZWM-99-22X	S	5/1/2002	MANGANESE	2.0E+00		1	1
ZWM-99-22X	S	11/1/2002	MANGANESE	1.5E+00		1	1
ZWM-99-22X	S	5/1/2003	MANGANESE	2.7E+00		1	1
ZWM-99-22X	S	11/1/2003	MANGANESE	2.3E+00		1	1
ZWM-99-22X	S	4/1/2004	MANGANESE	3.1E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

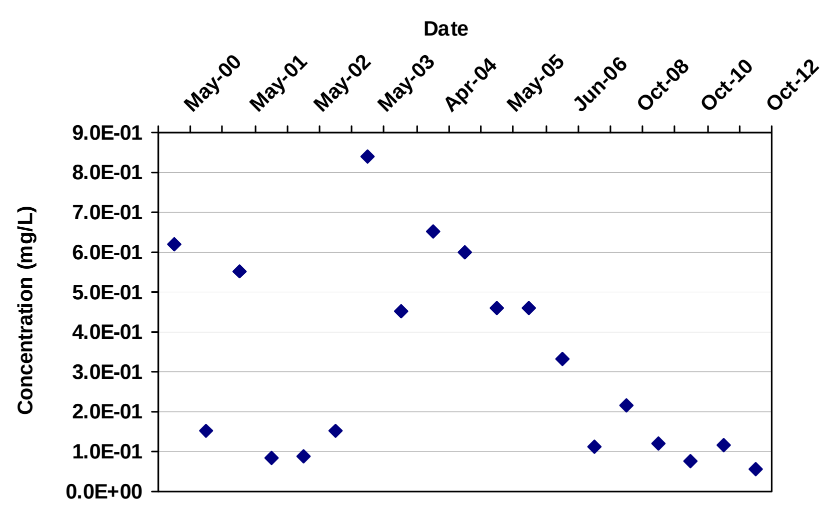
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-99-22X	S	11/1/2004	MANGANESE	1.9E+00		1	1
ZWM-99-22X	S	5/1/2005	MANGANESE	3.4E+00		1	1
ZWM-99-22X	S	11/1/2005	MANGANESE	3.2E+00		1	1
ZWM-99-22X	S	6/1/2006	MANGANESE	3.7E+00		1	1
ZWM-99-22X	S	10/1/2007	MANGANESE	3.1E+00		1	1
ZWM-99-22X	S	10/1/2008	MANGANESE	3.8E+00		1	1
ZWM-99-22X	S	11/1/2009	MANGANESE	2.7E+00		1	1
ZWM-99-22X	S	10/1/2010	MANGANESE	1.8E+00		1	1
ZWM-99-22X	S	10/1/2011	MANGANESE	2.2E+00		1	1
ZWM-99-22X	S	10/1/2012	MANGANESE	1.1E+00		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project:	AOC 69W, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

Well:	ZWM-99-22X	**Time Period:**	5/1/2000 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	VOLATILE PETROLEUM HYDROCAR	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-59

Confidence in Trend:

97.9%

Coefficient of Variation:

0.76

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-99-22X	S	5/1/2000	VOLATILE PETROLEU	6.2E-01		1	1
ZWM-99-22X	S	11/1/2000	VOLATILE PETROLEU	1.5E-01		1	1
ZWM-99-22X	S	5/1/2001	VOLATILE PETROLEU	5.5E-01		1	1
ZWM-99-22X	S	11/1/2001	VOLATILE PETROLEU	8.3E-02		1	1
ZWM-99-22X	S	5/1/2002	VOLATILE PETROLEU	8.8E-02		1	1
ZWM-99-22X	S	11/1/2002	VOLATILE PETROLEU	1.5E-01		1	1
ZWM-99-22X	S	5/1/2003	VOLATILE PETROLEU	8.4E-01		1	1
ZWM-99-22X	S	11/1/2003	VOLATILE PETROLEU	4.5E-01		1	1
ZWM-99-22X	S	4/1/2004	VOLATILE PETROLEU	6.5E-01		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-99-22X	S	11/1/2004	VOLATILE PETROLEU	6.0E-01		1	1
ZWM-99-22X	S	5/1/2005	VOLATILE PETROLEU	4.6E-01		1	1
ZWM-99-22X	S	11/1/2005	VOLATILE PETROLEU	4.6E-01		1	1
ZWM-99-22X	S	6/1/2006	VOLATILE PETROLEU	3.3E-01		1	1
ZWM-99-22X	S	10/1/2007	VOLATILE PETROLEU	1.1E-01		1	1
ZWM-99-22X	S	10/1/2008	VOLATILE PETROLEU	2.2E-01		1	1
ZWM-99-22X	S	11/1/2009	VOLATILE PETROLEU	1.2E-01		1	1
ZWM-99-22X	S	10/1/2010	VOLATILE PETROLEU	7.6E-02		1	1
ZWM-99-22X	S	10/1/2011	VOLATILE PETROLEU	1.1E-01		1	1
ZWM-99-22X	S	10/1/2012	VOLATILE PETROLEU	5.6E-02		1	1

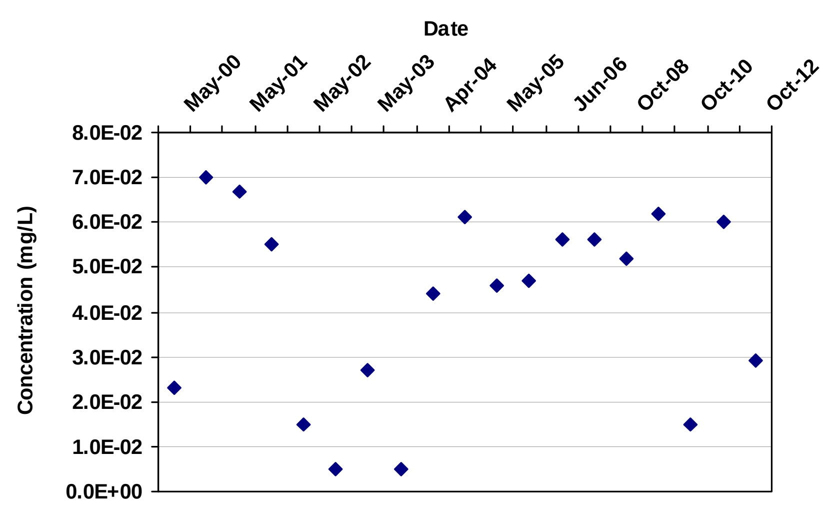
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well:	ZWM-99-23X	**Time Period:**	5/1/2000 **to** 10/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	ARSENIC	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

14

Confidence in Trend:

67.4%

Coefficient of Variation:

0.51

Mann Kendall Concentration Trend: (See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-99-23X	T	5/1/2000	ARSENIC	2.3E-02		1	1
ZWM-99-23X	T	11/1/2000	ARSENIC	7.0E-02		1	1
ZWM-99-23X	T	5/1/2001	ARSENIC	6.7E-02		1	1
ZWM-99-23X	T	11/1/2001	ARSENIC	5.5E-02		1	1
ZWM-99-23X	T	5/1/2002	ARSENIC	1.5E-02		1	1
ZWM-99-23X	T	11/1/2002	ARSENIC	5.0E-03	ND	1	0
ZWM-99-23X	T	5/1/2003	ARSENIC	2.7E-02		1	1
ZWM-99-23X	T	11/1/2003	ARSENIC	5.0E-03	ND	1	0
ZWM-99-23X	T	4/1/2004	ARSENIC	4.4E-02		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

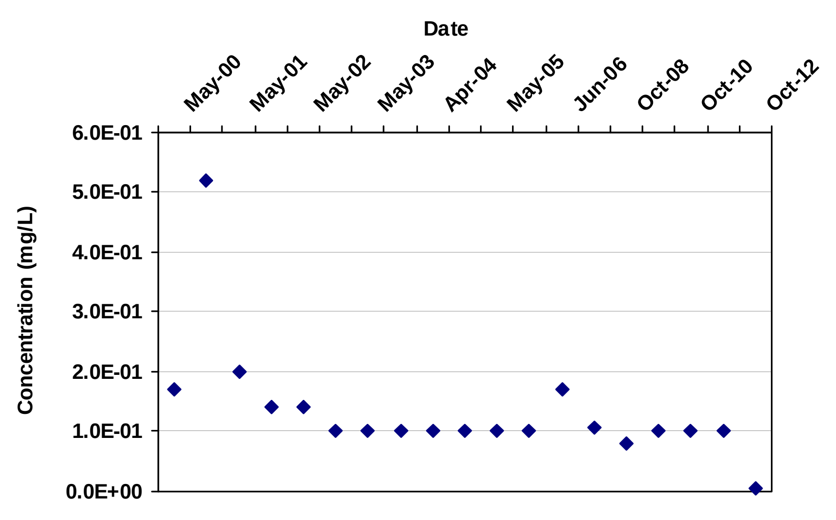
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-99-23X	T	11/1/2004	ARSENIC	6.1E-02		1	1
ZWM-99-23X	T	5/1/2005	ARSENIC	4.6E-02		1	1
ZWM-99-23X	T	11/1/2005	ARSENIC	4.7E-02		1	1
ZWM-99-23X	T	6/1/2006	ARSENIC	5.6E-02		1	1
ZWM-99-23X	T	10/1/2007	ARSENIC	5.6E-02		1	1
ZWM-99-23X	T	10/1/2008	ARSENIC	5.2E-02		1	1
ZWM-99-23X	T	11/1/2009	ARSENIC	6.2E-02		1	1
ZWM-99-23X	T	10/1/2010	ARSENIC	1.5E-02		1	1
ZWM-99-23X	T	10/1/2011	ARSENIC	6.0E-02		1	1
ZWM-99-23X	T	10/1/2012	ARSENIC	2.9E-02		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project:	AOC 69W, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

Well:	ZWM-99-23X	**Time Period:**	5/1/2000 **to** 10/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	C10-C12 PETROLEUM HYDROCARB	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-81

Confidence in Trend:

99.8%

Coefficient of Variation:

0.77

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-99-23X	T	5/1/2000	C10-C12 PETROLEU	1.7E-01		1	1
ZWM-99-23X	T	11/1/2000	C10-C12 PETROLEU	5.2E-01		1	1
ZWM-99-23X	T	5/1/2001	C10-C12 PETROLEU	2.0E-01		1	1
ZWM-99-23X	T	11/1/2001	C10-C12 PETROLEU	1.4E-01		1	1
ZWM-99-23X	T	5/1/2002	C10-C12 PETROLEU	1.4E-01		1	1
ZWM-99-23X	T	11/1/2002	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-99-23X	T	5/1/2003	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-99-23X	T	11/1/2003	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-99-23X	T	4/1/2004	C10-C12 PETROLEU	1.0E-01	ND	1	0

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens | **User Name:** T Lillys

Location: Devens | **State:** Massachusetts

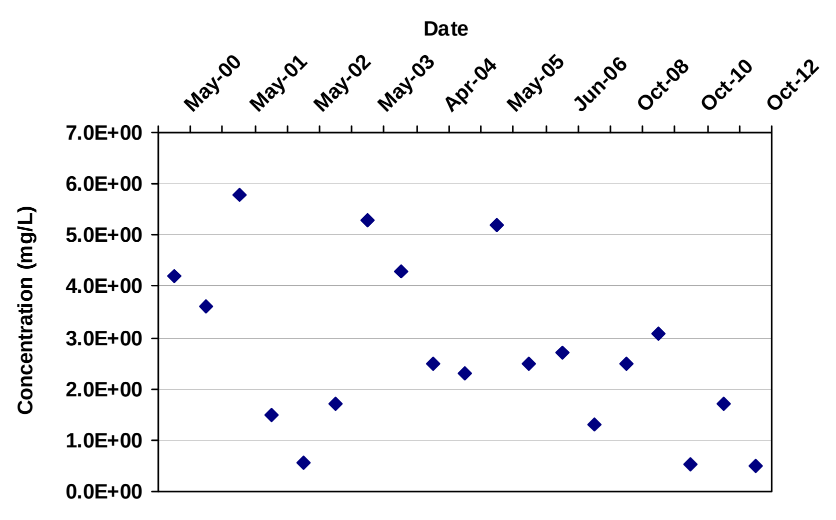
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-99-23X	T	11/1/2004	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-99-23X	T	5/1/2005	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-99-23X	T	11/1/2005	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-99-23X	T	6/1/2006	C10-C12 PETROLEU	1.7E-01		1	1
ZWM-99-23X	T	10/1/2007	C10-C12 PETROLEU	1.1E-01		1	1
ZWM-99-23X	T	10/1/2008	C10-C12 PETROLEU	8.0E-02		1	1
ZWM-99-23X	T	11/1/2009	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-99-23X	T	10/1/2010	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-99-23X	T	10/1/2011	C10-C12 PETROLEU	1.0E-01	ND	1	0
ZWM-99-23X	T	10/1/2012	C10-C12 PETROLEU	5.0E-03	ND	1	0

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project:	AOC 69W, Former Ft. Devens	**User Name:**	T Lillys
Location:	Devens	**State:**	Massachusetts

Well:	ZWM-99-23X	**Time Period:**	5/1/2000 **to** 10/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	MANGANESE	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-52

Confidence in Trend:

96.3%

Coefficient of Variation:

0.60

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-99-23X	T	5/1/2000	MANGANESE	4.2E+00		1	1
ZWM-99-23X	T	11/1/2000	MANGANESE	3.6E+00		1	1
ZWM-99-23X	T	5/1/2001	MANGANESE	5.8E+00		1	1
ZWM-99-23X	T	11/1/2001	MANGANESE	1.5E+00		1	1
ZWM-99-23X	T	5/1/2002	MANGANESE	5.5E-01		1	1
ZWM-99-23X	T	11/1/2002	MANGANESE	1.7E+00		1	1
ZWM-99-23X	T	5/1/2003	MANGANESE	5.3E+00		1	1
ZWM-99-23X	T	11/1/2003	MANGANESE	4.3E+00		1	1
ZWM-99-23X	T	4/1/2004	MANGANESE	2.5E+00		1	1

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-99-23X	T	11/1/2004	MANGANESE	2.3E+00		1	1
ZWM-99-23X	T	5/1/2005	MANGANESE	5.2E+00		1	1
ZWM-99-23X	T	11/1/2005	MANGANESE	2.5E+00		1	1
ZWM-99-23X	T	6/1/2006	MANGANESE	2.7E+00		1	1
ZWM-99-23X	T	10/1/2007	MANGANESE	1.3E+00		1	1
ZWM-99-23X	T	10/1/2008	MANGANESE	2.5E+00		1	1
ZWM-99-23X	T	11/1/2009	MANGANESE	3.1E+00		1	1
ZWM-99-23X	T	10/1/2010	MANGANESE	5.2E-01		1	1
ZWM-99-23X	T	10/1/2011	MANGANESE	1.7E+00		1	1
ZWM-99-23X	T	10/1/2012	MANGANESE	5.0E-01		1	1

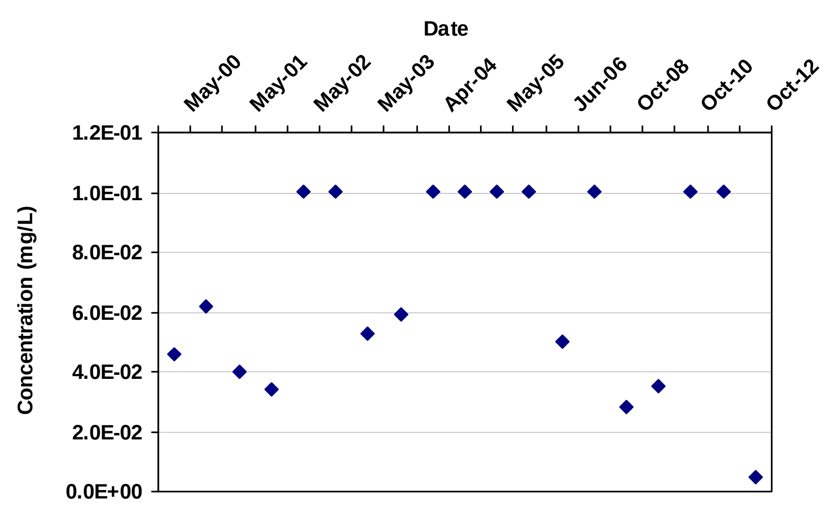
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well:	ZWM-99-23X	**Time Period:**	5/1/2000 **to** 10/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	VOLATILE PETROLEUM HYDROCAR	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

5

Confidence in Trend:

55.5%

Coefficient of Variation:

0.47

Mann Kendall Concentration Trend: (See Note)

NT

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-99-23X	T	5/1/2000	VOLATILE PETROLEU	4.6E-02		1	1
ZWM-99-23X	T	11/1/2000	VOLATILE PETROLEU	6.2E-02		1	1
ZWM-99-23X	T	5/1/2001	VOLATILE PETROLEU	4.0E-02		1	1
ZWM-99-23X	T	11/1/2001	VOLATILE PETROLEU	3.4E-02		1	1
ZWM-99-23X	T	5/1/2002	VOLATILE PETROLEU	1.0E-01	ND	1	0
ZWM-99-23X	T	11/1/2002	VOLATILE PETROLEU	1.0E-01	ND	1	0
ZWM-99-23X	T	5/1/2003	VOLATILE PETROLEU	5.3E-02		1	1
ZWM-99-23X	T	11/1/2003	VOLATILE PETROLEU	5.9E-02		1	1
ZWM-99-23X	T	4/1/2004	VOLATILE PETROLEU	1.0E-01	ND	1	0

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
ZWM-99-23X	T	11/1/2004	VOLATILE PETROLEU	1.0E-01	ND	1	0
ZWM-99-23X	T	5/1/2005	VOLATILE PETROLEU	1.0E-01		1	1
ZWM-99-23X	T	11/1/2005	VOLATILE PETROLEU	1.0E-01	ND	1	0
ZWM-99-23X	T	6/1/2006	VOLATILE PETROLEU	5.0E-02		1	1
ZWM-99-23X	T	10/1/2007	VOLATILE PETROLEU	1.0E-01	ND	1	0
ZWM-99-23X	T	10/1/2008	VOLATILE PETROLEU	2.8E-02		1	1
ZWM-99-23X	T	11/1/2009	VOLATILE PETROLEU	3.5E-02		1	1
ZWM-99-23X	T	10/1/2010	VOLATILE PETROLEU	1.0E-01	ND	1	0
ZWM-99-23X	T	10/1/2011	VOLATILE PETROLEU	1.0E-01	ND	1	0
ZWM-99-23X	T	10/1/2012	VOLATILE PETROLEU	5.0E-03	ND	1	0

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Linear Regression Statistics Summary

Project: AOC 69W, Former Ft. Devens **User Name:** T Lillys

Location: Devens **State:** Massachusetts

Time Period: 5/1/2000 **to** 10/1/2012

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value

Well	Source/Tail	Average Conc (mg/L)	Median Conc (mg/L)	Standard Deviation	All Samples "ND" ?	Ln Slope	Coefficient of Variation	Confidence in Trend	Concentration Trend
ARSENIC									
69W-94-13	S	8.2E-02	7.3E-02	3.9E-02	No	-1.6E-05	0.47	56.6%	S
ZWM-99-22X	S	2.0E-01	1.5E-01	9.4E-02	No	2.4E-04	0.47	100.0%	I
ZWM-99-23X	T	4.2E-02	4.7E-02	2.1E-02	No	8.9E-05	0.51	73.1%	NT
C10-C12 PETROLEUM HYDROCARBO									
69W-94-13	S	4.4E-01	2.4E-01	4.9E-01	No	-2.3E-04	1.11	92.8%	PD
ZWM-95-15X	T	1.6E-01	1.0E-01	3.0E-01	No	-3.2E-04	1.84	97.8%	D
ZWM-99-22X	S	5.3E-01	2.4E-01	6.8E-01	No	-3.2E-04	1.28	96.6%	D
ZWM-99-23X	T	1.3E-01	1.0E-01	1.0E-01	No	-3.9E-04	0.77	99.9%	D
MANGANESE									
69W-94-13	S	2.1E+00	1.9E+00	7.3E-01	No	-7.0E-05	0.35	89.0%	S
ZWM-01-25X	T	1.3E+00	7.5E-01	1.6E+00	No	8.8E-04	1.19	100.0%	I
ZWM-95-15X	T	1.1E+00	9.8E-01	1.0E+00	No	3.5E-04	0.94	92.3%	PI
ZWM-99-22X	S	2.5E+00	2.3E+00	7.5E-01	No	-9.8E-06	0.31	100.0%	D
ZWM-99-23X	T	2.7E+00	2.5E+00	1.6E+00	No	-2.7E-04	0.60	98.3%	D
VOLATILE PETROLEUM HYDROCARB									
69W-94-13	S	1.4E-01	1.4E-01	7.0E-02	No	-2.0E-04	0.49	99.7%	D
ZWM-99-22X	S	3.2E-01	2.2E-01	2.5E-01	No	-3.1E-04	0.76	98.3%	D
ZWM-99-23X	T	6.9E-02	6.2E-02	3.2E-02	No	-1.5E-04	0.47	88.1%	S

MAROS Linear Regression Statistics Summary

AOC 69W, Former Ft. Devens

Devens

User Name: T Lillys

State: Massachusetts

VOLATILE PETROLEUM HYDROCARB

Well	Source/Tail	Average Conc (mg/L)	Median Conc (mg/L)	Standard Deviation	All Samples "ND" ?	Ln Slope	Coefficient of Variation	Confidence in Trend	Concentration Trend

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Non-detect (ND); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); COV = Coefficient of Variation

MAROS Mann-Kendall Statistics Summary

Project: AOC 69W, Former Ft. Devens
User Name: T Lillys
Location: Devens
State: Massachusetts

Time Period: 5/1/2000 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
ARSENIC								
69W-94-13	S	19	19	0.47	8	59.6%	No	NT
ZWM-99-22X	S	19	19	0.47	71	99.4%	No	I
ZWM-99-23X	T	19	17	0.51	14	67.4%	No	NT
C10-C12 PETROLEUM HYDROCARBONS, AR								
69W-94-13	S	19	15	1.11	-23	77.7%	No	NT
ZWM-95-15X	T	19	1	1.84	-27	81.6%	No	NT
ZWM-99-22X	S	19	15	1.28	-35	88.1%	No	NT
ZWM-99-23X	T	19	8	0.77	-81	99.8%	No	D
MANGANESE								
69W-94-13	S	19	19	0.35	-22	76.6%	No	S
ZWM-01-25X	T	16	16	1.19	73	100.0%	No	I
ZWM-95-15X	T	19	19	0.94	19	73.3%	No	NT
ZWM-99-22X	S	19	19	0.31	25	79.7%	No	NT
ZWM-99-23X	T	19	19	0.60	-52	96.3%	No	D
VOLATILE PETROLEUM HYDROCARBONS C9								
69W-94-13	S	19	19	0.49	-74	99.6%	No	D
ZWM-99-22X	S	19	19	0.76	-59	97.9%	No	D
ZWM-99-23X	T	19	10	0.47	5	55.5%	No	NT

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Statistical Trend Analysis Summary

Project: AOC 69W, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Time Period: 5/1/2000 **to** 10/1/2012

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value

Well	Source / Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
ARSENIC								
69W-94-13	S	19	19	8.2E-02	7.3E-02	No	NT	S
ZWM-99-22X	S	19	19	2.0E-01	1.5E-01	No	I	I
ZWM-99-23X	T	19	17	4.2E-02	4.7E-02	No	NT	NT
C10-C12 PETROLEUM HYDROCARBONS								
69W-94-13	S	19	15	4.4E-01	2.4E-01	No	NT	PD
ZWM-95-15X	T	19	1	1.6E-01	1.0E-01	No	NT	D
ZWM-99-22X	S	19	15	5.3E-01	2.4E-01	No	NT	D
ZWM-99-23X	T	19	8	1.3E-01	1.0E-01	No	D	D
MANGANESE								
69W-94-13	S	19	19	2.1E+00	1.9E+00	No	S	S
ZWM-01-25X	T	16	16	1.3E+00	7.5E-01	No	I	I
ZWM-95-15X	T	19	19	1.1E+00	9.8E-01	No	NT	PI
ZWM-99-22X	S	19	19	2.5E+00	2.3E+00	No	NT	D
ZWM-99-23X	T	19	19	2.7E+00	2.5E+00	No	D	D
VOLATILE PETROLEUM HYDROCARBON								
69W-94-13	S	19	19	1.4E-01	1.4E-01	No	D	D
ZWM-99-22X	S	19	19	3.2E-01	2.2E-01	No	D	D
ZWM-99-23X	T	19	10	6.9E-02	6.2E-02	No	NT	S

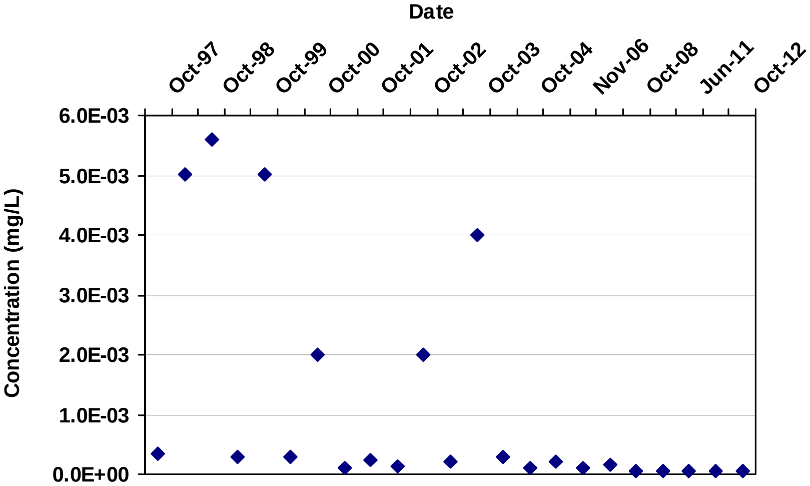
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); No Detectable Concentration (ND)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Mann-Kendall Statistics Summary

Well: OHM-A7-08
Well Type: S
COC: p,p-DDD

Time Period: 6/1/1992 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

-157

Confidence in Trend:

100.0%

Coefficient of Variation:

1.62

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
OHM-A7-08	S	10/1/1997	p,p-DDD	3.5E-04		1	1
OHM-A7-08	S	4/1/1998	p,p-DDD	5.0E-03		1	1
OHM-A7-08	S	10/1/1998	p,p-DDD	5.6E-03		1	1
OHM-A7-08	S	4/1/1999	p,p-DDD	3.0E-04		1	1
OHM-A7-08	S	10/1/1999	p,p-DDD	5.0E-03		1	1
OHM-A7-08	S	4/1/2000	p,p-DDD	2.8E-04		1	1
OHM-A7-08	S	10/1/2000	p,p-DDD	2.0E-03		1	1
OHM-A7-08	S	5/1/2001	p,p-DDD	1.0E-04		1	1
OHM-A7-08	S	10/1/2001	p,p-DDD	2.5E-04		1	1
OHM-A7-08	S	4/1/2002	p,p-DDD	1.3E-04		1	1
OHM-A7-08	S	10/1/2002	p,p-DDD	2.0E-03		1	1
OHM-A7-08	S	4/1/2003	p,p-DDD	2.1E-04		1	1
OHM-A7-08	S	10/1/2003	p,p-DDD	4.0E-03		1	1
OHM-A7-08	S	4/1/2004	p,p-DDD	2.9E-04		1	1
OHM-A7-08	S	10/1/2004	p,p-DDD	1.1E-04		1	1
OHM-A7-08	S	9/1/2005	p,p-DDD	2.1E-04		1	1
OHM-A7-08	S	11/1/2006	p,p-DDD	1.0E-04		1	1
OHM-A7-08	S	10/1/2007	p,p-DDD	1.6E-04		1	1
OHM-A7-08	S	10/1/2008	p,p-DDD	4.0E-05		1	1
OHM-A7-08	S	11/1/2009	p,p-DDD	5.0E-05		1	1
OHM-A7-08	S	6/1/2011	p,p-DDD	5.3E-05		1	1
OHM-A7-08	S	10/1/2011	p,p-DDD	4.3E-05		1	1

MAROS Mann-Kendall Statistics Summary

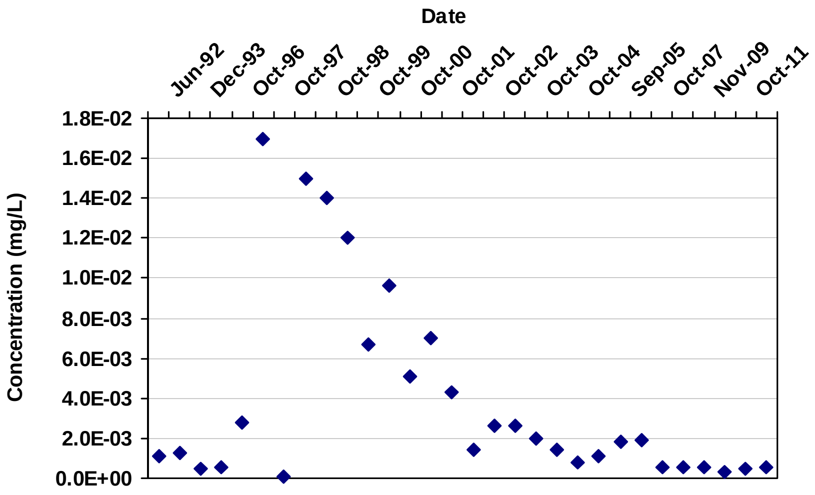
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
OHM-A7-08	S	10/1/2012	p,p-DDD	4.9E-05		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: OHM-A7-08
Well Type: S
COC: GAMMA BHC (LINDANE)

Time Period: 6/1/1992 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

-166

Confidence in Trend:

99.9%

Coefficient of Variation:

1.26

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
OHM-A7-08	S	6/1/1992	GAMMA BHC (LINDANE)	1.1E-03		1	1
OHM-A7-08	S	11/1/1992	GAMMA BHC (LINDANE)	1.3E-03		1	1
OHM-A7-08	S	12/1/1993	GAMMA BHC (LINDANE)	4.9E-04		1	1
OHM-A7-08	S	7/1/1996	GAMMA BHC (LINDANE)	5.4E-04		1	1
OHM-A7-08	S	10/1/1996	GAMMA BHC (LINDANE)	2.8E-03		1	1
OHM-A7-08	S	4/1/1997	GAMMA BHC (LINDANE)	1.7E-02		1	1
OHM-A7-08	S	10/1/1997	GAMMA BHC (LINDANE)	5.2E-05		1	1
OHM-A7-08	S	4/1/1998	GAMMA BHC (LINDANE)	1.5E-02		1	1
OHM-A7-08	S	10/1/1998	GAMMA BHC (LINDANE)	1.4E-02		1	1
OHM-A7-08	S	4/1/1999	GAMMA BHC (LINDANE)	1.2E-02		1	1
OHM-A7-08	S	10/1/1999	GAMMA BHC (LINDANE)	6.7E-03		1	1
OHM-A7-08	S	4/1/2000	GAMMA BHC (LINDANE)	9.6E-03		1	1
OHM-A7-08	S	10/1/2000	GAMMA BHC (LINDANE)	5.1E-03		1	1
OHM-A7-08	S	5/1/2001	GAMMA BHC (LINDANE)	7.0E-03		1	1
OHM-A7-08	S	10/1/2001	GAMMA BHC (LINDANE)	4.3E-03		1	1
OHM-A7-08	S	4/1/2002	GAMMA BHC (LINDANE)	1.4E-03		1	1
OHM-A7-08	S	10/1/2002	GAMMA BHC (LINDANE)	2.6E-03		1	1
OHM-A7-08	S	4/1/2003	GAMMA BHC (LINDANE)	2.6E-03		1	1
OHM-A7-08	S	10/1/2003	GAMMA BHC (LINDANE)	2.0E-03		1	1
OHM-A7-08	S	4/1/2004	GAMMA BHC (LINDANE)	1.4E-03		1	1
OHM-A7-08	S	10/1/2004	GAMMA BHC (LINDANE)	8.2E-04		1	1
OHM-A7-08	S	5/1/2005	GAMMA BHC (LINDANE)	1.1E-03		1	1

MAROS Mann-Kendall Statistics Summary

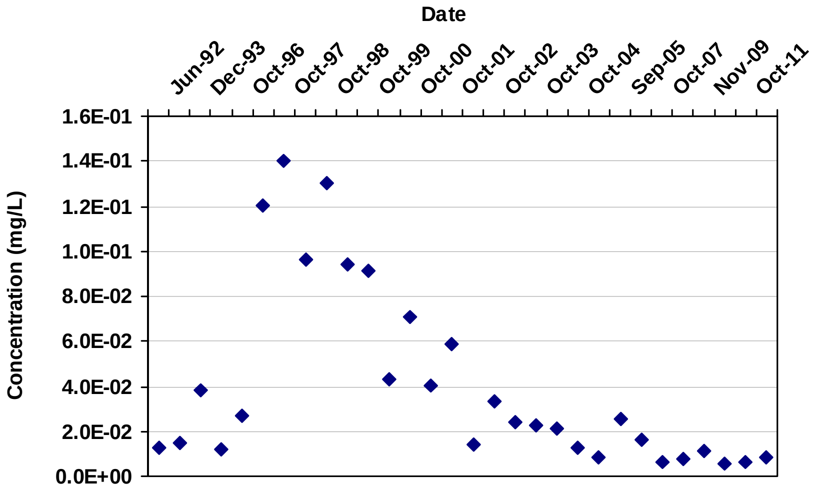
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
OHM-A7-08	S	9/1/2005	GAMMA BHC (LINDANE)	1.8E-03		1	1
OHM-A7-08	S	11/1/2006	GAMMA BHC (LINDANE)	1.9E-03		1	1
OHM-A7-08	S	10/1/2007	GAMMA BHC (LINDANE)	5.8E-04		1	1
OHM-A7-08	S	10/1/2008	GAMMA BHC (LINDANE)	5.2E-04		1	1
OHM-A7-08	S	11/1/2009	GAMMA BHC (LINDANE)	5.2E-04		1	1
OHM-A7-08	S	6/1/2011	GAMMA BHC (LINDANE)	3.3E-04		1	1
OHM-A7-08	S	10/1/2011	GAMMA BHC (LINDANE)	4.5E-04		1	1
OHM-A7-08	S	10/1/2012	GAMMA BHC (LINDANE)	5.3E-04		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: OHM-A7-08
Well Type: S
COC: TETRACHLOROETHYLENE(PCE)

Time Period: 6/1/1992 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:
-221

Confidence in Trend:
100.0%

Coefficient of Variation:
1.00

Mann Kendall Concentration Trend: (See Note)
D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
OHM-A7-08	S	6/1/1992	TETRACHLOROETHYLENE(PCE	1.3E-02		1	1
OHM-A7-08	S	11/1/1992	TETRACHLOROETHYLENE(PCE	1.5E-02		1	1
OHM-A7-08	S	12/1/1993	TETRACHLOROETHYLENE(PCE	3.8E-02		1	1
OHM-A7-08	S	7/1/1996	TETRACHLOROETHYLENE(PCE	1.2E-02		1	1
OHM-A7-08	S	10/1/1996	TETRACHLOROETHYLENE(PCE	2.7E-02		1	1
OHM-A7-08	S	4/1/1997	TETRACHLOROETHYLENE(PCE	1.2E-01		1	1
OHM-A7-08	S	10/1/1997	TETRACHLOROETHYLENE(PCE	1.4E-01		1	1
OHM-A7-08	S	4/1/1998	TETRACHLOROETHYLENE(PCE	9.6E-02		1	1
OHM-A7-08	S	10/1/1998	TETRACHLOROETHYLENE(PCE	1.3E-01		1	1
OHM-A7-08	S	4/1/1999	TETRACHLOROETHYLENE(PCE	9.4E-02		1	1
OHM-A7-08	S	10/1/1999	TETRACHLOROETHYLENE(PCE	9.1E-02		1	1
OHM-A7-08	S	4/1/2000	TETRACHLOROETHYLENE(PCE	4.3E-02		1	1
OHM-A7-08	S	10/1/2000	TETRACHLOROETHYLENE(PCE	7.1E-02		1	1
OHM-A7-08	S	5/1/2001	TETRACHLOROETHYLENE(PCE	4.0E-02		1	1
OHM-A7-08	S	10/1/2001	TETRACHLOROETHYLENE(PCE	5.9E-02		1	1
OHM-A7-08	S	4/1/2002	TETRACHLOROETHYLENE(PCE	1.4E-02		1	1
OHM-A7-08	S	10/1/2002	TETRACHLOROETHYLENE(PCE	3.3E-02		1	1
OHM-A7-08	S	4/1/2003	TETRACHLOROETHYLENE(PCE	2.4E-02		1	1
OHM-A7-08	S	10/1/2003	TETRACHLOROETHYLENE(PCE	2.3E-02		1	1
OHM-A7-08	S	4/1/2004	TETRACHLOROETHYLENE(PCE	2.1E-02		1	1
OHM-A7-08	S	10/1/2004	TETRACHLOROETHYLENE(PCE	1.3E-02		1	1
OHM-A7-08	S	5/1/2005	TETRACHLOROETHYLENE(PCE	8.7E-03		1	1

MAROS Mann-Kendall Statistics Summary

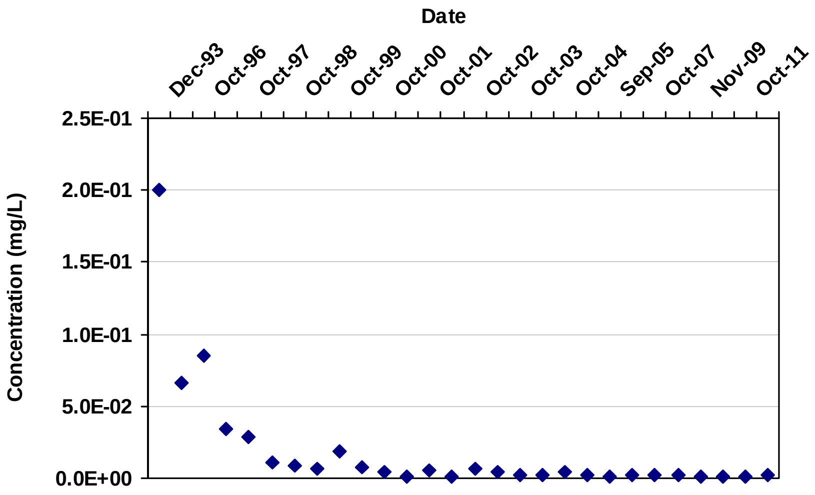
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
OHM-A7-08	S	9/1/2005	TETRACHLOROETHYLENE(PCE	2.5E-02		1	1
OHM-A7-08	S	11/1/2006	TETRACHLOROETHYLENE(PCE	1.6E-02		1	1
OHM-A7-08	S	10/1/2007	TETRACHLOROETHYLENE(PCE	6.2E-03		1	1
OHM-A7-08	S	10/1/2008	TETRACHLOROETHYLENE(PCE	8.1E-03		1	1
OHM-A7-08	S	11/1/2009	TETRACHLOROETHYLENE(PCE	1.1E-02		1	1
OHM-A7-08	S	6/1/2011	TETRACHLOROETHYLENE(PCE	5.6E-03		1	1
OHM-A7-08	S	10/1/2011	TETRACHLOROETHYLENE(PCE	6.2E-03		1	1
OHM-A7-08	S	10/1/2012	TETRACHLOROETHYLENE(PCE	8.2E-03		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: OHM-A7-51
Well Type: S
COC: 1,1,2,2-TETRACHLOROETHANE

Time Period: 6/1/1992 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

-281

Confidence in Trend:

100.0%

Coefficient of Variation:

2.22

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
OHM-A7-51	S	12/1/1993	1,1,2,2-TETRACHLOROETHANE	2.0E-01		1	1
OHM-A7-51	S	7/1/1996	1,1,2,2-TETRACHLOROETHANE	6.6E-02		1	1
OHM-A7-51	S	10/1/1996	1,1,2,2-TETRACHLOROETHANE	8.5E-02		1	1
OHM-A7-51	S	4/1/1997	1,1,2,2-TETRACHLOROETHANE	3.4E-02		1	1
OHM-A7-51	S	10/1/1997	1,1,2,2-TETRACHLOROETHANE	2.9E-02		1	1
OHM-A7-51	S	4/1/1998	1,1,2,2-TETRACHLOROETHANE	1.1E-02		1	1
OHM-A7-51	S	10/1/1998	1,1,2,2-TETRACHLOROETHANE	9.0E-03		1	1
OHM-A7-51	S	4/1/1999	1,1,2,2-TETRACHLOROETHANE	6.5E-03		1	1
OHM-A7-51	S	10/1/1999	1,1,2,2-TETRACHLOROETHANE	1.9E-02		1	1
OHM-A7-51	S	4/1/2000	1,1,2,2-TETRACHLOROETHANE	7.7E-03		1	1
OHM-A7-51	S	10/1/2000	1,1,2,2-TETRACHLOROETHANE	4.9E-03		1	1
OHM-A7-51	S	5/1/2001	1,1,2,2-TETRACHLOROETHANE	1.0E-03		1	1
OHM-A7-51	S	10/1/2001	1,1,2,2-TETRACHLOROETHANE	6.0E-03		1	1
OHM-A7-51	S	4/1/2002	1,1,2,2-TETRACHLOROETHANE	1.0E-03		1	1
OHM-A7-51	S	10/1/2002	1,1,2,2-TETRACHLOROETHANE	6.1E-03		1	1
OHM-A7-51	S	4/1/2003	1,1,2,2-TETRACHLOROETHANE	4.8E-03		1	1
OHM-A7-51	S	10/1/2003	1,1,2,2-TETRACHLOROETHANE	2.4E-03		1	1
OHM-A7-51	S	4/1/2004	1,1,2,2-TETRACHLOROETHANE	2.7E-03		1	1
OHM-A7-51	S	10/1/2004	1,1,2,2-TETRACHLOROETHANE	4.4E-03		1	1
OHM-A7-51	S	5/1/2005	1,1,2,2-TETRACHLOROETHANE	2.0E-03		1	1
OHM-A7-51	S	9/1/2005	1,1,2,2-TETRACHLOROETHANE	1.4E-03		1	1
OHM-A7-51	S	11/1/2006	1,1,2,2-TETRACHLOROETHANE	1.9E-03		1	1

MAROS Mann-Kendall Statistics Summary

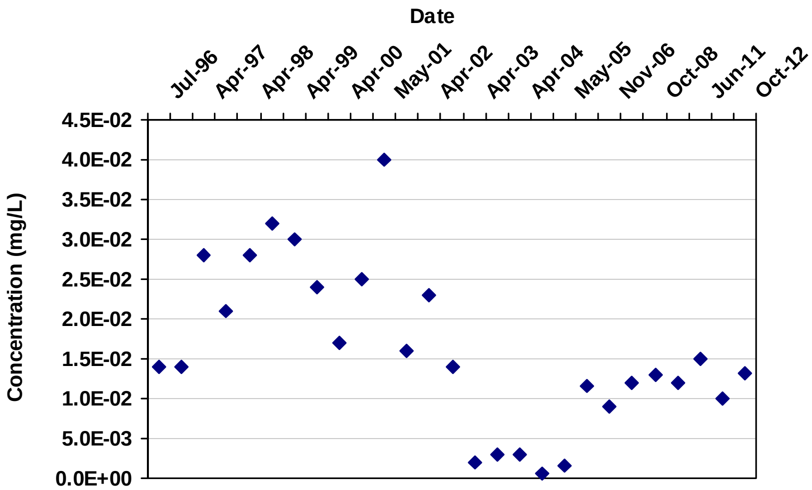
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
OHM-A7-51	S	10/1/2007	1,1,2,2-TETRACHLOROETHANE	2.4E-03		1	1
OHM-A7-51	S	10/1/2008	1,1,2,2-TETRACHLOROETHANE	2.0E-03		1	1
OHM-A7-51	S	11/1/2009	1,1,2,2-TETRACHLOROETHANE	9.4E-04		1	1
OHM-A7-51	S	6/1/2011	1,1,2,2-TETRACHLOROETHANE	1.2E-03		1	1
OHM-A7-51	S	10/1/2011	1,1,2,2-TETRACHLOROETHANE	5.8E-04		1	1
OHM-A7-51	S	10/1/2012	1,1,2,2-TETRACHLOROETHANE	1.8E-03		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: SUD-A07-06
Well Type: T
COC: TETRACHLOROETHYLENE(PCE)

Time Period: 6/1/1992 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:
-127

Confidence in Trend:
99.6%

Coefficient of Variation:
0.64

Mann Kendall Concentration Trend: (See Note)
D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
SUD-A07-065	T	7/1/1996	TETRACHLOROETHYLENE(PCE	1.4E-02		1	1
SUD-A07-065	T	10/1/1996	TETRACHLOROETHYLENE(PCE	1.4E-02		1	1
SUD-A07-065	T	4/1/1997	TETRACHLOROETHYLENE(PCE	2.8E-02		1	1
SUD-A07-065	T	10/1/1997	TETRACHLOROETHYLENE(PCE	2.1E-02		1	1
SUD-A07-065	T	4/1/1998	TETRACHLOROETHYLENE(PCE	2.8E-02		1	1
SUD-A07-065	T	10/1/1998	TETRACHLOROETHYLENE(PCE	3.2E-02		1	1
SUD-A07-065	T	4/1/1999	TETRACHLOROETHYLENE(PCE	3.0E-02		1	1
SUD-A07-065	T	10/1/1999	TETRACHLOROETHYLENE(PCE	2.4E-02		1	1
SUD-A07-065	T	4/1/2000	TETRACHLOROETHYLENE(PCE	1.7E-02		1	1
SUD-A07-065	T	10/1/2000	TETRACHLOROETHYLENE(PCE	2.5E-02		1	1
SUD-A07-065	T	5/1/2001	TETRACHLOROETHYLENE(PCE	4.0E-02		1	1
SUD-A07-065	T	10/1/2001	TETRACHLOROETHYLENE(PCE	1.6E-02		1	1
SUD-A07-065	T	4/1/2002	TETRACHLOROETHYLENE(PCE	2.3E-02		1	1
SUD-A07-065	T	10/1/2002	TETRACHLOROETHYLENE(PCE	1.4E-02		1	1
SUD-A07-065	T	4/1/2003	TETRACHLOROETHYLENE(PCE	1.9E-03		1	1
SUD-A07-065	T	10/1/2003	TETRACHLOROETHYLENE(PCE	3.0E-03		1	1
SUD-A07-065	T	4/1/2004	TETRACHLOROETHYLENE(PCE	2.9E-03		1	1
SUD-A07-065	T	10/1/2004	TETRACHLOROETHYLENE(PCE	6.0E-04		1	1
SUD-A07-065	T	5/1/2005	TETRACHLOROETHYLENE(PCE	1.5E-03		1	1
SUD-A07-065	T	9/1/2005	TETRACHLOROETHYLENE(PCE	1.2E-02		1	1
SUD-A07-065	T	11/1/2006	TETRACHLOROETHYLENE(PCE	8.9E-03		1	1
SUD-A07-065	T	10/1/2007	TETRACHLOROETHYLENE(PCE	1.2E-02		1	1

MAROS Mann-Kendall Statistics Summary

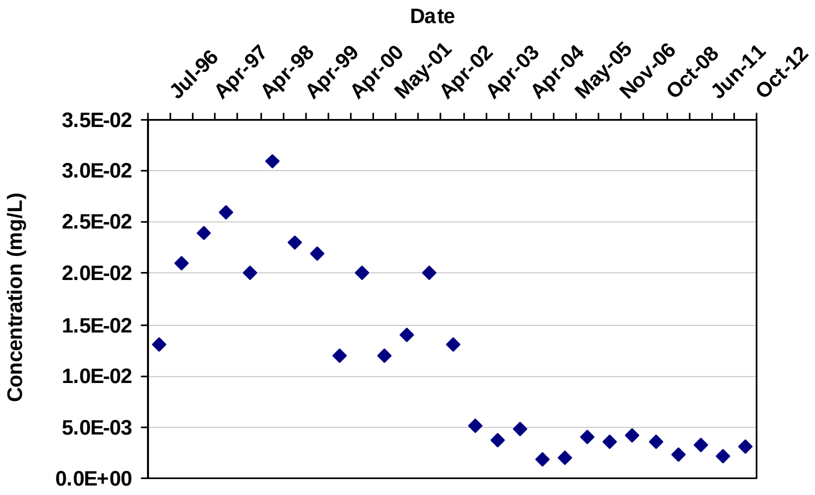
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
SUD-A07-065	T	10/1/2008	TETRACHLOROETHYLENE(PCE	1.3E-02		1	1
SUD-A07-065	T	11/1/2009	TETRACHLOROETHYLENE(PCE	1.2E-02		1	1
SUD-A07-065	T	6/1/2011	TETRACHLOROETHYLENE(PCE	1.5E-02		1	1
SUD-A07-065	T	10/1/2011	TETRACHLOROETHYLENE(PCE	9.9E-03		1	1
SUD-A07-065	T	10/1/2012	TETRACHLOROETHYLENE(PCE	1.3E-02		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: SUD-A07-06
Well Type: T
COC: 1,1,2,2-TETRACHLOROETHANE

Time Period: 6/1/1992 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:

-237

Confidence in Trend:

100.0%

Coefficient of Variation:

0.79

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
SUD-A07-065	T	7/1/1996	1,1,2,2-TETRACHLOROETHANE	1.3E-02		1	1
SUD-A07-065	T	10/1/1996	1,1,2,2-TETRACHLOROETHANE	2.1E-02		1	1
SUD-A07-065	T	4/1/1997	1,1,2,2-TETRACHLOROETHANE	2.4E-02		1	1
SUD-A07-065	T	10/1/1997	1,1,2,2-TETRACHLOROETHANE	2.6E-02		1	1
SUD-A07-065	T	4/1/1998	1,1,2,2-TETRACHLOROETHANE	2.0E-02		1	1
SUD-A07-065	T	10/1/1998	1,1,2,2-TETRACHLOROETHANE	3.1E-02		1	1
SUD-A07-065	T	4/1/1999	1,1,2,2-TETRACHLOROETHANE	2.3E-02		1	1
SUD-A07-065	T	10/1/1999	1,1,2,2-TETRACHLOROETHANE	2.2E-02		1	1
SUD-A07-065	T	4/1/2000	1,1,2,2-TETRACHLOROETHANE	1.2E-02		1	1
SUD-A07-065	T	10/1/2000	1,1,2,2-TETRACHLOROETHANE	2.0E-02		1	1
SUD-A07-065	T	5/1/2001	1,1,2,2-TETRACHLOROETHANE	1.2E-02		1	1
SUD-A07-065	T	10/1/2001	1,1,2,2-TETRACHLOROETHANE	1.4E-02		1	1
SUD-A07-065	T	4/1/2002	1,1,2,2-TETRACHLOROETHANE	2.0E-02		1	1
SUD-A07-065	T	10/1/2002	1,1,2,2-TETRACHLOROETHANE	1.3E-02		1	1
SUD-A07-065	T	4/1/2003	1,1,2,2-TETRACHLOROETHANE	5.1E-03		1	1
SUD-A07-065	T	10/1/2003	1,1,2,2-TETRACHLOROETHANE	3.8E-03		1	1
SUD-A07-065	T	4/1/2004	1,1,2,2-TETRACHLOROETHANE	4.8E-03		1	1
SUD-A07-065	T	10/1/2004	1,1,2,2-TETRACHLOROETHANE	1.8E-03		1	1
SUD-A07-065	T	5/1/2005	1,1,2,2-TETRACHLOROETHANE	2.0E-03		1	1
SUD-A07-065	T	9/1/2005	1,1,2,2-TETRACHLOROETHANE	4.1E-03		1	1
SUD-A07-065	T	11/1/2006	1,1,2,2-TETRACHLOROETHANE	3.6E-03		1	1
SUD-A07-065	T	10/1/2007	1,1,2,2-TETRACHLOROETHANE	4.2E-03		1	1

MAROS Mann-Kendall Statistics Summary

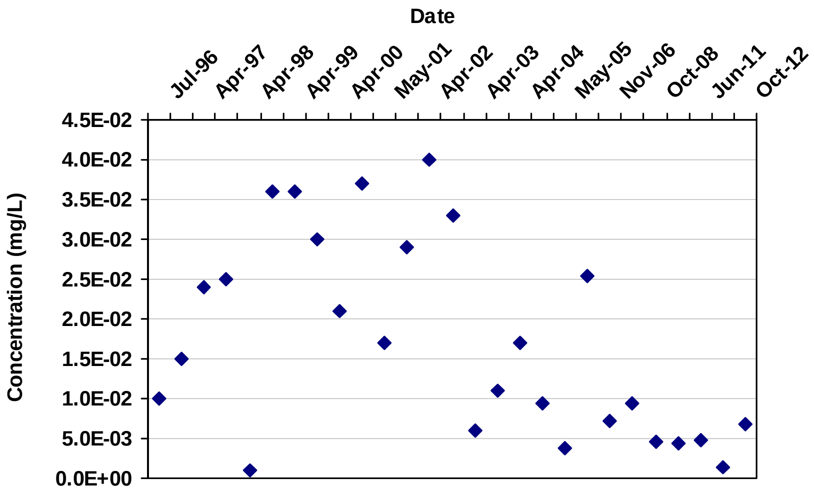
Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
SUD-A07-065	T	10/1/2008	1,1,2,2-TETRACHLOROETHANE	3.6E-03		1	1
SUD-A07-065	T	11/1/2009	1,1,2,2-TETRACHLOROETHANE	2.3E-03		1	1
SUD-A07-065	T	6/1/2011	1,1,2,2-TETRACHLOROETHANE	3.3E-03		1	1
SUD-A07-065	T	10/1/2011	1,1,2,2-TETRACHLOROETHANE	2.1E-03		1	1
SUD-A07-065	T	10/1/2012	1,1,2,2-TETRACHLOROETHANE	3.1E-03		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Well: SUD-A07-06
Well Type: T
COC: TRICHLOROETHYLENE (TCE)

Time Period: 6/1/1992 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Maximum
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value



Mann Kendall S Statistic:
-126

Confidence in Trend:
99.6%

Coefficient of Variation:
0.73

Mann Kendall Concentration Trend: (See Note)
D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
SUD-A07-065	T	7/1/1996	TRICHLOROETHYLENE (TCE)	1.0E-02		1	1
SUD-A07-065	T	10/1/1996	TRICHLOROETHYLENE (TCE)	1.5E-02		1	1
SUD-A07-065	T	4/1/1997	TRICHLOROETHYLENE (TCE)	2.4E-02		1	1
SUD-A07-065	T	10/1/1997	TRICHLOROETHYLENE (TCE)	2.5E-02		1	1
SUD-A07-065	T	4/1/1998	TRICHLOROETHYLENE (TCE)	1.0E-03		1	1
SUD-A07-065	T	10/1/1998	TRICHLOROETHYLENE (TCE)	3.6E-02		1	1
SUD-A07-065	T	4/1/1999	TRICHLOROETHYLENE (TCE)	3.6E-02		1	1
SUD-A07-065	T	10/1/1999	TRICHLOROETHYLENE (TCE)	3.0E-02		1	1
SUD-A07-065	T	4/1/2000	TRICHLOROETHYLENE (TCE)	2.1E-02		1	1
SUD-A07-065	T	10/1/2000	TRICHLOROETHYLENE (TCE)	3.7E-02		1	1
SUD-A07-065	T	5/1/2001	TRICHLOROETHYLENE (TCE)	1.7E-02		1	1
SUD-A07-065	T	10/1/2001	TRICHLOROETHYLENE (TCE)	2.9E-02		1	1
SUD-A07-065	T	4/1/2002	TRICHLOROETHYLENE (TCE)	4.0E-02		1	1
SUD-A07-065	T	10/1/2002	TRICHLOROETHYLENE (TCE)	3.3E-02		1	1
SUD-A07-065	T	4/1/2003	TRICHLOROETHYLENE (TCE)	5.9E-03		1	1
SUD-A07-065	T	10/1/2003	TRICHLOROETHYLENE (TCE)	1.1E-02		1	1
SUD-A07-065	T	4/1/2004	TRICHLOROETHYLENE (TCE)	1.7E-02		1	1
SUD-A07-065	T	10/1/2004	TRICHLOROETHYLENE (TCE)	9.3E-03		1	1
SUD-A07-065	T	5/1/2005	TRICHLOROETHYLENE (TCE)	3.8E-03		1	1
SUD-A07-065	T	9/1/2005	TRICHLOROETHYLENE (TCE)	2.5E-02		1	1
SUD-A07-065	T	11/1/2006	TRICHLOROETHYLENE (TCE)	7.1E-03		1	1
SUD-A07-065	T	10/1/2007	TRICHLOROETHYLENE (TCE)	9.3E-03		1	1

MAROS Mann-Kendall Statistics Summary

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
SUD-A07-065	T	10/1/2008	TRICHLOROETHYLENE (TCE)	4.6E-03		1	1
SUD-A07-065	T	11/1/2009	TRICHLOROETHYLENE (TCE)	4.4E-03		1	1
SUD-A07-065	T	6/1/2011	TRICHLOROETHYLENE (TCE)	4.7E-03		1	1
SUD-A07-065	T	10/1/2011	TRICHLOROETHYLENE (TCE)	1.3E-03		1	1
SUD-A07-065	T	10/1/2012	TRICHLOROETHYLENE (TCE)	6.8E-03		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Linear Regression Statistics Summary

Project: AOC 7, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Time Period: 6/1/1992 **to** 10/1/2012

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value

Well	Source/ Tail	Average Conc (mg/L)	Median Conc (mg/L)	Standard Deviation	All Samples "ND" ?	Ln Slope	Coefficient of Variation	Confidence in Trend	Concentration Trend
1,1,2,2-TETRACHLOROETHANE									
OHM-A7-51	S	1.8E-02	4.6E-03	4.1E-02	No	-6.8E-04	2.22	100.0%	D
SUD-A07-065	T	1.2E-02	1.2E-02	9.2E-03	No	-4.6E-04	0.79	100.0%	D
GAMMA BHC (LINDANE)									
OHM-A7-08	S	3.9E-03	1.6E-03	4.9E-03	No	-2.2E-04	1.26	96.1%	D
p,p-DDD									
OHM-A7-08	S	1.1E-03	2.1E-04	1.9E-03	No	-7.1E-04	1.62	100.0%	D
TETRACHLOROETHYLENE(PCE)									
OHM-A7-08	S	4.0E-02	2.4E-02	4.0E-02	No	-2.9E-04	1.00	100.0%	D
SUD-A07-065	T	1.6E-02	1.4E-02	1.0E-02	No	-1.9E-04	0.64	95.1%	D
TRICHLOROETHYLENE (TCE)									
SUD-A07-065	T	1.7E-02	1.5E-02	1.3E-02	No	-2.9E-04	0.73	99.7%	D

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Non-detect (ND); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); COV = Coefficient of Variation

MAROS Mann-Kendall Statistics Summary

Project: AOC 7, Former Ft. Devens

User Name: T Lillys

Location: Devens

State: Massachusetts

Time Period: 6/1/1992 **to** 10/1/2012

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
1,1,2,2-TETRACHLOROETHANE								
OHM-A7-51	S	28	28	2.22	-281	100.0%	No	D
SUD-A07-065	T	27	27	0.79	-237	100.0%	No	D
GAMMA BHC (LINDANE)								
OHM-A7-08	S	30	30	1.26	-166	99.9%	No	D
p,p-DDD								
OHM-A7-08	S	23	23	1.62	-157	100.0%	No	D
TETRACHLOROETHYLENE(PCE)								
OHM-A7-08	S	30	30	1.00	-221	100.0%	No	D
SUD-A07-065	T	27	27	0.64	-127	99.6%	No	D
TRICHLOROETHYLENE (TCE)								
SUD-A07-065	T	27	27	0.73	-126	99.6%	No	D

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Statistical Trend Analysis Summary

Project: AOC 7, Former Ft. Devens

Location: Devens

User Name: T Lillys

State: Massachusetts

Time Period: 6/1/1992 **to** 10/1/2012

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
1,1,2,2-TETRACHLOROETHANE								
OHM-A7-51	S	28	28	1.8E-02	4.6E-03	No	D	D
SUD-A07-065	T	27	27	1.2E-02	1.2E-02	No	D	D
GAMMA BHC (LINDANE)								
OHM-A7-08	S	30	30	3.9E-03	1.6E-03	No	D	D
p,p-DDD								
OHM-A7-08	S	23	23	1.1E-03	2.1E-04	No	D	D
TETRACHLOROETHYLENE(PCE)								
OHM-A7-08	S	30	30	4.0E-02	2.4E-02	No	D	D
SUD-A07-065	T	27	27	1.6E-02	1.4E-02	No	D	D
TRICHLOROETHYLENE (TCE)								
SUD-A07-065	T	27	27	1.7E-02	1.5E-02	No	D	D

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); No Detectable Concentration (NDC)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Linear Regression Statistics

Project: Sudbury Landfill **User Name:**

Location: Devens **State:** Massachusetts

Well: SUD-A07-065

Well Type: T

COC: GAMMA BHC (LINDANE)

Time Period: 4/1/1996 **to** 10/1/2012

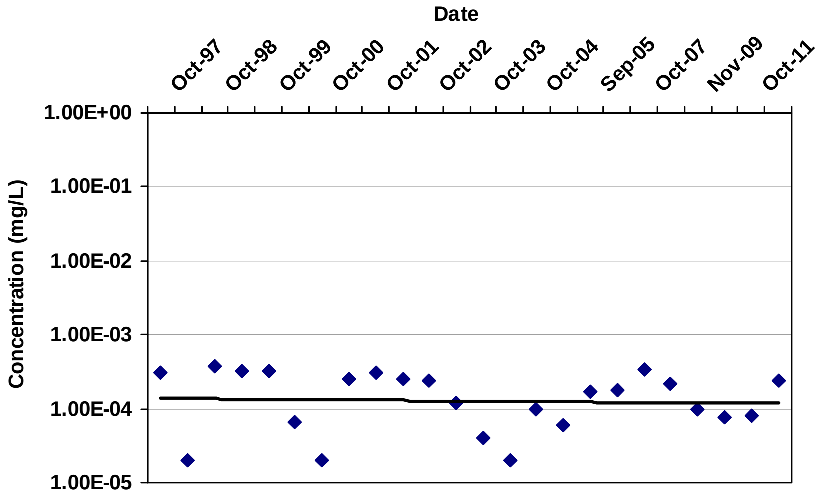
Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: Detection Limit

J Flag Values : Actual Value



COV:

0.67

Confidence in Trend:

56.3%

Ln Slope:

-2.0E-05

LR Concentration Trend:

S

Consolidation Data Table:

Well	Well Type	Consolidation Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
SUD-A07-065	T	10/1/1997	GAMMA BHC	3.1E-04		1	1
SUD-A07-065	T	4/1/1998	GAMMA BHC	2.0E-05	ND	1	0
SUD-A07-065	T	10/1/1998	GAMMA BHC	3.8E-04		1	1
SUD-A07-065	T	4/1/1999	GAMMA BHC	3.2E-04		1	1
SUD-A07-065	T	10/1/1999	GAMMA BHC	3.3E-04		1	1
SUD-A07-065	T	4/1/2000	GAMMA BHC	6.6E-05		1	1
SUD-A07-065	T	10/1/2000	GAMMA BHC	2.0E-05	ND	1	0
SUD-A07-065	T	5/1/2001	GAMMA BHC	2.5E-04		1	1

MAROS Linear Regression Statistics

Project: Sudbury Landfill **User Name:**

Location: Devens **State:** Massachusetts

Consolidation Data Table:

Well	Well Type	Consolidation Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
SUD-A07-065	T	10/1/2001	GAMMA BHC	3.1E-04		1	1
SUD-A07-065	T	4/1/2002	GAMMA BHC	2.5E-04		1	1
SUD-A07-065	T	10/1/2002	GAMMA BHC	2.4E-04		1	1
SUD-A07-065	T	4/1/2003	GAMMA BHC	1.2E-04		1	1
SUD-A07-065	T	10/1/2003	GAMMA BHC	4.1E-05		1	1
SUD-A07-065	T	4/1/2004	GAMMA BHC	2.0E-05	ND	1	0
SUD-A07-065	T	10/1/2004	GAMMA BHC	1.0E-04		1	1
SUD-A07-065	T	5/1/2005	GAMMA BHC	5.9E-05		1	1
SUD-A07-065	T	9/1/2005	GAMMA BHC	1.7E-04		1	1
SUD-A07-065	T	11/1/2006	GAMMA BHC	1.8E-04		1	1
SUD-A07-065	T	10/1/2007	GAMMA BHC	3.4E-04		1	1
SUD-A07-065	T	10/1/2008	GAMMA BHC	2.2E-04		1	1
SUD-A07-065	T	11/1/2009	GAMMA BHC	9.7E-05		1	1
SUD-A07-065	T	6/1/2011	GAMMA BHC	7.7E-05		1	1
SUD-A07-065	T	10/1/2011	GAMMA BHC	7.9E-05		1	1
SUD-A07-065	T	10/1/2012	GAMMA BHC	2.4E-04		1	1

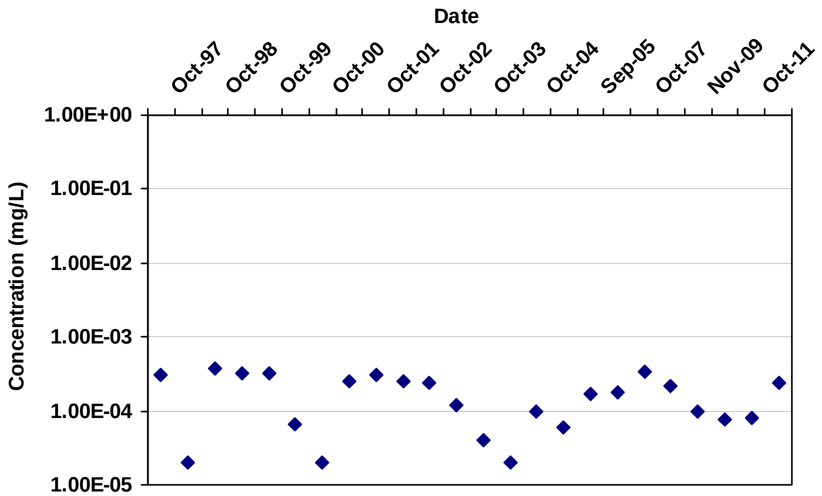
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = All Samples are Non-detect

MAROS Mann-Kendall Statistics Summary

Project: Sudbury Landfill **User Name:**

Location: Devens **State:** Massachusetts

Well:	SUD-A07-065	**Time Period:**	4/1/1996 **to** 10/1/2012
Well Type:	T	**Consolidation Period:**	No Time Consolidation
COC:	GAMMA BHC (LINDANE)	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-45

Confidence in Trend:

86.1%

Coefficient of Variation:

0.67

Mann Kendall Concentration Trend: (See Note)

S

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
SUD-A07-065	T	10/1/1997	GAMMA BHC (LINDA	3.1E-04		1	1
SUD-A07-065	T	4/1/1998	GAMMA BHC (LINDA	2.0E-05	ND	1	0
SUD-A07-065	T	10/1/1998	GAMMA BHC (LINDA	3.8E-04		1	1
SUD-A07-065	T	4/1/1999	GAMMA BHC (LINDA	3.2E-04		1	1
SUD-A07-065	T	10/1/1999	GAMMA BHC (LINDA	3.3E-04		1	1
SUD-A07-065	T	4/1/2000	GAMMA BHC (LINDA	6.6E-05		1	1
SUD-A07-065	T	10/1/2000	GAMMA BHC (LINDA	2.0E-05	ND	1	0
SUD-A07-065	T	5/1/2001	GAMMA BHC (LINDA	2.5E-04		1	1
SUD-A07-065	T	10/1/2001	GAMMA BHC (LINDA	3.1E-04		1	1

MAROS Mann-Kendall Statistics Summary

Project: Sudbury Landfill **User Name:**

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
SUD-A07-065	T	4/1/2002	GAMMA BHC (LINDA	2.5E-04		1	1
SUD-A07-065	T	10/1/2002	GAMMA BHC (LINDA	2.4E-04		1	1
SUD-A07-065	T	4/1/2003	GAMMA BHC (LINDA	1.2E-04		1	1
SUD-A07-065	T	10/1/2003	GAMMA BHC (LINDA	4.1E-05		1	1
SUD-A07-065	T	4/1/2004	GAMMA BHC (LINDA	2.0E-05	ND	1	0
SUD-A07-065	T	10/1/2004	GAMMA BHC (LINDA	1.0E-04		1	1
SUD-A07-065	T	5/1/2005	GAMMA BHC (LINDA	5.9E-05		1	1
SUD-A07-065	T	9/1/2005	GAMMA BHC (LINDA	1.7E-04		1	1
SUD-A07-065	T	11/1/2006	GAMMA BHC (LINDA	1.8E-04		1	1
SUD-A07-065	T	10/1/2007	GAMMA BHC (LINDA	3.4E-04		1	1
SUD-A07-065	T	10/1/2008	GAMMA BHC (LINDA	2.2E-04		1	1
SUD-A07-065	T	11/1/2009	GAMMA BHC (LINDA	9.7E-05		1	1
SUD-A07-065	T	6/1/2011	GAMMA BHC (LINDA	7.7E-05		1	1
SUD-A07-065	T	10/1/2011	GAMMA BHC (LINDA	7.9E-05		1	1
SUD-A07-065	T	10/1/2012	GAMMA BHC (LINDA	2.4E-04		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Linear Regression Statistics

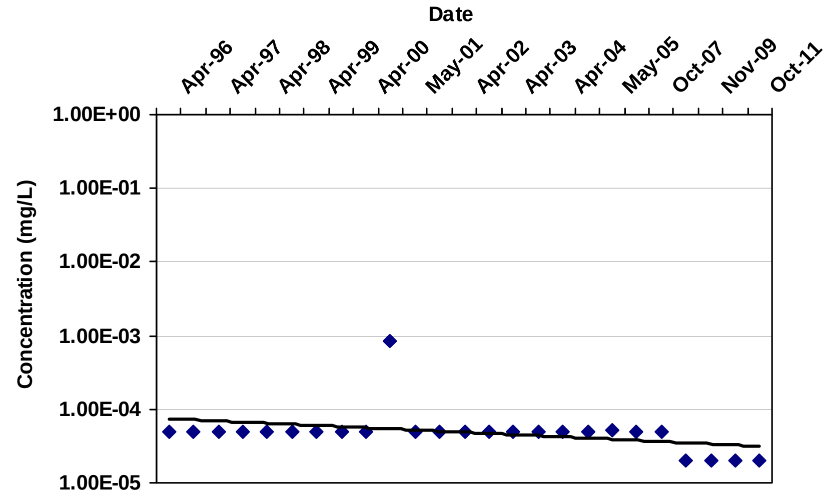
Project: Sudbury Landfill

User Name:

Location: Devens

State: Massachusetts

Well:	JO-A07-M62	**Time Period:**	4/1/1996 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	GAMMA BHC (LINDANE)	**Consolidation Type:**	Median
		Duplicate Consolidation:	Maximum
		ND Values:	Detection Limit
		J Flag Values :	Actual Value



COV:

2.07

Confidence in Trend:

98.7%

Ln Slope:

-1.8E-04

LR Concentration Trend:

D

Consolidation Data Table:

Well	Well Type	Consolidation Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
JO-A07-M62	S	4/1/1996	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/1996	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	4/1/1997	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/1997	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	4/1/1998	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/1998	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	4/1/1999	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/1999	GAMMA BHC	5.0E-05	ND	1	0

MAROS Linear Regression Statistics

Project: Sudbury Landfill **User Name:**

Location: Devens **State:** Massachusetts

Consolidation Data Table:

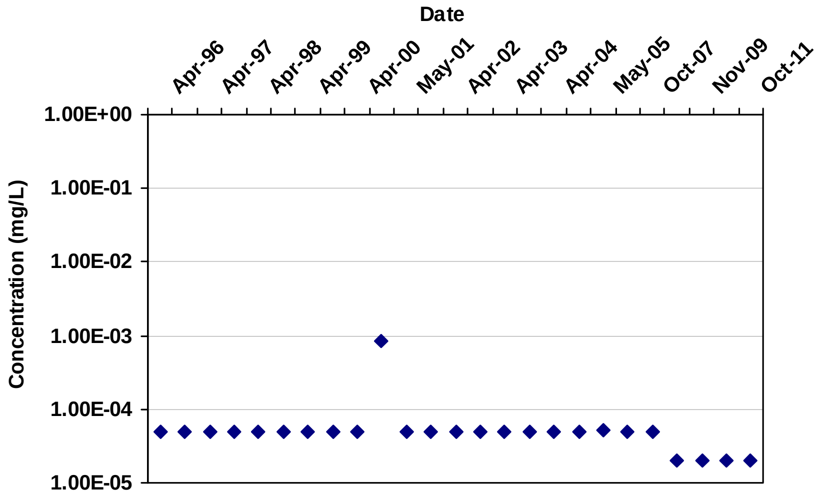
Well	Well Type	Consolidation Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
JO-A07-M62	S	4/1/2000	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/2000	GAMMA BHC	8.4E-04		1	1
JO-A07-M62	S	5/1/2001	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/2001	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	4/1/2002	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/2002	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	4/1/2003	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/2003	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	4/1/2004	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/2004	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	5/1/2005	GAMMA BHC	5.3E-05	ND	1	0
JO-A07-M62	S	11/1/2006	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/2007	GAMMA BHC	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/2008	GAMMA BHC	2.0E-05	ND	1	0
JO-A07-M62	S	11/1/2009	GAMMA BHC	2.0E-05	ND	1	0
JO-A07-M62	S	6/1/2011	GAMMA BHC	2.0E-05	ND	1	0
JO-A07-M62	S	10/1/2011	GAMMA BHC	2.0E-05	ND	1	0

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = All Samples are Non-detect

MAROS Mann-Kendall Statistics Summary

Project: Sudbury Landfill
User Name:
Location: Devens
State: Massachusetts

Well:	JO-A07-M62	**Time Period:**	4/1/1996 **to** 10/1/2012
Well Type:	S	**Consolidation Period:**	No Time Consolidation
COC:	GAMMA BHC (LINDANE)	**Duplicate Consolidation:**	Median
		Consolidation Type:	Maximum
		ND Values:	Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-71

Confidence in Trend:

94.9%

Coefficient of Variation:

2.07

Mann Kendall Concentration Trend: (See Note)

PD

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
JO-A07-M62	S	4/1/1996	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/1996	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	4/1/1997	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/1997	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	4/1/1998	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/1998	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	4/1/1999	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/1999	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	4/1/2000	GAMMA BHC (LINDA	5.0E-05	ND	1	0

MAROS Mann-Kendall Statistics Summary

Project: Sudbury Landfill **User Name:**

Location: Devens **State:** Massachusetts

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
JO-A07-M62	S	10/1/2000	GAMMA BHC (LINDA	8.4E-04		1	1
JO-A07-M62	S	5/1/2001	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/2001	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	4/1/2002	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/2002	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	4/1/2003	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/2003	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	4/1/2004	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/2004	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	5/1/2005	GAMMA BHC (LINDA	5.3E-05	ND	1	0
JO-A07-M62	S	11/1/2006	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/2007	GAMMA BHC (LINDA	5.0E-05	ND	1	0
JO-A07-M62	S	10/1/2008	GAMMA BHC (LINDA	2.0E-05	ND	1	0
JO-A07-M62	S	11/1/2009	GAMMA BHC (LINDA	2.0E-05	ND	1	0
JO-A07-M62	S	6/1/2011	GAMMA BHC (LINDA	2.0E-05	ND	1	0
JO-A07-M62	S	10/1/2011	GAMMA BHC (LINDA	2.0E-05	ND	1	0

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Linear Regression Statistics Summary

Project: Sudbury Landfill

User Name:

Location: Devens

State: Massachusetts

Time Period:	4/1/1996	**to** 10/1/2012
Consolidation Period:	No Time Consolidation	
Consolidation Type:	Median	
Duplicate Consolidation:	Maximum	
ND Values:	Detection Limit	
J Flag Values :	Actual Value	

Well	Source/Tail	Average Conc (mg/L)	Median Conc (mg/L)	Standard Deviation	All Samples "ND" ?	Ln Slope	Coefficient of Variation	Confidence in Trend	Concentration Trend
GAMMA BHC (LINDANE)									
SUD-A07-065	T	1.8E-04	1.8E-04	1.2E-04	No	-2.0E-05	0.67	56.3%	S
JO-A07-M62	S	7.7E-05	5.0E-05	1.6E-04	No	-1.8E-04	2.07	98.7%	D

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Non-detect (ND); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); COV = Coefficient of Variation

MAROS Mann-Kendall Statistics Summary

Project: Sudbury Landfill

User Name:

Location: Devens

State: Massachusetts

Time Period: 4/1/1996 **to** 10/1/2012

Consolidation Period: No Time Consolidation

Consolidation Type: Median

Duplicate Consolidation: Maximum

ND Values: Detection Limit

J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
GAMMA BHC (LINDANE)								
SUD-A07-065	T	24	21	0.67	-45	86.1%	No	S
JO-A07-M62	S	25	1	2.07	-71	94.9%	No	PD

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Statistical Trend Analysis Summary

Project: Sudbury Landfill **User Name:**

Location: Devens **State:** Massachusetts

Time Period: 4/1/1996 **to** 10/1/2012
Consolidation Period: No Time Consolidation
Consolidation Type: Median
Duplicate Consolidation: Maximum
ND Values: Detection Limit
J Flag Values : Actual Value

Well	Source / Tail	Number of Samples	Number of Detects	Average Conc. (mg/L)	Median Conc. (mg/L)	All Samples "ND" ?	Mann-Kendall Trend	Linear Regression Trend
GAMMA BHC (LINDANE)								
SUD-A07-065	T	24	21	1.8E-04	1.8E-04	No	S	S
JO-A07-M62	S	25	1	7.7E-05	5.0E-05	No	PD	D

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); No Detectable Concentration (ND)

The Number of Samples and Number of Detects shown above are post-consolidation values.

APPENDIX B

ATTAINMENT

Appendix B

General Approach for Assessing Attainment Based on USEPA Guidance *Methods for Evaluating the Attainment of Cleanup Standards, Vol. 2: Ground Water* (EPA 230/R/92/014, July 1992)

The U.S. Environmental Protection Agency (USEPA) guidance assumes that a sampling and analysis plan is determined *a priori* to treatment as either a fixed plan (a set sampling frequency and sample period after which the data are evaluated) or as a sequential plan (determine a frequency, conduct attainment sampling for a number of years, begin evaluation and continue the plan until cleanup is established). The sequence of events, in the best case, is as follows:

1. Sampling is conducted prior to implementing the remedy at the predetermined frequency to establish pre-treatment conditions of the groundwater system.
2. Sampling continues during and after the implementation of the selected remedy.
3. Sampling continues post-treatment until *steady state conditions* for the groundwater system and analytical measurements can be established, whether they resemble pre-treatment groundwater system conditions or a some new augmented state as a result of the treatment applied (e.g., a permanent slurry wall).
4. Attainment sampling is conducted for some fixed or minimum timeframe depending to the selected plan.
5. Analytical data is evaluated and a statistic (a long term mean, a confidence interval on the mean, a select percentile of observed concentrations or some combination of these) is compared to the cleanup goal directly or indirectly.
6. A decision is made based on the outcome of the comparison: declare that cleanup has been attained, more data is required, or more treatment is required.

The minimum recommended sampling frequency is quarterly and in all cases, except for the percentile comparison approach, the statistical analyses for assessing cleanup attainment examines yearly averages of analytical results at individual wells or in groups of wells. The suggested sampling frequencies in the guidance, quarterly or more frequent, have the potential of capturing seasonal fluctuations which may or may not need to be addressed prior to calculating annual averages or percentiles of concentration and other statistical measures of variability, uncertainty and autocorrelation. And the use of specific equations for determining statistical parameters is still further dependent on other factors such as the distributional characteristics of the raw, transformed or adjusted analytical data, or whether there are missing values in the time sequence. The final criteria for determining whether cleanup has been attained is the comparison of a single, representative mean (raw or transformed), upper confidence limit on the mean, or a select percentage of concentration measures are below a cleanup goal, or the likelihood that the statistic is below a cleanup goal.

Establishing that a site has satisfied the steady state criteria is the crux of the analysis as it provides the basis for addressing the uncertainty of forecasting the current decision into the future. The guidance states that "[c]onclusions drawn from tests assessing the attainment of cleanup standards assume that the current state of the ground water will persist into the future. There must be confidence that once a site is judged clean, it will remain clean. Achieving a steady state gives credence to future projections derived from current data."

Proposed Approach for Assessing Cleanup at Former Fort Devens

The current sampling and analysis plans at Devens' Areas of Contamination (AOC) have evolved with the emphasis on optimization of long term costs while investigating and evaluating site closure. Using the definitions from the USEPA guidance, the current sampling plans can be best characterized as sequential – these plans will continue until site closure can be established. Sampling frequency currently varies across AOCs from semi-annual to annual or longer. Although there significant differences between the "best case" scenario presented in the Guidance and the reality of the Devens Long-Term Monitoring Plan (LTMP), the methodology presented in the Guidance is still applicable to hydrologic and analytical data collected over a 9 to 13 year period. It is possible that longer sampling frequencies used at Devens may not estimate annual averages used in the statistical analyses as well as quarterly or higher frequency sampling programs. The same holds for capturing potential seasonal variations. However, longer sampling frequencies increase the likelihood that the samples are independent (a common assumption for many statistical tests) and decrease the likelihood that the sequence of measurements are correlated in time which can mask true long term behavior and potentially lead to incorrect conclusions based on statistical outcomes.

Four AOCs at Devens have undergone source removals and, in some cases, additional treatments to remove or destroy groundwater contaminants. Removal actions and treatment were conducted between 4 and 34 years ago. The lapse of time after the application of various remedies increases the likelihood that steady state conditions have been achieved at each of the AOCs.

Active sampling locations at Devens remaining after optimization are predominantly sentry wells and located in hot spots. Individual locations that have attained the cleanup standard have been optimized: the sampling frequency at those locations have been reduced or discontinued. A sampling and analysis plan based on the sole objective of evaluating cleanup attainment may require more frequent sampling and more locations to statistically establish cleanup attainment for an area of concern using multiple wells. After an initial evaluation, one possible outcome may be to sample more frequently and to re-introduce sampling at previously "optimized" locations. Estimating a new frequency requires adjusting the collected data for seasonal fluctuations (if any) and the degree of serial correlations in the data.

On that basis, a progressive approach for evaluating attainment of cleanup goals is proposed that statistically evaluates the current sampling plan at the various AOCs. If cleanup at an AOC is statistically established, then site closure can be considered. However, if attainment is not statistically established at a point in time, the following options can be considered:

1. Continue the current sampling plan and re-evaluate after each sampling event.
2. Incorporate data from monitoring wells where sampling has been recently discontinued provided that these locations are:

   a. Physically close to active sampling locations at the AOC;
   b. The screened intervals of the discontinued wells are in similar geologic conditions as the active monitoring wells; and
   c. Discontinued sampling locations can be sampled again in the future.

3. Initiate sampling at previously discontinued monitoring locations (provided they meet the above criteria) for at least 2 years for future evaluation.

The following sequence of steps outlines the proposed approach. The subsections are labeled to correspond to specific steps in the decision tree presented in Figure 1.

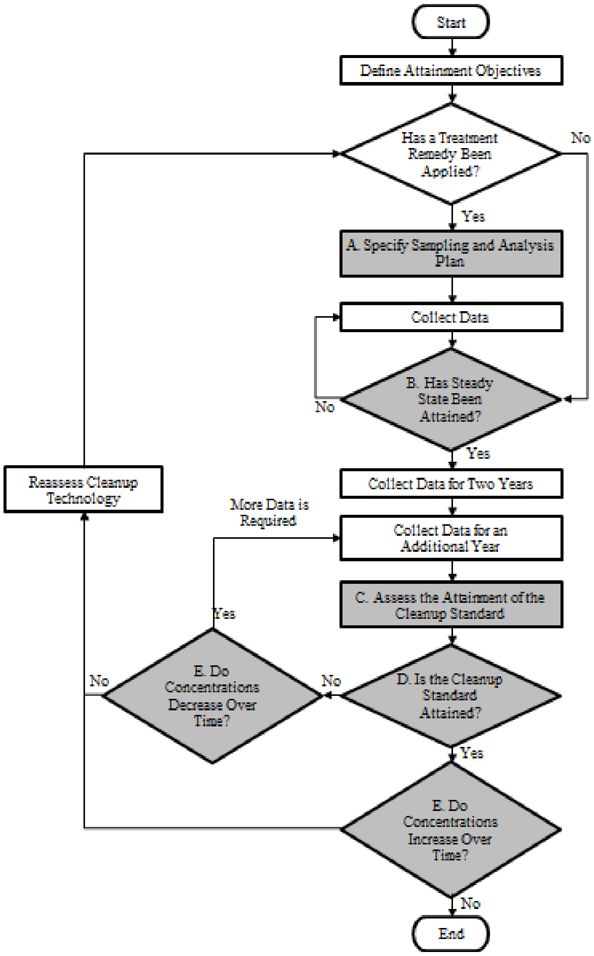


Figure 1. Steps in Cleanup Process for Sequential Statistical Testing

A. Specify Sampling and Analysis Plan

The USEPA guidance assumes that the sampling and analysis plan are determined *a priori* as either a fixed sampling plan (a set sampling frequency and sample period after which the data are evaluated) or as a sequential plan (determine frequency and sample for minimum of three years and then begin evaluation). The current sampling and analysis plan has evolved over time with the emphasis on optimization of long term costs while investigating and evaluating site closure. At Devens, analytical data has been collected for as long as thirteen years, which meets the sufficiency requirements. Based on definitions from the USEPA guidance, the current sampling plan can be characterized as sequential. As mentioned above, iterative application of this proposed procedure may involve re-evaluating the current sampling and analysis plan to include the resampling monitoring wells that have been “optimized”. For now, this step is assumed to be concluded.

B. Establishing Steady State

Assuming that a sufficient amount of time has passed since the application of remedies at AOCs or if no remedy has been applied, analytical and field data can be evaluated to establish that the ground water system has attained steady state conditions. A groundwater system must satisfy the following two criteria to establish whether system has achieved steady state conditions:

1. Post-remedy water levels, flow velocity and direction (and variability) are essentially the same as pre-remedy –OR- permanent post-remedy changes to flow system are verified – OR – in the absence of pre-remedy data, the post-remedy flow system can be shown as stable – AND – that the current state is a good approximation of the future state.
2. Contaminant levels have statistical characteristics which will be similar to those of future periods – OR – stable or downward trends can be established.

Both criteria can be evaluated at each individual well using the following methods:

1. Change of level rule of thumb – given prior average (say average head at a well, velocity, direction), if 7 to 10 consecutive data points are above or below the prior average, a change in the state has occurred as a result of treatment.
2. Visual inspection of trends in charted data or contour plots of head.
3. 5 to 7 consecutive data points increasing or decreasing to indicate trend (after adjusting for seasonal affects).
4. Statistical tests for trends accounting for season variation if necessary (regression, Mann-Kendall Test).

Once steady state conditions are established at an AOC, attainment can be evaluated. If steady state conditions are not established based on analytical data, then either additional sampling may be required to establish stable or downward trends, or additional treatment may be necessary if concentration trends are increasing.

C. Assess the Attainment of the Cleanup Standard

The guidance allows the application of statistical tests to individual wells or to groups of wells. Evaluating groups of wells is allowed provided that the wells are “close”, their screened intervals are located in the same geologic formation, and the wells are sampled at the same time.

The options for statistically assessing attainment with a sequential sampling plan for individual wells are based on one or both of:

a) Comparisons of the mean concentration based on yearly averages to the cleanup standard

b) Comparisons of a select percentile (e.g., 90th percentile) of all samples to the cleanup standard.

The options for statistically assessing attainment with a sequential sampling plan for a group of wells are based on one or both of:

a) Comparisons of the mean concentration, based on yearly averages across monitoring wells in the group, to the cleanup standard;

b) Comparisons of a select percentile (e.g., 90th percentile) of all samples to the cleanup standard.

Options are available to eliminate seasonal fluctuations (if observed) by averaging over a year if sampling frequency is greater than annual (preferred method), or by correcting for the seasonal patterns. The presence of seasonal fluctuations will be examined where semi-annual sampling is conducted.

The following paragraphs for AOCs 57, 69W, 43G, and 32/43A provide a path forward for cleanup attainment as per USEPA 1992 (EPA 230-F-92-014). In the event that attainment is not established, the sampling and analysis plan will be re-evaluated to determine if modifications might enhance future attainment evaluations.

AOC 57: Area 3 Arsenic

AOC 57, Area 3, is a suitable candidate for an evaluation of attainment of arsenic cleanup goals using the long-term, average concentration given arsenic's stable or decreasing long-term concentration trends near or below the cleanup goal. If grouping is applicable, then a multi-well average will be calculated. The decision of attainment would consist of evaluating the likelihood ratio based on the arsenic cleanup goal (10 ug/L) and the false positive and negative error rates (α and β), as per Chapter 9.3 of USEPA 1992.

AOC 69W: C_{11}–C_{22} and C_9-C_{10} Aromatics and Manganese (69WP-08-01)

AOC 69W is a suitable candidate for evaluation of attainment of C_{11}–C_{22} and C_9-C_{10} aromatics cleanup goals using the long-term average concentration given the aromatics' stable or decreasing long-term concentration trends near or below the cleanup goal. If grouping is applicable, then a multi-well average will be calculated. The decision of attainment would consist of evaluating the likelihood ratio based on the arsenic cleanup goal (200 μg/L) and the false positive and negative error rates (α and β), as per Chapter 9.3 of USEPA 1992.

Although some stability is observed in long-term arsenic trends, the magnitudes of observed concentrations are not approaching the cleanup standard. If additional remedial actions are taken, evaluation of cleanup attainment for arsenic would have to be postponed until the system reaches a new steady state.

Based on manganese in groundwater exceedances at well point 69WP-08-01, it is recommended that 2 years of quarterly or 3 years of semiannual sampling be conducted at this location to establish a sufficient number of data points to evaluate trends and potential seasonality of manganese concentrations. The trend will be evaluated using linear regression and Mann-Kendall tests with 95% level of confidence in the estimated trend direction. If seasonal variations are identified, the trends will be evaluated using linear regression and Mann-Kendall on seasonally adjusted data, and using the seasonal-Kendall test with the unadjusted data.

AOC 43G: Evaluation for cleanup attainment not yet practical as long-term trends are not yet near or below the cleanup standards for COCs at this site.

AOC 32/43A: TCE, 1,4-Dichlorobenzene, Aliphatics

AOCs 32 and 43A are suitable candidates for assessing attainment of TCE, 1,4 DCB, and aliphatics cleanup goals using sequentially determined, short-term average concentrations at individual wells or grouped wells, if applicable, given stable or decreasing long-term concentration trends near or below the cleanup goal after the persulfate injection event for these COCs. The evaluation would include testing the assumption that the groundwater system has reached steady state after the persulfate injection event. If it can be shown that the system has reached steady state, the evaluation would consist of comparing mean concentrations to cleanup goals using the sequential approach detailed in Chapter 9.3 of USEPA, 1992, after collecting three consecutive years of sampling data. If the test comparison indicates that cleanup has been attained of a COC, then that COC is a candidate for removal from the sampling plan.

D. Is the Cleanup Standard Attained?

In each of the above scenarios, the likelihood ratio is calculated as per the guidance. The equations for evaluating the likelihood ratio are not repeated here. However, once the ratio, LR, is determined, the following comparison is made. Calculate:

$$A = \frac{\beta}{(1-\alpha)}, B = \frac{(1-\beta)}{\alpha}$$

If LR ≤ A, conclude that the groundwater in wells does not attain the cleanup standard.
If LR $>$B, conclude that the average groundwater concentration in the well or group of wells is less than the cleanup standard.
If A$<$LR ≤B, collect an additional year of data before performing the test again.

E. Do Concentrations Increase/Decrease Over Time?

As a final check, evaluate the sequence of yearly averages using a regression model (e.g., linear regression), a significance test is conducted to determine the reliability of the predicted slope, especially positive slopes. A positive slope would indicate an increasing trend in the average concentrations which indicates that the current state is not a good indicator of the future state. In this case, additional or alternative treatment should be considered. Stable or negative slopes would confirm that current conditions are good indicators of future conditions.

APPENDIX C

SURFACE WATER AND SUMP SAMPLING PROCEDURES

Appendix C
Environmental Sampling Instructions

C.1 Sampling Strategies

C.1.1 Scope and application. This instruction discusses strategies that can be employed to sample various media, including but not limited to soils, sediments, or water. Several different types of sampling strategies exist that can be categorized as either statistical or nonstatistical methods. Applications and limitations of each sampling strategy will be briefly described.

C.1.2 Sampling strategies. One of the main goals of any investigation is to collect samples that are representative of the site conditions so that an accurate assessment of contamination can be made with a minimum number of samples. Based on the conceptual site model (CSM) , crucial pathways and media requiring assessment are identified, and are later used to evaluate whether the data make sense for what is known about the site. The various sampling strategies available can be grouped into two basic categories: statistical and nonstatistical methods. To ensure that samples are as representative as possible, statistics are often used to design an appropriate sampling strategy and to provide a sound basis for supporting project decisions. Depending on data needed to support project decisions, input from an environmental statistician may be obtained. In addition, software programs (e.g., DQO Pro, DEFT, DataQuest, Visual Sampling Plan) are available to aid in the evaluation of various sampling scenarios and the uncertainty associated with them. Classical statistical methods are most applicable to sampling media that are considered fairly homogeneous (e.g., ground water, surface water). However, because of the spatial variability of soils, application of sampling strategies using classical statistical techniques may be limiting. The use of geostatistical methods is recommended for sediments and soils to account for the variability of the media. A related factor to consider is the distribution of the contaminant within the environmental medium, and how this may impact the use of the data or what is considered representative. Information on how the contaminant was dispersed at the time of waste generation, spill, or discharge may help in assessing whether the contamination is present on a molecular scale (e.g., solvent or solution spills) or on a macroscale (e.g., lead shot, ammunition debris, and TNT chunks). The latter situation increases the likelihood that samples may exhibit a high short-range heterogeneity, and the challenge of obtaining representative samples becomes even more difficult. The use of compositing and homogenizing techniques can improve representativeness of the samples (i.e., when amenable to the eventual physical/chemical analyses) by invoking the physical process of averaging. Refer to Instructions E-2 and E-3 of Appendix E for additional information on homogenizing and compositing techniques and to E-4 for information on the collection, handling, and storage of solid volatile organic analysis (VOA) samples. Statistics can also be used to determine the number of samples required to reach a prescribed level of uncertainty. However, when statistical calculations result in an unacceptably high number of samples being defined, the use of field analytical technologies or field screening techniques should be pursued to reduce the cost of sample analyses while maintaining a desired level of site coverage. Refer to Appendix H for additional information on this subject. Typically, more than one sampling strategy or approach is necessary when several media or types of contamination are under investigation, and most sampling plans employ a combination of sampling strategies. The following text and Table C-1 summarize basic descriptions, applications, and limitations for some frequently used sampling strategies. Additional references are also included to provide more detailed discussions on the subjects.

C.1.2.1 Classical statistical sampling. A discussion of statistical sampling is presented in the following sections. For a detailed discussion of classical statistical methods see U.S. Environmental Protection Agency (USEPA) EPA/530/SW-89/026, EPA/SW-846 (Volume II)), Gilbert (1987), and Pitard (1993).

Table C-1
Comparison of Sampling Strategies

Sampling Strategy	Description	Application	Limitations
		Classical Statistical Sampling Strategies	
Simple random sampling	Representative sampling locations are chosen using the theory of random chance probabilities.	Sites where background information is not available and no visible signs of contamination are present.	May not be cost-effective for samples located too close together. Does not take into account spatial variability of media.
Stratified random sampling	Site is divided into several sampling areas (strata) based on background or site survey information; each stratum is evaluated using a separate random sampling strategy.	Large sites characterized by a number of soil types, topographic features, past/present uses, or manufacturing/storage areas.	Often more cost-effective than random sampling. More difficult to implement in the field and analyze results. Does not take into account spatial variability of media.
Systematic grid sampling	Most common statistical strategy; involves collecting samples at predetermined, regular intervals within a grid pattern.	Best strategy for minimizing bias and providing complete site coverage. Can be used effectively at sites where no background information exists. Ensures that samples will not be taken too close together.	Does not take into account spatial variability of media.
Hot-spot sampling	Systematic grid sampling strategy tailored to search for hot spots.	Sites where background information or site survey data indicate that hot spots may exist.	Does not take into account spatial variability of media. Trade-offs between number of samples, chance of missing a hot-spot, and hot-spot size/shape must be weighed carefully.
Geostatistical approach	Representative sampling locations are chosen based on spatial variability of media. Resulting data are analyzed using kriging, which creates contour maps of the contaminant concentrations and the precision of concentration estimates.	More appropriate than other statistical sampling strategies because it takes into account spatial variability of media. Especially applicable to sites where presence of contamination is unknown.	Previous investigation data must be available and such data must be shown to have a spatial relationship.
		Nonstatistical Sampling Strategies	
Biased sampling	Sampling locations are chosen based on available information.	Sites with specific known contamination sources.	Contaminated areas can be overlooked if they are not indicated by background information or visual signs of contamination. Best if used with statistical approach, depending on the project objectives.
Judgmental sampling	An individual subjectively selects sampling locations that appear to be representative of average conditions.	Homogeneous, well-defined sites.	Not usually recommended due to bias imposed by individual, especially for final investigations.

C.1.2.1.1 Simple random sampling. Simple random sampling is the most basic statistical approach and is usually applied when minimal site background information (e.g., past practices, uses of hazardous materials, etc.) is available and visible signs of contamination are not evident during the initial site survey. This strategy uses the theory of random chance probabilities to choose representative sampling locations. Each sample location is chosen independently of any previously chosen sample location. It is most effective when the number of available sampling points is large enough to lend statistical validity to the random selection process. The simple random sampling approach may be more costly than other statistical methods since a larger number of samples may be required to characterize the site.

C.1.2.1.2 Stratified random sampling. Investigations of large sites that encompass a number of soil types, topographic features, or land uses may benefit by using a modified random sampling approach, called stratified random sampling. In this strategy, the site is divided into different sampling areas (strata) that are internally homogeneous based on existing data and background information. The division of the site into strata is based on the assumption that each stratum is more internally homogeneous than the site as a whole. Each stratum is sampled at locations based on a simple random sampling approach. By grouping similar sampling points and treating each group separately, each with its own individual random sampling scheme, the precision of the study is increased. In addition, this approach controls the variability due to contaminant concentration, location, terrain type. etc., and it often results in more efficient allocation of resources than would be possible with a simple random sampling method. Sampling analyses from each stratum may be used to determine the mean or total contaminant concentration within the stratum. However, data from each stratum may be used to make comparisons between the different strata or combined to provide information about the entire site.

C.1.2.1.3 Systematic grid. Systematic grid sampling, sometimes referred to as systematic random sampling, is the most common statistical sampling strategy. It involves collecting samples at predetermined. regular intervals (i.e., within a grid pattern). The location of the first sampling point is selected at random and all subsequent sample locations are determined using a systematic pattern from that point. This approach is typically used when a large site (e.g., measured in acres) must be sampled to characterize the presence and distribution of contaminants. The grid-based option is probably the best classical statistical sampling strategy for minimizing bias and providing complete site coverage. The most basic grid system is a straight line between two points on which regularly spaced sampling locations are designated. This one- dimensional sampling grid may be used for sampling along a straight drainage ditch or other man-made feature. However, most soil sampling schemes require a two-dimensional grid system for locating sampling points. The following types of grids are generally used: square, triangular, or other systematic pattern. Sampling is usually performed at each grid-line intersection. However, sampling in the center of each grid square/triangle or obtaining a composite of samples within a grid square/triangle is also acceptable.

C.1.2.1.4 Hot-spot sampling. "Hot spots" are usually defined as small, localized areas of a media that are characterized by high contaminant concentrations. In order to detect hot spots, a special systematic grid sampling approach is necessary. However, because all of the media cannot be sampled, there is still a possibility that hot spots exist even if none are discovered during the sampling process. Statistical approaches for detection of hot spots are discussed in Gilbert (1987). A hot-spot sampling plan should consider the following factors:

- Grid spacing and geometry. A triangular grid pattern increases the efficiency of the hot-spot search. In addition, the probability of finding hot-spots increases as the spacing between grid points decreases.

- Hot-spot shape/size. The larger a hot spot is, the more likely it is to be discovered. The shape of the hot spot also affects the probability of its being detected. Narrow or small-circular patterns may escape detection because they are located between grid sampling locations. Large-circular and wide-elliptical hot spots are the easiest to find.

- False negative rate. This measures the probability that a hot spot will be missed even if one is present.

C.1.2.1.5 Geostatistical approach. Classical statistical methods for the design of sampling projects are well-known and have been the standard approach in the past. However, these strategies have one major drawback—they do not take the natural variability of the media into account. As such, they may not adequately characterize contamination at sites, especially those sites that are fairly heterogeneous and/or where the presence of contamination is unknown. Consequently, classical statistical methods are most appropriately applied to sites where the source of contamination is known (e.g., a landfill, waste pile, etc.) or small sites where the entire area is to be remediated as a unit (e.g., in the case of soils, the entire site will be solidified). To more accurately characterize sites where the presence of contamination is unknown, statisticians now believe that geostatistical methods are more appropriate than classical statistical methods because they take into account the spatial variability of the media when estimating contaminant concentrations. Geostatistical methods may be used for sampling naturally occurring materials such as soils or ground water and man-made units such as landfills or waste piles. Characterization of any media is difficult because contaminant levels are spatially correlated. This means that contaminant concentrations from samples taken close together are more likely to be similar than contaminant concentrations from samples taken farther apart (regional variability). Geostatistics describes how to sample and analyze regional variability by defining the representativeness of a sample in terms of its range of correlation or zone of influence. For example, a sample location selected through geostatistics will represent a circular area with a radius less than or equal to the zone of influence. In other words, the sample would be representative of the media within the circular area. A two- stage sampling approach is typically used in geostatistical sampling strategies. Initially, a sampling survey is performed to collect basic data. These data are used to create a graph that defines the distance over which samples are representative. This graph is then used to dictate the shape, size, and orientation of another systematic grid that is used in the second, final sampling event. Geostatistical sampling strategies are relatively complex, and further discussions of this approach are found in Engineer Technical Letter (ETL) 1110-1-175, Borgman and Quimby (1988), and Gilbert (1987).

C.1.2.2 Nonstatistical sampling. Types of nonstatistical sampling are described as follows.

C.1.2.2.1 Biased sampling. Biased sampling is used to evaluate sites with specific, known sources of contamination (e.g., the site survey discovered visible signs of contamination or records indicate that certain locations are suspect based on past/present practices). As such, sampling locations are chosen based solely on available information.

C.1.2.2.2 Judgmental sampling. In judgmental sampling schemes, an individual subjectively selects the sampling locations that appear to be representative of average conditions. If the individual is knowledgeable, judgmental sampling can result in accurate estimates of site conditions. Although a certain amount of judgment is necessary in any sampling approach, total reliance on judgment decisions is not recommended because an individual's bias often leads to poor quality data and improper conclusions. However, if judgmental sampling is necessary, multiple samples should be collected to add some measure of precision.

C.1.3 Potential problem. Table C-1 shows the limitations associated with these sampling strategies.

C.2 Ground Water Sampling

C.2.1 Scope and application. This instruction presents guidelines for collecting representative ground water samples from temporary and permanent ground water monitoring wells and, where applicable, from other direct push well screen samplers. Guidance for the installation of temporary wellpoints by direct push methods for sampling ground water at discrete points may be found in American Society for Testing and Materials (ASTM) D 6001. Typical ground water monitoring wells are 5 or 10 cm (2 or 4 in.) in diameter and are constructed of polyvinyl chloride (PVC) or stainless steel. Instructions presented herein are intended to include sample collection from wells that have not been completed as production or extraction wells. The instructions can be used to identify an appropriate sampling protocol for the acquisition of a representative sample. Instruction C-4, "Potable Water Sampling," includes procedures for sampling permanent production wells or any other well constructed with a discharge tap. Instructions for purging and sampling wells by the following techniques are included in this section: bailer, portable submersible pump, bladder pump, hand pump, centrifugal pump, peristaltic pump, air lift pump, and low-flow sampling.

C.2.2 Sampling strategies. Sampling strategies are developed by the project team to satisfy project-specific data needs identified in the hazardous, toxic, and radioactive waste (HTRW) technical planning process. The sampling strategy developed for a particular site will influence several project decisions, including, but not limited to, sampling locations, types of samples, sampling frequency, and sampling and analytical protocols. Sampling strategies may be significantly influenced by such factors as physical site constraints, safety, and cost, to name a few. The technical planning process that results in the development of the sampling strategy is critical because of the difficulty in acquiring representative samples, the reduction of contaminant action levels, and the problems associated with trace level cross-contamination. Successful investigations of hazardous waste sites are highly dependent on an effective sampling scheme. Development of a sampling scheme for purposes of characterizing a hazardous waste site should follow the fundamentals of the scientific approach. A successful sampling scheme requires a logical design to allow an evaluation of potential contaminants in relation to background conditions, vertical extent, horizontal extent, and mobility in various media. Additional guidance may be found in ASTM D 5903.

C.2.2.1 Sampling locations. Sampling at hazardous waste sites is usually conducted in an attempt to identify contamination and to define its extent and variability. With such an objective, it is most logical to choose sample locations that will yield the most information about site conditions. During evaluation of a site, sampling can be conducted by random, systematic, or biased sampling. Instruction C-1 discusses random, systematic, and biased sampling in detail. Often biased and random sampling techniques can be used together to thoroughly address an entire site. Some wells may be biased to potentially contaminated areas (e.g., former wastewater lagoons, former process or disposal areas), or potentially impacted areas (e.g., downgradient locations). In areas less likely to be contaminated or areas with little available background information, random samples may be used to allow adequate assessment of the entire site. Ground water monitoring wells are positioned at locations and depths to satisfy ground water monitoring objectives. Ground water samples collected from monitoring wells are evaluated as discrete samples collected from the same location. Ground water samples collected from the same well are distinguished from one another because they are distributed through time. Unless each ground water monitoring well has a sampler dedicated to the well, the order of sampling monitoring should be from the least contaminated to the most contaminated.

C.2.2.2 Sample type. Ground water samples are typically discrete samples. A discrete (grab) sample is a discrete aliquot representative of a specific location at a given point in time. The sample is collected at once and at a particular point in the sample matrix. The representativeness of such samples is defined by the nature of the materials being sampled. In general, since contamination in ground water disperses over time and distance, it will take more grab samples to characterize the extent of contamination as the time from a release increases.

C.2.2.3 Suggested samplers. Each sampling technique presents various disadvantages and advantages for its application. For example, sample disturbance, sample volume, chemical/physical reactivity between potential contaminants and sampling tool materials, well diameter, depth to ground water, limitations of lift capacity of the sampling device, specified analytical parameters, and ease of decontamination vary from technique to technique. The advantages and disadvantages of each sampling technique are presented in the discussion of the technique.

C.2.2.4 Sample frequency. Contaminant concentrations in ground water vary across both time and space. Therefore, it is important to consider the potential temporal variability of the data collected. Determination of the number of samples needed to characterize a site is dependent upon the objectives and the site-specific conditions. For example, if the objective of the event is to determine whether the site is contaminated, a limited number of samples from properly chosen locations will yield useful information. If, however, the site is contaminated and the objective is to establish the boundaries of the ground water contamination or trends in the data over time, a greater number of samples may be needed. Often statistical considerations can be helpful in determining sampling strategy.

C.2.3 Sample preservation and handling. Many chemical constituents and physicochemical parameters that are to be measured or evaluated in ground water monitoring programs are not chemically stable, and therefore sample preservation is required. Appropriate preservation techniques for various parameters and sample containers that should be used for each constituent or common set of parameters are specified in Appendix B. These preservation methods and sample containers are based on "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods" (EPA/SW-846). Procedures and techniques for transporting the samples to the offsite laboratory are discussed in Instruction F-2 of Appendix F, "Packaging and Shipping Procedures." Improper sample handling may alter the analytical results of the sample, causing the results to be invalid. Samples should be transferred in the field from the sampling equipment directly into the container required for that analysis or set of compatible parameters. The sample should then be preserved in the field as specified in Appendix B. Because of the low analytical detection limits required for certain data uses, care must be taken when collecting the sample to avoid the loss/gain of any contaminants. The samples for volatile analysis should be carefully transferred directly from the sample collection device to the sample container to minimize contaminant loss through agitation/volatilization or adherence to another container. Samples should be collected in the order of the parameters listed in Section C.2.3.1. If more than one container is required per parameter, the sample should be split equally among all containers until filled. Containers used to collect samples for organic analyses should not be prerinsed with water because of the possibility of preservation loss or the loss/gain of contaminants that may taint the analytical results. Decisions to filter samples are dictated by sampling objectives. Consideration should be given to what the application of field filtration is trying to accomplish. For assessment of dissolved concentrations of major ions and trace metals, 0.1-• m filters are recommended, although 0.45-• m filters are normally used for most regulatory programs. In-line filtration is recommended because it provides better consistency through less sample handling and minimizes sample exposure to the atmosphere. Filters must be prerinsed following manufacturers' recommendations or using a minimum of 1 L of ground water following purging and before sampling. Further information on filtration considerations and consequences is given in Instruction E-1, Appendix E.

C.2.3.1 Sample containers. When metals are the analytes of interest, high-density polyethylene containers with polytetrafluoroethylene-lined polypropylene caps should be used. (Polytetrafluoroethylene is commonly referred to using the registered name of Teflon. Polytetrafluoroethylene will be referred to as PTFE.) When organics are the analytes of interest, glass bottles with PTFE-lined caps should be used. Refer to Appendix B or the specific analytical method for acceptable containers. Containers should be cleaned based on the analyte of interest. Instruction E-6, "Decontamination Procedures" (Appendix E), contains additional information on appropriate glassware cleaning protocols. If precleaned bottles are used, the cleanliness of each lot of precleaned bottles should be verified by the container supplier or in the laboratory and appropriate paperwork (i.e., certificates) retained with other field documentation. Refer to Appendix B for information on the required size and type of sample containers. Samples should be collected and containerized in the order of the volatilization sensitivity of the parameters. The following is a preferred collection order for some common ground water parameters:

- Volatile organics (VOA)
- Purgeable organic carbon (POC)
- Purgeable organic halogens (POX)
- Total organic halogens (TOX)
- Total organic carbon (TOC)
- Extractable organics
- Total metals
- Dissolved metals
- Phenols
- Cyanide
- Sulfate and chloride
- Turbidity
- Nitrate and ammonia
- Radionuclides

C.2.3.2 Sample preservation. Methods of sample preservation are relatively limited and are generally intended to retard biological action, retard hydrolysis, and reduce sorption effects. Preservation methods are generally limited to pH control, chemical addition, cooling, and protection from light. Prepreserved sample containers are not recommended. Because different amounts of preservative may be necessary to bring the sample to the required pH, it is recommended to add the preservative to the container in the field and to verify that the pH of the sample has been achieved. This information should be documented within field logbooks. The sampler should refer to Appendix B or the specific preservation method in EPA/SW-846 for the appropriate preservation technique.

C.2.3.3 Special handling for VOA samples. Water samples to be analyzed for purgeable organic compounds should be stored in 40-mL vials with septum inserts and screw caps. The septum should be placed on the sample vial so that the PTFE side is in contact with the sample. The 40-mL vials should be completely filled to prevent volatilization. Extreme caution should be exercised when filling a vial to avoid any turbulence that could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to pour the last few drops into the vial gently so that surface tension holds the water in a convex meniscus. The septum is then applied and some overflow is lost, but air space in the bottle is eliminated. After the bottle is capped, it should be turned over and tapped to check for bubbles. If any bubbles are present, the procedure must be repeated. Care should be taken to ensure that no loss of preservative occurs, if applicable.

C.2.3.4 Special precautions for trace contaminant sampling. Contaminants can be detected in the parts per billion and/or parts per trillion ranges. Therefore, extreme care must be taken to prevent cross-contamination of these samples. The following general precautions should be taken when sampling:

- A clean pair of new disposable gloves should be worn each time a different location is sampled, and gloves should be donned immediately before sampling.
- To prevent cross-contamination between samples, it is suggested that the multiple VOA vials from each sampling location be sealed in a separate smaller plastic bag when the sampled medium is suspected of containing high concentrations of volatile organics.
- Sample containers filled with source or waste samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting and preserving, and activated carbon should be included in the bags to prevent cross-contamination.
- If possible, background samples and source samples should be collected by different field teams. If different field teams cannot be used, all background samples should be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples should never be placed in the same ice chest as environmental samples. It is good practice to enclose waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean plastic bags.
- If possible, one member of the field team should take all the notes, fill out sample tags, field sheets, etc., while the other members collect all of the samples.
- Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.
- Field personnel should use equipment constructed of PTFE, stainless steel, or glass that has been properly precleaned. PTFE or glass is preferred for collecting samples where trace metals are of concern.
- Adequate field control samples should be collected.

C.2.4 Sampling methods. Sampling instructions for the most common techniques for collecting ground water samples from ground water monitoring wells are presented in this section. A summary of the methods is presented in Table C-2. Additional information is presented in EPA/540/S-95/504, EPA/625/R-93/003a, ASTM D 4448, ASTM D 6232, and ASTM D 6452. Additional information on the installation, development, and decommissioning of monitoring wells can be found in ASTM Standards D 5092, D 5299, and D 5521. After installation, the well should be developed to remove any fine material adjacent to the well casing. Wells should not be sampled immediately after development, due to the time needed to reach chemical equilibrium with the well construction materials. This lag time may often extend beyond 1 week. Consequently, well development is not addressed in this sampling and analysis guidance document. Refer to EM 1110-1-4000 for further information on well development. Once a well has been

Table C-2
Summary of Ground Water Sampling Techniques

	Advantages				Disadvantages			
Method	**Compatible Construction Material**	**Ease of Use**	**Economical**	**External Power Source Needed**	**VOC Degassing**	**Ease of Decontamination**	**Large Water Volumes**	**Restrictive Ground Water Depth**
Bailer	●	●	●			●		
Submersible Pump	●			●	●		●	
Bladder Pump	●			●				
Hand Pump	●	●	●		●			
Centrifugal Pump			●	●	●		●	●
Peristaltic Pump	●			●	●	●		●
Air-Lift Pump		●		●	●		●	●
Passive Samplers	●	●	●					

located and properly identified, field measurements should be noted in a bound field logbook. A cross-reference should be made between the previously recorded physical location/identification locating the well to be sampled to ensure the proper well has been selected. Misidentification of a sampling point in the field will result in erroneous data that may affect management decisions. Also included in field measurements are the physical measurements of the well and its physicochemical parameters. Physical measurements that may be recorded in the field logbook include the presence and diameter of protective casing, diameter and construction material of the well casing, total depth of well from the top of casing, surveyors' mark, depth from top of casing to water, and the volume of water in the well and filter pack. The volume of water can be calculated by the submerged length of the well and calculating the volume of water in the submerged casing and filter pack. The total depth of the well should not be measured before sampling, but be obtained from well logs. Measuring to the bottom of the well casing may cause resuspension of settled solids from the formation materials and require longer purging times for turbidity equilibration. The well depth should be measured after sampling is complete. Volumes of water in various well casing diameters are listed in Table C-3.

Table C-3
Water Volume in Casing

Nominal Casing Diameter centimeters (inches)	**Water Volume liters/linear meter (gallons/linear foot)**
5.1 (2)	2.03 (0.16)
10.2 (4)	8.11 (0.65)
15.2 (6)	18.24 (1.47)
20.3 (8)	32.43 (2.61)
25.4 (10)	50.67 (4.08)
30.5 (12)	72.96 (5.88)

The volume of water in the filter pack should be calculated assuming a porosity of 30 percent within the filter pack. The volume of water present in the well casing and filter pack may be calculated as shown in the following example:

Assumptions: 2-in. well casing; well depth is 100 ft below ground surface, ground water depth is 20 ft below the ground surface, and the boring diameter is 8 in.

Volume of water in well = (well depth - depth to water) × (water volume in casing)
= (100 - 20) ft (0.1632 gal/ft)
= 13.0 gal

Volume of water in filter pack = (volume of filter pack) × 30%/231 in.^{3}/gal
= {[(•) (8 in.)^2/2] × 80 ft (12 in./ft)} × 0.3/231 in.^{3}/gal
= 58.7 gal

Total volume in well casing and filter pack = 13 gal + 58.7 gal
= 71.7 gal

The volume of water in any size casing can be determined using the following formula:

No. of gallons = 5.8752 × C^2 × H

where C = casing diameter, ft

H = height of water column, ft

Besides the physical measurements taken as described previously and other information that may identify the well, physicochemical information such as dissolved oxygen, pH, specific conductance, temperature, and turbidity should be recorded initially (and in that order), during purging and before sampling (see Section C.2.4.1).

C.2.4.1 Well purging. To obtain a representative sample of ground water from a ground water monitoring well, the water that has stagnated and/or thermally stratified in the well casing must be purged or evacuated. The purging procedure allows fresh or representative ground water to enter the well. The optimum or preferred method to ensure that fresh water representative of the aquifer in contact with the well screen is being sampled is to perform a controlled sampling experiment. When indicator parameters such as specific conductance, pH, temperature, turbidity, and dissolved oxygen are stabilized, the well is presumed to be adequately flushed for the representative sample. In some instances, purging rates must be kept below 500 mL/min to avoid overpumping or pumping the well to dryness. Guidance on recommended stabilization criteria for the indicator parameters is included within the individual sampling equipment instructions. Ideally, wells should never be pumped to dryness. To accomplish this, pump rates may be adjusted, sometimes to less than 500 mL/min, and pumping times extended. Pumping with low-flow rates may also reduce the need for filtering water samples. Additional guidance on low-flow purging may be found in EPA/540/S-95/504. The volume of purging is significantly less in low-flow sampling, because the flow rate is designed to be low enough that flow is being induced only horizontally through the screen at a rate that replaces the evacuated water. This flow rate (typically 100-500 mL/min) will also have minimal effect on entraining particulates, which lowers the sample turbidity, which is crucial to metals analyses. The well can be purged or evacuated in several ways. In any instance it is paramount to ensure that the purging procedure does not cause cross-contamination from one well to the next. Therefore, the preferred method employs dedicated equipment and pumps. Because, commonly, it may not be practicable to dedicate a pump to a specific well, it is permissible to decontaminate this equipment, using approved methods. Tubing should always be dedicated and never used for more than one well. The selection of an evacuation method most often relies on the depth to water (DTW) in the well. If the static DTW is less than 7.6 m (25 ft), a hand pump or bailer may be the best method for evacuation. If the static DTW is greater than 7.6 m (25 ft), a submersible pump should be used. As mentioned earlier, care must be taken to ensure that this does not act as a route of cross-contamination. Pumps should be decontaminated between well locations. During evacuation, pump intake must not be set greater than 1.8 m (6 ft) below the dynamic water level. This requires that the evacuation device be lowered as purging continues and the water level drops. Hand bailing may be utilized with a static water level greater than 7.6 m (25 ft) if a submersible pump is not available or with a static water level less than 7.6 m (25 ft) if other conventional pumps are not available. However, use of a bailer is not recommended because it has the potential to aerate the well water, produce inadequate removal of fines, concentrate floating product on the bailer that may introduce contamination, introduce contaminants from inside the well casing, and cause nonsteady removal of water, which may result in dilution instead of evacuation of the well. In general, the mechanics of the hand-bailing method for well purging may introduce contamination potential and variability. There are many pumps that may be used for well purging. Not all pumps are acceptable under all conditions. The preferred and most commonly used pumps are centrifugal and peristaltic pumps (when depth to water is less than 7.6 m (25 ft)) and submersible pumps (when depth to water is greater than 7.6 m (25 ft)). Information on various pumps and methods of purging is provided later in this instruction. Recent studies have found that some in situ ground water sampling devices minimize or eliminate the need for purging (EPA/600/S4-90/028). These devices are stand-alone systems installed directly into the subsurface and are not used to sample existing ground water monitoring wells. For existing ground water monitoring wells, innovative samplers have been developed that sample the ground water monitoring well without the need to purge the well initially. These diffusion samplers have shown through case studies to be an effective means of acquiring volatile organic compound (VOC) samples (Vroblesky and Hyde 1997). Occasionally, a light, nonaqueous phase layer (LNAPL) (floating product) may be present in a monitoring well designated for sampling. If it is suspected that the well contains an LNAPL, an interface probe should be used to verify its presence. If an LNAPL is present, the thickness should be measured and an appropriate inert bailer should be used to collect a sample of the floating product. Whenever possible, measurements of the free product should be taken using either steel tape and paste or an interface probe. A bailer can significantly under- or overestimate the thickness of free product in the well and should not be used for determining the elevations of air/free product and free product/water interfaces. The use of bailers should be limited to verification of the presence of free product in a well or collection of a sample of it (EPA/510/R-96/001). Collection of a ground water sample may not be appropriate if an LNAPL is present in the well, for the sampler will likely become contaminated as it passes through the LNAPL to reach and sample the ground water below.

C.2.4.2 Bailers. Bailers are one of the simplest and most commonly used sampling methods for sampling ground water monitoring wells (Figure C-1).

C.2.4.2.1 Applicability. Bailers are constructed of a variety of materials compatible with the parameter of interest. They are economical and convenient enough that a separate bailer may be dedicated to each well to minimize cross-contamination. An external power source is not required. Bailers provide a low surface-to-volume ratio, which reduces degassing of VOCs. Cross-contamination can be a problem if the bailer is not adequately decontaminated. Bailers offer a relatively limited sample volume and may not be desirable for purging a well if large amounts of water need to be removed from the well for purging. The sampling technique used with bailers may, however, cause a surging action on the well, which may increase the turbidity of the well sample. Consequently, bailers have a higher potential for loss of volatiles and are not recommended for either volatile or metals sampling. Where representative numbers for metals and volatiles are required, it is recommended that the low-flow procedures detailed in Section C.2.4.9 be utilized.

C.2.4.2.2 Method summary and equipment. Bailers are manufactured in numerous types, sizes, and construction materials. Bailers are typically weighted lengths of pipe attached to a cord with a check valve at the lower end. They are typically constructed of PVC, PTFE, or stainless steel. The PTFE bailer is recommended if the bailer is used to collect ground water samples for VOC analysis. Bailers can be dedicated to a specific well, i.e., used only for purging and sampling that well. Dedicated bailers are typically stored to prevent cross-contamination or, less preferably, left hanging in the well itself. It should be noted that stainless steel bailers left stored in a well will likely rust under high-humidity conditions. The bailer should be decontaminated after each use. Disposable bailers are also available and are cost-effective for certain investigations. Haul lines for bailers may consist of PTFE-coated stainless steel cable, polyethylene rope, or nylon rope. Of these three, nylon rope is the least desirable because it may introduce contaminants. The use of braided rope is discouraged, because it cannot be decontaminated. For each sampling event, the rope for dedicated bailers should be changed following purging and before sampling. For nondedicated bailers, rope should be changed between wells. After removal, the rope should be properly discarded.

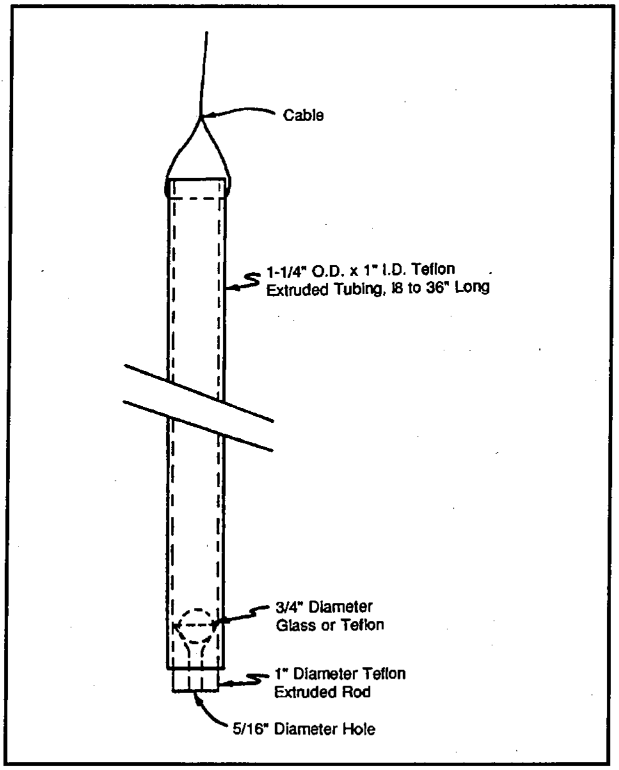


Figure C-1. Bailer (to convert dimensions to mm, multiply by 25.4)

C.2.4.2.3 Sampling procedure.

- Prepare the work area outside the well by placing plastic sheeting on the ground to avoid cross-contamination.
- Determine the saturated water column in the well using an electronic water level indicator. Calculate the fluid volume in the casing and determine the amount of water to be removed for purging.
- Attach a decontaminated bailer to cable or line for lowering, or use dedicated bailer already in well.
- Lower bailer slowly until it contacts water surface.
- Allow bailer to sink and fill with a minimum of surface disturbance.
- Slowly raise bailer to surface. Do not allow bailer line or bailer to contact ground.

- Purge well until the dissolved oxygen (DO), pH, specific conductance, temperature, and turbidity are each at equilibrium, and begin sampling. Equilibrium is established as follows: ±10 percent for DO, ±0.2 pH units, ±3 percent for specific conductance, ±1 degree Celsius for temperature, and ±10 percent for turbidity. (If redox potential is used as an indicator, ±10 mV should be used as the stabilization criterion.)

- Ensure that equilibrium is established by making three consecutive readings, where one casing volume is pumped between each reading.

- Collect VOA samples first following guidelines specified within this appendix.

- Fill sample bottles for remaining parameters by tipping bailer to allow slow discharge from top to flow gently down the side of the sample bottle with minimum entry turbulence. If a bottom drain is present on the bailer, recommended that a slow steady flow be achieved.

- Repeat these steps as needed to acquire sufficient volume to fill all sample containers.

- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.

- Verify that a PTFE liner is present in the cap. Secure the cap tightly.

- Label the sample bottle with an appropriate label. Be sure to include all necessary information.

- Place filled sample containers on ice immediately along with the required trip blank, if analyzing for VOCs.

- Record the information in the field logbook and field sheet, and complete all chain-of-custody documents (see Instruction F-1, "Documentation," in Appendix F).

- Thoroughly decontaminate the bailer after each use, regardless of whether the bailer is dedicated to one well or used to sample other wells.

- Close well.

C.2.4.3 Portable submersible pump. Portable submersible pumps are an effective technique for pumping large volumes of water at a steady rate but require an external electrical power source.

C.2.4.3.1 Applicability. Advantages of submersible pumps include their ability to pump variable amounts from various depths. This advantage makes these pumps applicable not only for purging and sampling but also for aquifer characterization tests. Pumping rates for various units range from as little as 100 mL per minute to 3,784 L per minute (1,000 gpm). The pumping rate for most units can be individually adjusted. Disadvantages of submersible pumps are that they require an external electrical power source and may be difficult to decontaminate between wells. The propeller construction of the pump assembly may cause degassing of volatile organic compounds; therefore, some states or USEPA regions may restrict the use of submersible pumps when sampling for VOCs.

C.2.4.3.2 Method summary and equipment. For submersible pumps, the pump assembly, the electric drive motor, and associated hoses and electrical cables are suspended from a steel cable or discharge pipe and submerged in the well. Intake is typically located between the motor and the pump assembly.

Horsepower, head, and lift capacity range widely. Submersible pumps are available for 5-cm (2-in.) and larger wells. Some pumps are constructed of stainless steel and PTFE to maintain sample integrity. Submersible pumps far exceed the pumping limitations of other sampling equipment.

C.2.4.3.3 Sampling procedure. Recommended sampling procedures are as follows:

- Prepare the work area outside the well by placing plastic sheeting on the ground to avoid cross-contamination.
- Determine the saturated water column in the well using an electronic water level indicator. Calculate fluid volume in the casing and determine the amount of water to be removed for purging.
- Lower the decontaminated pump to below the water level and begin pumping. Collect or dispose of purged water in an acceptable manner. Lower the pump as required to maintain submergence.
- Measure rate of discharge frequently. A bucket and stopwatch are commonly used.
- Purge well until the DO, pH, specific conductance, temperature, and turbidity are each at equilibrium, and begin sampling. Equilibrium is established as follows: ±10 percent for DO, ±0.2 pH units, ±3 percent for specific conductance, ±1 degree Celsius for temperature, and ±10 percent for turbidity. (If redox potential is used as an indicator, ±10 mV should be used as the stabilization criterion.)
- Ensure that equilibrium is established by making three consecutive readings, where one casing volume is pumped between readings.
- Reduce the pump discharge rate to less than 500 mL/min. Collect VOA samples first following guidelines specified within this appendix.
- Fill bottles for remaining parameters by allowing pump discharge to flow gently down the side of the bottle with minimal entry turbulence. Cap each bottle as filled.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Ensure that the PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.
- Complete chain-of-custody documents, field logbook, and field sheet (see Instruction F-1, “Documentation,” in Appendix F).
- Pull pump and allow system to drain and decontaminate.
- Close well.

C.2.4.4 Bladder pump. Bladder pumps employ a closed collection system that eliminates agitation and air or gas contact with the sample (Figure C-2).

C.2.4.4.1 Applicability. Advantages of the bladder pump include its ideal design for sampling wells for VOC analysis from wells as small as 5 cm (2 in.) in diameter. The pump can pump water from various depths and at adjustable rates. It can operate in low-yielding wells without the possibility of burning out the pump if the well is pumped dry. The inlet for the pump body is typically at the lower end, thus requiring minimum submergence. Top-ended inlet pumps are also available for floating product recovery. Disadvantages of the bladder pump include its relatively low pumping rate. It also requires an outside power source of compressed air or gas and may be difficult to decontaminate between wells.

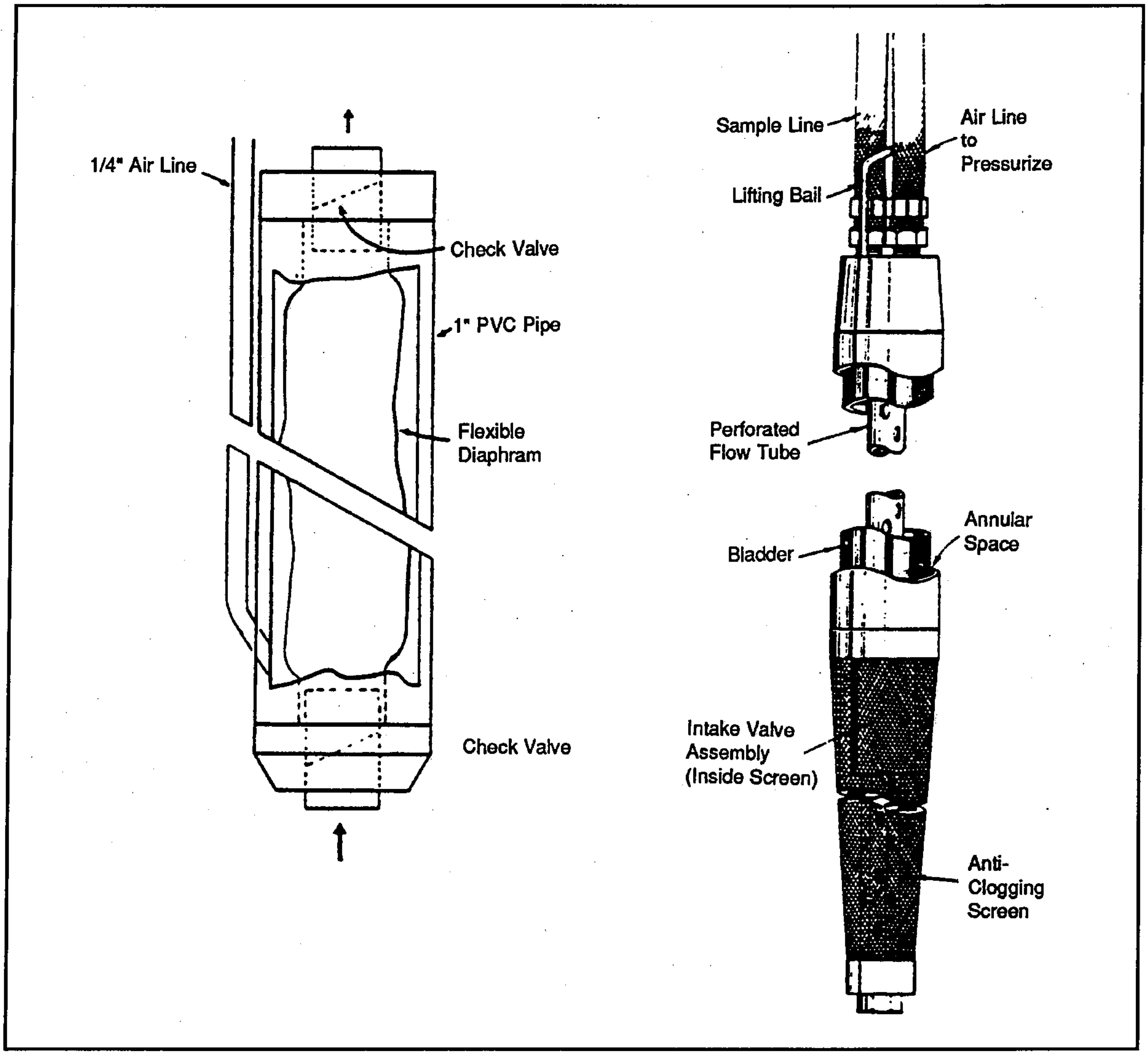


Figure C-2. Bladder pump (to convert dimensions to mm, multiply by 25.4)

C.2.4.4.2 Method summary and equipment. The closed system provides the best method available for sampling wells for VOCs. The pump fills through a lower check valve under hydrostatic pressure, collapsing the bladder in the pump body. The bladder is then pressurized with gas or air causing it to expand, thus applying pressure in the pump body. The bladder is pressurized using a control box and air compressor assembly. This in turn closes the lower check valve and forces the contents of the pump body up through the sample line check valve. Venting the bladder will allow the pump to refill and begin another cycle. An inflatable packer is often used in conjunction with bladder pumps to reduce the amount of water to be purged for sampling. The packer is often positioned immediately above the well screen so that only water in the screened area of the well will require purging once the packer is properly inflated.

C.2.4.4.3 Sampling procedure. Recommended sampling procedures are as follows:

- Prepare the work area outside the well by placing plastic sheeting on the ground to avoid cross-contamination.
- Determine the amount of water to be removed for purging. Determine the saturated water column in the well using an electronic water level indicator. Calculate the fluid volume in the casing if an inflatable packer is not present in the well. If an inflatable packer is present in the well, refer to construction diagrams of the well to determine the saturated water column below the packer. Make sure that the packer is not within the screened interval.
- Attach a pressurized air hose to the packer connection (if present) and inflate packer to proper pressurization level, typically 60 to 80 psi. After the packer is inflated, reattach pressurized air hose to the bladder pump connection and purge the well as discussed in Section C.2.4.4.2.
- Measure the rate of discharge frequently. A bucket of known volume and a stopwatch are commonly used.
- Purge well until the DO, pH, specific conductance, temperature, and turbidity are each at equilibrium, and begin sampling. Equilibrium is established as follows: ±10 percent for DO, ±0.2 pH units, ±3 percent for specific conductance, ±1 degree Celsius for temperature, and ±10 percent for turbidity. (If redox potential is used as an indicator, ±10 mV should be used as the stabilization criterion.)
- Ensure that equilibrium is established by making three consecutive readings, where one casing volume is pumped between each reading.
- Collect VOA samples first following guidelines specified within this appendix.
- Fill sample bottles of remaining parameters by allowing pump discharge to flow gently down the side of the bottle with minimal entry turbulence. The pump discharge rate should be less than 500 mL/min. Cap each bottle as filled.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample with an appropriate label. Be sure to complete the label with all necessary information.

- Place filled sample containers on ice immediately along with the required trip blank, if analyzing for VOCs.

- Complete chain-of-custody documents, field logbook, and appropriate field sheet (see Instruction F-1, "Documentation," in Appendix F).

- Depressurize packer (if present), remove the pump, and close well.

C.2.4.5 Hand pumps. Hand pumps are positive displacement pumping systems designed for developing, purging, and sampling (for some analyses) 5-cm (2-in.) or larger ground water monitoring wells.

C.2.4.5.1 Applicability. Hand pumps do not require an external power source. Units are easily transported. A sustained pumping rate can be achieved. The hand pump could cause cross- contamination if the unit is not thoroughly decontaminated. The hand pump may not be suitable for collecting samples for VOCs because the pump creates a vacuum pressure on the water during operation, which may result in degassing of volatile compounds.

C.2.4.5.2 Method summary and equipment. Hand pumps are readily transportable and can be used to provide sampling in remote areas. Hand operation enables the user to vary the pumping rate to more than 4 gpm at depths exceeding 30 m (100 ft). Hand pumps are typically constructed of offset sizes of PVC piping and check valves. Typically, a small-diameter pipe resides within a larger diameter pipe. The small-diameter pipe is forced up and down and the resulting movement creates a positive displacement.

C.2.4.5.3 Sampling procedure. Recommended sampling procedures are as follows:

- Prepare the work area outside the well by placing plastic sheeting on the ground to prevent cross-contamination.

- Determine the saturated water column in the well using an electronic water level indicator. Calculate the fluid volume in the casing and determine the amount of water to be removed for purging..

- Lower the decontaminated hand pump assembly into the well and begin operating the pump in a steady motion.

- Measure the rate of discharge frequently. A bucket of known volume and a stopwatch are commonly used.

- Purge well until the DO, pH, specific conductance, temperature, and turbidity are each at equilibrium, and begin sampling. Equilibrium is established as follows: ±10 percent for DO, ±0.2 pH units, ±3 percent for specific conductance, ±1 degree Celsius for temperature, and ±10 percent for turbidity. (If redox potential is used as an indicator, ±10 mV should be used as the stabilization criterion.)

- Ensure that equilibrium is established by making three consecutive readings, where one casing volume is pumped between each reading.

- Collect VOA samples first.

- Fill sample bottles for remaining parameters by allowing pump discharge to flow gently down the side of the bottle with minimal entry turbulence. The pump discharge rate should be less than 500 mL/min. Cap each bottle as filled.

- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.

- Check that a PTFE liner is present in the cap. Secure the cap tightly.

- Label the sample with an appropriate label. Be sure to complete the label with all necessary information.

- Place filled sample containers on ice immediately along with the required trip blank, if analyzing for VOCs.

- Complete chain-of-custody documents, field logbook, and appropriate field sheet (see Instruction F-1, "Documentation," in Appendix F).

- Remove the pump assembly and decontaminate.

- Close the well.

C.2.4.6 Centrifugal pump. A centrifugal pump is a type of suction pump used to purge wells.

C.2.4.6.1 Applicability. Advantages of centrifugal pumps include their ability to provide substantial pumping rates and their ready availability. Disadvantages are that they require an external power source and may be difficult to decontaminate between wells. The materials with which these pumps are constructed may frequently be incompatible with certain sample analytes. The centrifugal pump is not suitable for collecting samples for VOC analysis because the pump creates a vacuum pressure on the water during operation, which results in degassing of volatile compounds. These pumps cannot pull water more than 6 m (20 vertical ft).

C.2.4.6.2 Method summary and equipment. Centrifugal pumps are a type of suction pump. An impeller rotating inside the pump chamber discharges water by centrifugal force. The resulting pressure drop in the chamber creates a suction that causes water to enter the intake pipe in the well. Since entrance of water into the intake depends on atmospheric pressure, the height of the intake lift is limited to about 6 m (20 ft) at sea level and less at higher altitudes. Discharge rates from 19 to 151 L per minute (5 to 40 gpm) can be attained and water can be pushed as high as 46 m (150 ft) above the pump. Pumps are typically motorized by a small gasoline engine attached to the pump.

C.2.4.6.3 Sampling procedure. Recommended sampling procedures are as follows:

- Prepare the work area outside the well by placing plastic sheeting on the ground to avoid cross-contamination.

- Determine the saturated water column in the well using an electronic water level indicator. Calculate the fluid volume in the casing and determine the amount of water to be removed for purging.

- Lower decontaminated intake hose into well.

- Prime pump with distilled water and start pump.

- Containerize or discharge purge water accordingly.

- Measure the rate of discharge frequently. A bucket of known volume and a stopwatch are commonly used.

- Purge well until the DO, pH, specific conductance, temperature, and turbidity are each at equilibrium, and begin sampling. Equilibrium is established as follows: ±10 percent for DO, ±0.2 pH units, ±3 percent for specific conductance, ±1 degree Celsius for temperature, and ±10 percent for turbidity. (If redox potential is used as an indicator, ±10 mV should be used as the stabilization criterion.)

- Ensure that equilibrium is established by making three consecutive readings, where one casing volume is pumped between each reading.

- Collect VOA samples first.

- Fill sample bottles for remaining parameters by allowing pump discharge to flow gently down the side of the bottle with minimal entry turbulence. The pump discharge rate should be less than 500 mL/min. Cap each bottle as filled.

- Preserve the samples as necessary and verify that the pH is sufficient for the criteria.

- Check that a PTFE liner is present in the cap. Secure the cap tightly.

- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.

- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.

- Complete chain-of-custody documents, field sheet, and field logbook (see Instruction F-1, "Documentation," in Appendix F).

- Close the well.

C.2.4.7 Peristaltic pump. Peristaltic pumps operate in a manner similar to that of centrifugal pumps but displace the fluid by mechanical peristalsis (Figure C-3).

C.2.4.7.1 Applicability. An advantage of the peristaltic pump is its design, which isolates the sample from the moving part of the pump and allows for easy decontamination by removal or replacement of the flexible tubing. Tubing can be dedicated to wells to reduce decontamination time. Disadvantages of these pumps include their low pumping rates and their limited height of intake lift (less than 6 m (20 ft)). These pumps also require an outside power source and, like other suction pumps, are not suitable for collecting samples for VOC analysis because of potential degassing effects.

C.2.4.7.2 Method summary and equipment. A flexible sampling tube is mounted around the pump chamber, and rotating rollers compress the tubing, forcing fluid movement ahead (the peristaltic effect) and

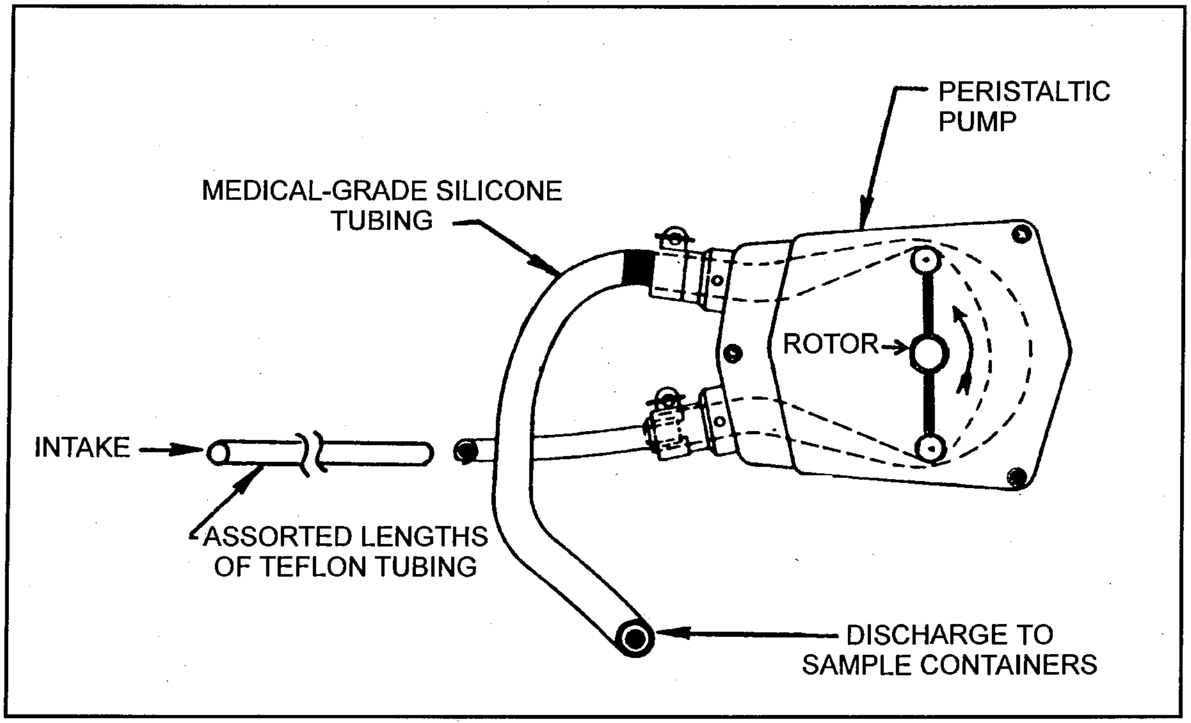


Figure C-3. Peristaltic pump

inducing suction behind each roller (Figure C-3). Peristaltic pumps generally have very low pumping rates suitable only for sampling shallow water tables in small-diameter wells.

C.2.4.7.3 Sampling procedures. Recommended sampling procedures are as follows:

- Prepare the work area outside the well by placing plastic sheeting on the ground to avoid cross-contamination.

- Determine the saturated water column in the well using an electronic water level indicator. Calculate the fluid volume in the casing and determine the amount of water to be removed for purging.

- Install clean medical-grade silicone tubing in the peristaltic pump head and attach the silicone tubing to the glass tubing outlet from the sample bottle.

- Attach the inlet glass tubing from the sample bottle to the required length of new PTFE suction line and lower to the midpoint of the well screen, if known, or slightly below the existing water level.

- Purge well until the DO, pH, specific conductance, temperature, and turbidity are each at equilibrium, and begin sampling. Equilibrium is established as follows: ±10 percent for DO, ±0.2 pH units, ±3 percent for specific conductance, ±1 degree Celsius for temperature, and ±10 percent for turbidity. (If redox potential is used as an indicator, ±10 mV should be used as the stabilization criterion.)

- Ensure that equilibrium is established by making three consecutive readings, where one casing volume is pumped between each reading.

- Collect VOA samples, if required, with a bailer following guidelines established within this appendix.

- Fill sample bottles for remaining parameters by allowing pump discharge to flow gently into the bottle with minimal entry turbulence. Pump discharge should be less than 500 mL/min. Cap each bottle as filled.

- Preserve the samples as necessary and verify that the pH is sufficient for the criteria.

- Verify that a PTFE liner is present in the cap. Secure the cap tightly.

- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.

- Place filled sample containers on ice immediately along with the required trip blank, if analyzing for VOCs.

- Complete chain-of-custody documents, field sheet, and field logbook (see Instruction F-1, "Documentation," in Appendix F).

- Allow system to drain, then disassemble. Decontaminate or replace tubing for next sampling.

- Close the well.

C.2.4.8 Air lift pump. Air lift pumps are usually used for developing or purging recovery wells rather than monitoring wells because of their ease of use and their ability to maintain moderate flow rates. Air lift pumps are not recommended for sampling monitoring wells. Because of the contact with well water and the source gas, the sample could be chemically altered. Depending on the source gas, the pH could be altered, oxidation and degassing of VOCs could occur, and lubricating oils from the air compressor could be introduced.

C.2.4.9 Low-flow (minimal-drawdown) sampling. This method uses any adjustable rate pump that can maintain low flow (typically less than 0.5 L/min) and minimize drawdown. Drawdown ideally should be less than <10 cm (4 in.) during the entire purging and sampling process. Typically used pumps include submersible centrifugal pumps, bladder pumps, and peristaltic pumps. Some pumps are better suited than others, given the well and aquifer constraints. Submersible pumps, for example, have reportedly had difficulty maintaining low flow in shallow 6- to 7.6-m (<20- to 25-ft) aquifers and may overheat under those circumstances. Additional equipment required includes an electronic water level indicator (accurate to 0.3 cm (± 0.01 ft), a multiparameter probe (dissolved oxygen, turbidity, redox potential, pH, temperature, and specific conductivity), and a flow-through cell compatible with the probe.

C.2.4.9.1 Applicability. Low-flow sampling is generally applicable in any instance where a representative nonturbid sample of the aquifer is desired. It is particularly appropriate in low-yield formations where the well would go dry if pumped at higher rates. It is also important to use low-flow techniques in wells that produce samples with high turbidity, which can result in high metals analytical results. Low-flow sampling induces a lower velocity through the screen, which entrains fewer particulates.

Another important advantage is that less purge water is produced, significantly decreasing the costs for handling and disposing of Investigation Derived Wastes (IDW). To implement low-flow sampling appropriately, the water level in the well being sampled needs to be monitored continuously, and the actual flow rate must be measured and adjusted to maintain drawdown in the well to less than 10 cm (4 in.).

C.2.4.9.2 Method summary and equipment. The pump must also be inserted into the well in a way that minimizes the disturbance of any sediments within the well casing, particularly those in the bottom of the well. In no circumstances should the water level probes or pumps be allowed to hit the bottom of the well before or during sampling. If possible the point where water enters the pump should be at least 0.6-0.9 m (2-3 ft) above the bottom of the well. The pump should be turned on at the lowest setting possible, and that setting should be raised gradually until a continuous flow is achieved from the discharge tube. During this time the water level needs to be monitored and the flow rate adjusted to maintain the drawdown to less than 10 cm (4 in.) if possible. In no circumstances should the water level be allowed to break suction in the pump. The pump is to be turned off when that happens and turned on again when sufficient recharge has occurred. If there is a stagnant column of water in the casing above the screen, it is essential that the water level not be allowed to come down to the screen. If this should appear imminent, the pump should be shut off and the well allowed to recover before purging continues. There are wells that even at pumping rates of 100-200 mL/min will not be able to recharge sufficiently. In those circumstances the sampling team needs to reassess the sampling goals for that location and determine whether there are other more appropriate ways to obtain a representative sample. To successfully monitor the representativeness of the water sample the most sensitive parameters (DO, redox potential, and turbidity) must be measured along with the traditional parameters of pH, temperature, and conductivity. To accurately measure DO and redox requires the use of a flow-through cell, which allows water to be pumped directly from the well and contact the probe(s) without contacting the atmosphere. There is no acceptable alternative to the flow-through cell for accurate measurement of DO and redox. Readings should be taken of all parameters every 3-5 minutes. If after three casing volumes have been removed from the well the turbidity is not <5, this should be noted in the log and the samples should be collected.

C.2.4.9.3 Sampling procedures. Recommended sampling procedures are as follows:

- Prepare the work area outside the well by placing plastic sheeting on the ground to avoid cross-contamination.

- Determine the saturated water column in the well using an electronic water level indicator. NOTE: Do not tag the bottom of the well since the total depth should be on the well construction diagram. Anything that hits the bottom of the well risks disturbing any fines that are there, and they may subsequently be entrained in the sample. Calculate the fluid volume in the casing and determine the amount of water to be removed for purging.

- Connect the pump tubing to the flow-through cell and connect the multiparameter probe to the cell.

- Purge well until the DO, pH, specific conductance, temperature, and turbidity are each at equilibrium, and begin sampling. Equilibrium is established as follows: ±10 percent for DO, ±0.2 pH units, ±3 percent for specific conductance, ±1 degree Celsius for temperature, and ±10 percent for turbidity. (If redox potential is used as an indicator, ±10 mV should be used as the stabilization criterion.)

- Establish equilibrium by making three consecutive readings, with 3 to 5 minutes between each reading.

- Detach the tubing from the flow-through cell and collect VOA samples first.
- Collect VOA samples, if required, following guidelines established within this appendix. Fill sample bottles for remaining parameters by allowing pump discharge to flow gently into the bottle with minimal entry turbulence. Pump discharge should be less than 500 mL/min. Cap each bottle as filled.
- Preserve the samples as necessary and verify that the pH is sufficient for the criteria.
- Verify that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately along with the required trip blank, if analyzing for VOCs.
- Complete chain-of-custody documents, field sheet, and field logbook (see Instruction F-1, "Documentation," in Appendix F).
- Allow system to drain, then disassemble. Decontaminate or replace tubing for next sampling.
- Close the well.

C.2.4.10 Emerging and innovative sampling procedures. All of the standard samplers described in this appendix for the sampling of ground water disrupt equilibrium during the sampling event to some degree. This may lead to obtaining a sample that is not representative of the actual environmental conditions or contaminant concentrations. New sampling devices and sampling procedures have been designed to minimize the disturbance to the medium during sampling, circumvent the need to purge the well, and minimize the influence on and any bias to the results that this disturbance, the stagnant water above or below the well screen, or fines contained within the monitoring well may impose. Recent studies have shown the application of diffusion samplers to the acquisition of samples for VOCs, a chemical parameter susceptible to loss from the disturbance imposed by purging and sampling (Vroblesky and Hyde 1997). The diffusion samplers are constructed of polyethylene bags containing deionized water that is strategically hung within the screened interval of the monitoring well and left for a predetermined time (e.g., 11-54 days). Polyethylene is shown to allow the transmission of various halogenated and aromatic VOCs, and is used as a semipermeable membrane to allow the diffusion of VOCs from the ground water to the deionized water contained within the bags. The sampler may also be designed to have multiple discrete cells that are vertically separated. This configuration allows the monitoring of VOC concentrations as they pertain to different depth intervals. After the sampling period, the diffusion samplers are collected from the wells by the attached strings, and the water is gently poured from the sampler into 40-mL VOA vials through the PTFE stopcock. Samples are then processed in the same manner as other sampling techniques. The diffusion samplers are commercially available; easy to deploy, retrieve, and sample; and an inexpensive alternative for the acquisition of VOC samples in ground water monitoring wells or other water bodies.

C.2.4.11 Decontamination procedures. All equipment that will enter the well must be decontaminated before entry. The inside surface of pumps and tubing apparatus must be decontaminated by drawing the decontamination solution through the equipment. Field measurement equipment such as water level indicators should be cleaned as described in Instruction E-6, Appendix E. If the sampling equipment is being prepared for later use, it should be wrapped in cleaned foil. The sampling equipment should remain wrapped in this manner until immediately before use. Additional sampling devices may be needed onsite to ensure an adequate drying time. The requirement for dedicated equipment should apply to all bailers used for collecting samples. Bailers, other sampling equipment, and sample bottles must be physically separated from generators during transport and storage. Decontamination procedures for field equipment are discussed in Instruction E-6 (Appendix E).

C.2.4.12 Field control sample requirements. Field control samples are collected by the sampling team to determine whether the data are of suitable quality. They include blanks, replicates, and/or background (upgradient) samples. Quality Assurance (QA) samples are replicates sent to a referee (QA) laboratory and analyzed to evaluate the contractor's laboratory performance. Quality Control (QC) samples are blind replicates collected by the sampling team for analysis by the primary laboratory. A detailed discussion of field control samples is contained in Instruction G-2 (Appendix G).

C.2.4.13 Documentation requirements. Bound field logbooks should be used for the maintenance of field records. Record all aspects of the site setup and sample collection and handling as outlined previously and in Instruction F-1 of Appendix F.

C.3 Surface Water Sampling

C.3.1 Scope and application.

C.3.1.1 This instruction presents guidelines for collecting representative samples from surface water bodies. Surface water bodies can be classified into two primary types: flowing and standing. Flowing bodies include industrial effluent, municipal wastewater, rivers, sewers, leachate seeps, streams, or any other lotic water body. Standing bodies include lagoons, ponds, nonaqueous (e.g., surface impoundments), lakes, or any other lentic water body. Surface water samples can be collected from various depths of the water bodies using some of the techniques described herein. Instructions for sampling surface water bodies using the following techniques are included: hand-held bottle, dipper, pond sampler, peristaltic pump, Kemmerer sampler, weighted bottle, and Bacon bomb sampler.

C.3.1.2 Storm water runoff sampling is another type of surface water sampling done to acquire the qualitative and quantitative data necessary to complete National Pollution Discharge Elimination System (NPDES) storm water permits, and to determine the effectiveness of storm water management plans. NPDES permits are issued by the state for permanent areas that due to their purpose or mission (e.g., petroleum, oils, and lubricants (POL), runway, hazardous waste (HW) storage area) may pose a potential environmental risk from storm water runoff through the area. The permit should define the appropriate sampling locations and testing requirements based on the location and types of contaminant sources present and site topography. Sampling of storm water runoff is based on simple standard sampling techniques to acquire representative grab and composite samples from key runoff locations to monitor for visual properties and analytical chemistry parameters as defined by the NPDES permit. Further details on storm water runoff sampling requirements may be found in 40 CFR 122.21(g)(7), 40 CFR 136, and EPA/833/B-92/001.

C.3.2 Sampling strategies. Sampling strategies are developed by the project team to satisfy project-specific data needs that are identified in the HTRW technical planning process. The sampling strategy developed for a particular site will influence several project decisions, including but not limited to sampling locations, types of samples, sampling frequency, and sampling and analytical protocols. For instance, ecological risk assessment may require the need for colocated surface water and sediment samples. Sampling strategies may be significantly influenced by such factors as physical site constraints, safety, and cost, to name a few. The technical planning process that results in the development of the sampling strategy is critical because of the difficulty in acquiring representative surface water samples, the reduction of contaminant action levels, and the problems associated with trace level cross-contamination. Successful investigations of hazardous waste sites are highly dependent on an effective sampling scheme. Development of a sampling scheme to characterize a hazardous waste site should follow the fundamentals of the scientific approach. A successful sampling scheme requires a logical design to allow an evaluation of potential contaminants in relation to background conditions, vertical extent, horizontal extent, and mobility in various media. Regulations covering storm water runoff sampling require that it be performed during a qualifying storm event. The following criteria must be met for the storm event to qualify and the resulting data to be considered a valid data record: the storm event must be preceded by 72 hours of dry weather (rainfall <2.5 cm (<0.1 in.)), the variance in the duration and total rainfall of the storm event may not exceed 50 percent of the average storm event, the storm must produce greater than 2.5 cm (0.1 in.) of rain, and the storm must produce runoff.

C.3.2.1 Sampling locations. Sampling at hazardous waste sites is usually conducted in an attempt to identify contamination and to define its extent and variability. With such an objective, it is most logical to choose sample locations that will yield the most information about site conditions. However, other factors such as accessibility, sampling equipment requirements, and demands on the sampling team need to be considered when selecting locations. When a site is evaluated, sampling can be conducted by random, systematic, or biased sampling. Biased samples are those collected at locations that were chosen based on historical information, knowledge about the behavior of the contaminants, and/or knowledge about the effects of the physical system on the fate of the contaminant. Random sampling depends on the theory of random chance probabilities to choose the most representative sample. Often biased and random sampling techniques can be used together to address an entire site thoroughly. Some samples may be biased to potentially contaminated areas or potentially impacted areas (e.g., downstream from discharge pipe). In areas less likely to be contaminated or areas with little available background information, random samples may be used to allow adequate assessment of the entire site. Due to the nature of the media, locations for surface water samples are restricted to locations within the water body under evaluation. However, variations of those within the water body may include depth, horizontal location, and time. Storm water runoff sampling locations are defined within the NPDES permit based on the mission and purpose of the evaluated areas and the site topography. Each sample location is defined by the facility name and outfall number.

C.3.2.2 Types of samples. The type of sample should be designated when selecting a sampling method. Surface water samples may be discrete (grab) or composite samples. A discrete (grab) sample is defined as a discrete aliquot representative of a specific location at a given point in time. The sample is collected at one particular point in the sample matrix. The representativeness of such samples is defined by the nature of the materials being sampled. In general, as sources vary over time and distance, the representativeness of grab samples will decrease. Composites are samples composed of two or more specific aliquots (discrete samples) collected at various sampling locations and/or different points in time. Analysis of this type of sample produces an average value and can, in certain instances, be used as an alternative to analyzing a number of individual grab samples and calculating an average value. It should be noted, however, that compositing can mask the presence of contaminants by diluting isolated concentrations of analytes that may be present in the environmental matrix. Regulations covering storm water runoff sampling require that both grab and flow-weighted composite samples be collected. Grab storm water samples are discrete samples, normally collected within the first 30 minutes after the onset of runoff from the storm event or as soon as practicable, but no later than within the first 60 minutes of storm water runoff discharge. To comply with 40 CFR 136, grab sampling techniques are required for several potential analytical chemistry parameters (e.g., pH, temperature, VOCs, oil and grease, fecal coliform, fecal streptococcus, cyanide, total phenols, and residual chlorine). Flow-weighted composite samples are taken during the first 3 hours (or an entire event if less than 3 hours in length) of the storm event. It is a mixed sample from one location, combining discrete samples at specified time intervals in specific volumes that are proportional to the runoff flow. Details on the procedures for measuring or estimating rainfall and runoff flow rates should be referenced from EPA/833/B-92/001.

C.3.2.3 Suggested samplers. Each sampling technique presents various disadvantages and advantages for its application. For example, desired depth, tidal influences, sample disturbance, sample volume, chemical/physical reactivity between potential contaminants and sampling tool materials, and ease of decontamination vary from technique to technique. The following sections discuss the advantages and disadvantages of each sampling technique.

C.3.2.4 Sample frequency. Determination of the number of samples needed to characterize a site depends upon sampling objectives and site-specific conditions. For example, if the objective of the event is to determine whether the site is contaminated, a limited number of samples from properly chosen locations will yield useful information. If, however, the site is known to be contaminated and delineation of the contamination is the objective, a greater number of samples may be needed. In many cases, statistical considerations can be helpful in determining sampling strategy. It may also be necessary to strategically plan the timing of sampling. For example, industrial discharges may be more likely during working hours. Storm water runoff sampling frequency requirements are defined within the facility's NPDES permit.

C.3.3 Sample preservation and handling. Many of the chemical constituents and physicochemical parameters that are to be measured or evaluated in monitoring programs are not chemically stable; therefore, sample preservation is required. Appropriate preservation techniques for various parameters are specified in Appendix B. In addition, sample containers that should be used for each constituent or common set of parameters are specified in Appendix B. These preservation methods and sample containers are based on EPA/SW-846. Procedures and techniques for transporting the samples to the offsite laboratory are discussed in Instruction F-2, "Packaging and Shipping Procedures," in Appendix F. Improper sample handling may alter the analytical results of the sample, causing the results to be invalid. Samples should be transferred in the field from the sampling equipment directly into the container that is required for that analysis or set of compatible parameters and in sufficient volumes, including number of sample containers, to allow appropriate analyses. The sample should then be preserved in the field as specified in Appendix B. Because of the low analytical detection limits that are required for assessment of ecological risk and other data uses, care must be taken when collecting the sample to avoid the loss of any contaminants. The samples for volatile analysis should be carefully transferred directly from the sample collection device to the sample container in order to minimize contaminant loss through agitation/ volatilization or adherence to another container. Samples should be collected in the order listed in Section C.3.3.1 When more than one container is required per parameter, the sample should be split equally among all containers until they are filled. Containers used to collect samples for organic analyses should not be prerinsed with water because of the possibility of preservation loss or the loss/gain of contaminants that may taint the analytical results.

C.3.3.1 Sample containers. When metals are the analytes of interest, HDPE containers with PTFE-lined polypropylene caps should be used. When organics are the analytes of interest, glass bottles with PTFE-lined caps should be used. Refer to Appendix B or the specific analytical method to designate an acceptable container. Containers should be cleaned based on the analyte of interest. Instruction E-6, "Decontamination Procedures," (Appendix E) contains additional information on appropriate glassware cleaning protocols. If precleaned bottles are used, the cleanliness of each lot of precleaned bottles should be verified by the container supplier or in the laboratory and appropriate paperwork (i.e., certificates) retained with other field documentation. Refer to Appendix B for information on the required size, number, and type of sample containers. Samples should be collected and containerized in the order of the volatilization sensitivity of the parameters. A preferred collection order for some common parameters follows:

- VOA
- POC
- POX
- TOX
- TOC
- Extractable organics
- Total metals
- Dissolved metals
- Phenols
- Cyanide
- Sulfate and chloride

- Turbidity
- Nitrate and ammonia
- Radionuclides

C.3.3.2 Sample preservation. Methods of sample preservation are relatively limited and are generally intended to retard biological action and hydrolysis and to reduce sorption effects. Preservation methods are generally limited to pH control, chemical addition, refrigeration, and protection from light. Prepreserved sample containers are not recommended. Because of the potential loss of preservative if field errors occur and because different amounts of preservative may be necessary to bring the sample to the required pH, it is recommended to add the preservative to the container in the field and verify that the pH of the sample has been achieved. This information should be documented within field logbooks. The sampler should refer to Appendix B or the specific preservation method in EPA/SW-846 for the appropriate preservation technique.

C.3.3.3 Special handling for VOA samples. Water samples to be analyzed for purgeable organic compounds should be stored in 40-mL vials with septum inserts and screw caps. The septum should be placed on the sample vial so that the PTFE side is in contact with the sample. The 40-mL vials should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence that could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a convex meniscus. The septum is then applied and some overflow is lost, but air space in the bottle is eliminated. After the bottle is capped, it should be turned over and tapped to check for bubbles. If any bubbles are present, the procedure must be repeated. Care should be taken to ensure that no loss of preservative occurs, if applicable.

C.3.3.4 Special precautions for trace contaminant sampling. Contaminants can be detected in the parts per billion and/or parts per trillion ranges. Therefore, extreme care must be taken to prevent cross-contamination of these samples. The following general precautions should be taken when sampling:

- A clean pair of new disposable gloves should be worn each time a different location is sampled, and gloves should be donned immediately prior to sampling.
- To prevent cross-contamination between samples, it is suggested that the multiple vials from each sampling location be sealed in separate smaller plastic bags when the sampled medium is suspected of containing high concentrations of volatile organics.
- Sample containers filled with source or waste samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting and preserving, and activated carbon should be included in the bags to prevent cross-contamination.
- If possible, background samples and source samples should be collected by different field teams. If different field teams cannot be used, all background samples should be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples should never be placed in the same ice chest as environmental samples. It is good practice to enclose waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean, plastic bags.

- If possible, one member of the field team should take all the notes and fill out sample tags, field sheets, etc., while the other members collect all of the samples.

- Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

- Field personnel should use equipment constructed of PTFE, stainless steel, or glass that has been properly precleaned. PTFE or glass is preferred for collecting samples where trace metals are of concern.

- Adequate field control samples should be collected.

C.3.4 Sampling methods. Sampling instructions for the most common techniques for collecting surface water samples are presented in this section. Additional guidance on surface water sampling methods may be found in EM 200-1-2 and EPA/600/2-80/018. Prior to sample collection, water body characteristics (size, depth, flow) should be recorded in the field logbook. Sampling should proceed from downstream locations to upstream locations so that disturbance related to sampling does not affect the samples collected on the upstream side. In addition, if sediment samples are to be collected at the same locations as water samples, the water samples must be collected first. If the project requirements make it necessary to distinguish the concentration of metals in solution from the concentration of metals associated with solids, filtration of the surface water will be required. Filtration techniques are discussed in Instruction E-1 (Appendix E) of this manual. The factors that will contribute to the selection of a surface water sampler include the width, depth, and flow of the surface water body location being sampled, and whether the sample will be collected from the shore or a vessel. For flowing liquids an additional concern must be addressed. Tidal influence should be determined, and its influence on sample collection should be detailed in the sampling plan. At a minimum, the stage of the tide at the time of sample collection should be recorded. Consideration should be given to sampling at varied tidal stages. Samplers may encounter situations where rate of flow affects their ability to collect a sample. For fast-flowing rivers and streams, it may be nearly impossible to collect a midchannel sample at a specific point. Low- flowing streams and leachate seeps present the opposite problem. In these cases, the sampler should attempt to find a location where flow is obstructed and a pool is created. If this is not possible, the only way to obtain a sample may be to dig into the sediment with a decontaminated trowel to create a pooled area where the liquid will accumulate. However, this method is not recommended since the sample is likely to be highly turbid. If the banks are not sloping, sampling personnel may be able to collect the liquid directly into the sample bottle from the edge of the water body. In some instances where the liquid to be sampled cannot be reached, a pond sampler, by virtue of its extension capabilities, may be necessary. In these cases, the pond sampler should be assembled to ensure that sampling personnel are not in danger of falling into the water body being sampled. In cases where access is restricted, or data objectives require a sample taken from the middle of the water body, a boat, barge, or other stable working platform may be necessary. For a stream, channel, or river, the sample should be collected at middepth. For standing liquid, the sample should be collected just below the surface or at middepth. Specific sampling strategies may be altered depending on the contaminants of concern. For instance, when sampling for hydrocarbons or other light nonaqueous phase liquids, it may be better to sample at the surface. Once the sample is obtained, it should be transferred directly into the sample bottle. The sampling device should be decontaminated before the next sample is taken. If sampling below the water surface is required, some of the samplers discussed in the following sections will allow collection of discrete representative liquid samples at various depths. Proper use of the sampling device chosen includes slow lowering and retrieval of the sample, immediate transfer of the liquid into the sampling container, and notation in the logbook of the depth at which the sample was collected.

C.3.4.1 Hand-held bottle.

C.3.4.1.1 Applicability. Filling the sample containers directly is advantageous when the sample might be significantly altered during transfer from a collection vessel into another container. This would affect samples being collected for VOC analysis. The hand-held bottle is not applicable for samples required at depth.

C.3.4.1.2 Method summary and equipment. Samples from shallow depths can be readily collected by merely submerging the sample containers.

C.3.4.1.3 Sampling procedure. The recommended sampling procedure follows:

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination. If access to sampling location is restricted, locate a boat, barge, or other stable working platform adjacent to the area to be sampled.
- Submerge the sample container with the cap in place with minimal surface disturbance so that the open end is pointing upstream.
- Allow the device to fill slowly and continuously using the cap to regulate the speed of water entering the bottle.
- Retrieve the sample container from the surface water with minimal disturbance.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Verify that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately along with the required trip blank, if analyzing for VOCs.
- Record the information in the field logbook and complete the chain-of-custody form and field sheets (See Instruction F-1, “Documentation,” in Appendix F).

C.3.4.2 Dippers and pond samplers. Method Reference: ASTM D 5358.

C.3.4.2.1 Applicability. Dippers and pond samplers prevent unnecessary contamination of the outer surface of the sample bottle that would otherwise result from direct immersion in the source. Dippers and pond samplers can be either reused or discarded. Discarding the samplers would eliminate the need for decontamination. With the pond sampler, samples can be obtained at distances as far as 3 m (10 ft) from the edge of the source, preventing the technician from having to contact the source physically. The tubular handle may bow when sampling very viscous liquids if sampling is not done slowly. Dippers and pond samplers perform similar functions, except that the length of the dipper is smaller.

C.3.4.2.2 Method summary and equipment. The pond sampler consists of an adjustable clamp attached to the end of a two- or three-piece telescoping aluminum or fiberglass pole that serves as the handle. The clamp is used to secure a sampling beaker (Figure C-4).

C.3.4.2.3 Sampling procedure. The recommended sampling procedure follows:

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination. If access to sampling location is restricted, locate a boat, barge, or other stable working platform adjacent to the area to be sampled.
- Assemble the dipper or pond sampler. If appropriate, make sure that the sample container and the bolts and nuts that secure the clamp to the pole are tightened properly.

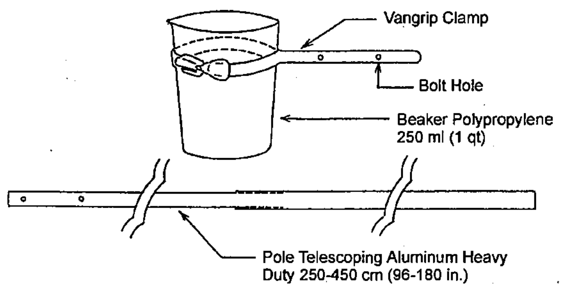


Figure C-4. Pond sampler

- Collect samples by slowly submerging the precleaned dipper or pond sampler with minimal surface disturbance. Make sure that the open end is pointed upstream.
- Retrieve the dipper or pond sampler from the surface water with minimal disturbance.
- Remove the cap from the sample bottle and slightly tilt the mouth of the bottle below the edge of the dipper/sampler.
- Empty the sampler slowly, allowing the sample stream to flow gently down the side of the bottle with minimal entry turbulence.
- Continue delivery of the sample until the bottle is filled.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.
- Record the information in the field logbook and complete the chain-of-custody documents and field sheets (See Instruction F-1, "Documentation," in Appendix F).
- Properly clean and decontaminate the equipment prior to reuse or storage.

C.3.4.3 Peristaltic pump. Method Reference: EPA/600/4-84/076

C.3.4.3.1 Applicability. An advantage of the peristaltic pump is its design, which isolates the sample from the moving part of the pump and allows for easy decontamination by removal or replacement of the flexible tubing. This method can both extend the lateral reach of the sampler and allow sampling from depths below the water surface. Disadvantages of these pumps include their low pumping rates and their limited height of intake lift (less than 6 m (20 ft)). These pumps also require an outside power source and, like other suction pumps, are not suitable for collecting samples for VOC analysis because of potential degassing effects.

C.3.4.3.2 Method summary and equipment. Peristaltic pumps displace fluid by mechanical peristalsis. A flexible sampling tube is mounted around the pump chamber, and rotating rollers compress the tubing, forcing fluid movement ahead (the peristaltic effect) and inducing suction behind each roller (Figure C-3).

C.3.4.3.3 Sampling procedure. The recommended sampling procedure follows:

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination. If access to sampling location is restricted, locate a boat, barge, or other stable working platform adjacent to the area to be sampled.

- Install clean, medical-grade silicone tubing in the pump head, as instructed by the manufacturer. Attach the silicone tubing to the glass tubing outlet from the sample bottle. If the sampling device is not constructed as shown in Figure C-3 and the sample bottle is filled directly from the discharge line of the peristaltic pump, the sample will be in direct contact with the intake tubing, the pump head, and the discharge tubing prior to release to the sample container. In this situation, PTFE tubing must be used for the discharge line to avoid cross-contamination of the samples from contaminant leaching that would occur from other "less inert" tubing.

- Select the length of suction intake tubing necessary to reach the required sample depth and attach it to the intake side of the sample bottle. Heavy-wall PTFE or a diameter equal to the required pump tubing will suit most applications. (A heavier wall will allow for a slightly greater lateral reach.)

- If possible, allow several liters of sample to pass through the system before actual sample collection. Collect this purge volume and return it to the source after the sample aliquot has been withdrawn.

- Collect VOA samples, if required, with an alternative sampling device following guidelines established in this appendix.

- Fill the necessary sample bottles by allowing pump discharge to flow gently down the side of bottle with minimal entry turbulence. Cap each bottle as filled.

- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.

- Check that a PTFE liner is present in the cap. Secure the cap tightly.

- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.

- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.

- Record the information in the field logbook and complete the chain- of-custody documents and field sheets (See Instruction F-1, "Documentation," in Appendix F).

- Allow system to drain, then disassemble it. Decontaminate tubing if necessary; otherwise discard appropriately.

C.3.4.4 Kemmerer sampler. Method References: ASTM D 4136 and EPA/540/P-91/005, Standard Operating Procedure (SOP) #2013, "Surface Water Sampling."

C.3.4.4.1 Applicability. The Kemmerer sampler is a practical method for collecting discrete, at-depth samples where the collection depth exceeds the lift capacity of pumps. The use of the Kemmerer sampler is limited, however, because it is typically constructed of brass.

C.3.4.4.2 Method summary and equipment. The Kemmerer sampler is a messenger-activated water sampling device that is used to sample water from a specific depth (Figure C-5). In the open position, water flows easily through the device. Once the device is lowered to the desired depth, a messenger is dropped down the sample line tripping the release mechanism and closing the container. In the closed position, the bottle is sealed at the top and bottom, isolating the sample during retrieval.

C.3.4.4.3 Sampling procedure. The recommended sampling procedure follows:

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination. If access to sampling location is restricted, locate a boat, barge, or other stable working platform adjacent to the area to be sampled.

- Inspect Kemmerer sampler to ensure that sample drain valve is closed (if equipped).

- Measure and mark sampler line at desired sampling depth.

- Open bottle by lifting top stopper-trip head assembly.

- Gradually lower bottle until desired sample depth is reached.

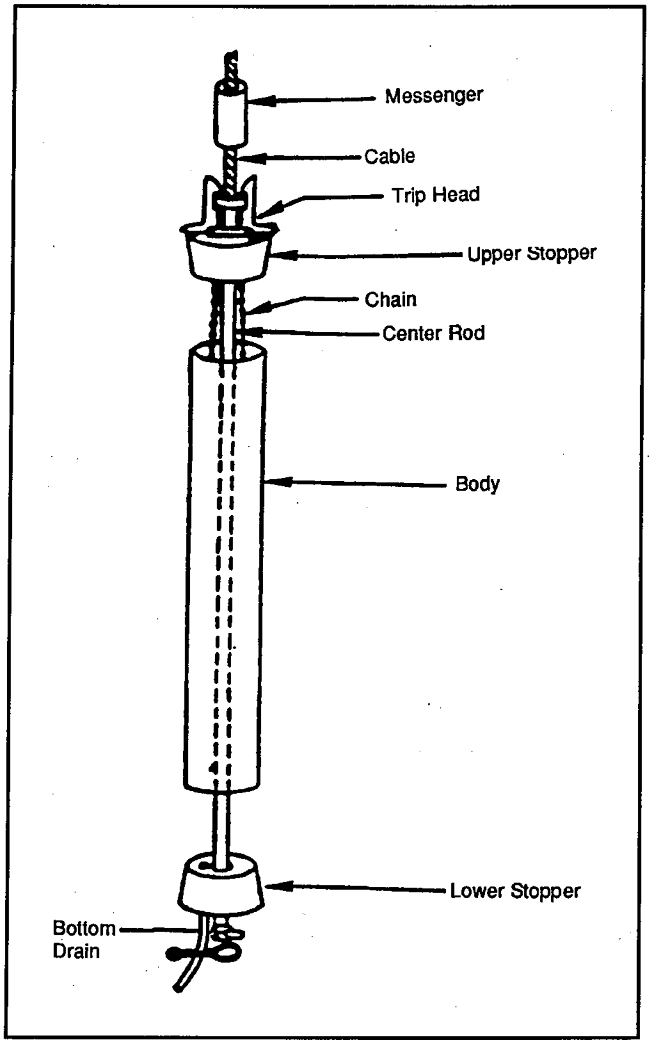


Figure C-5. Kemmerer sampler

- Place messenger on sample line and release.
- Retrieve sampler; hold sampler by center stem to prevent accidental opening of bottom stopper.
- Rinse or wipe off exterior of sampler body.
- Recover sample by grasping lower stopper and sampler body with one hand (gloved), and transfer sample by either lifting top stopper with other hand and carefully pouring contents into sample bottles or holding drain valve (if present) over sample bottle and opening valve.
- Allow sample to flow slowly down the side of the sample bottle with minimal disturbance.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.
- Record the information in the field logbook and complete all chain-of-custody records and field sheets (See Instruction F-1, "Documentation," in Appendix F).
- Decontaminate sampler.

C.3.4.5 Weighted bottle. Method References: ASTM D 4057 and ASTM E 300.

C.3.4.5.1 Applicability. The weighted bottle can be used to obtain samples from a specific depth. The glass construction of the sampler can make the use of this sampler more desirable than the Kemmerer in some sampling situations.

C.3.4.5.2 Method summary and equipment. The weighted bottle can be used for collecting representative samples from a specific depth. The sampler consists of a glass bottle, a weighted sinker, a bottle stopper, and a line that is used to lower and raise the sampler during sampling. Once the sampler is lowered to the desired sampling depth, the stopper is opened, and the bottle is filled and retrieved to the surface.

C.3.4.5.3 Sampling procedure. The recommended sampling procedure follows:

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross- contamination. If access to sampling location is restricted, locate a boat, barge, or other stable working platform adjacent to the area to be sampled.

- Assemble the weighted bottle sampler as shown in Figure C-6.

- Measure and mark the sampler line at the desired sampling depth.

- Lower the sampling device to the predetermined depth.

- When the sampler is at the required depth, pull out the bottle stopper with a sharp jerk of the sampler line and allow the bottle to fill completely. (This is usually evidenced by the cessation of air bubbles.)

- Retrieve the sampler.

- Rinse or wipe off the exterior of the sampler body.

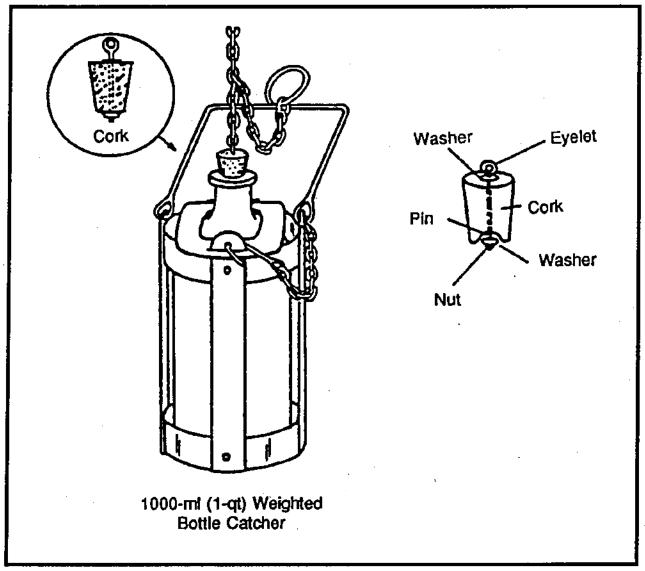


Figure C-6. Weighted bottle

- Allow sample to flow slowly down the side of sample bottle with minimal disturbance.

- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.

- Check that a PTFE liner is present in the cap. Secure the cap tightly.

- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.

- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.

- Record the information in the field logbook and complete all chain-of-custody records and field sheets (see Instruction F-1, "Documentation," in Appendix F).

- Decontaminate sampler.

C.3.4.6 Bacon bomb sampler. Method Reference: EPA/540/P-91/005, SOP #2013.

C.3.4.6.1 Applicability. The Bacon bomb sampler is a widely used, commercially available sampler, designed for sampling petroleum products and viscous liquids (Figure C-7). It is very useful for sampling larger storage tanks because the internal collection chamber is not exposed to a product until the sampler is triggered. It is useful in collecting samples at various vertical locations. Like the weighted bottle sampler, the Bacon sampler remains unopened until it reaches the desired sampling depth. The Bacon sampler is difficult to decontaminate, and it is difficult to transfer the sample into the sample bottles. The possibility of aerating the sample exists if the sampler does not completely fill with water and air is entrapped in the sampler during retrieval.

C.3.4.6.2 Method summary and equipment. The Bacon bomb sampler is constructed of brass or stainless steel and is available in two sizes: 37 mm (1.5 in.) or 87 mm (3.5 in.) in diameter. Samplers range in volume from 0.1 L to 1 L (4 oz to 32 oz). The Bacon bomb sampler is equipped with a trigger that is spring loaded. When opened, the trigger allows liquid to enter the collection chamber. When the trigger is released, liquid is prevented from flowing into or out of the collection chamber.

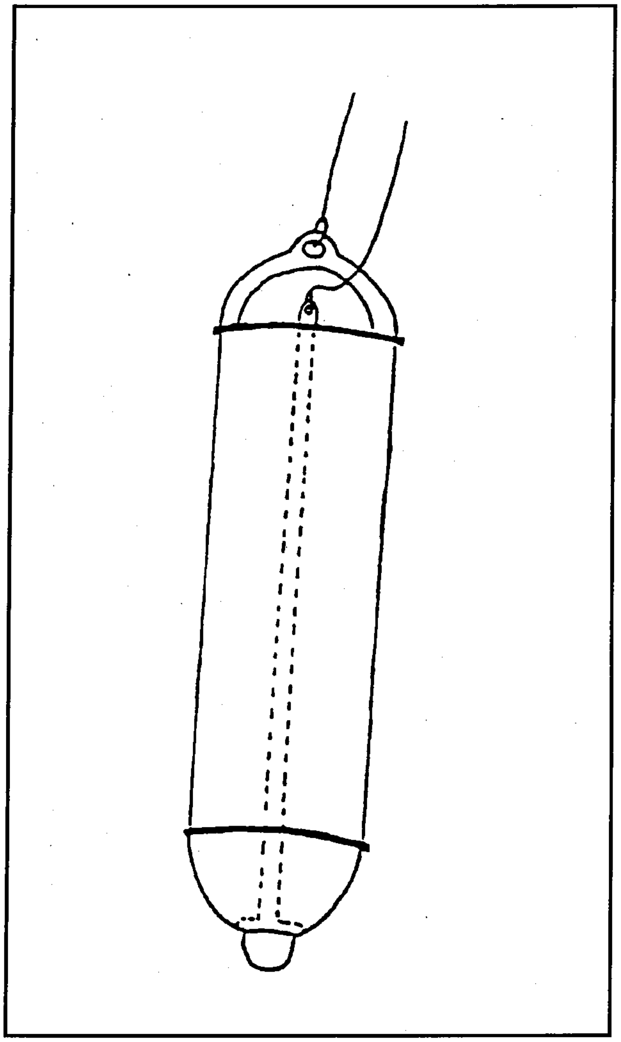


Figure C-7. Bacon bomb sampler

C.3.4.6.3 Sampling procedure. The recommended sampling procedure follows:

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination. If access to sampling location is restricted, locate a boat, barge, or other stable working platform adjacent to the area to be sampled.
- Measure and mark the sampler line at the desired sampling depth.
- Lower the Bacon bomb sampler carefully to the desired sampling depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line taut.
- Release the trigger line and retrieve the sampler.
- Transfer the sample to the sample bottles by pulling on the trigger. Allow the sample to flow down the side of the sample bottle with minimal disturbance.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.

- Record the information in the field logbook and complete all chain-of-custody records and field sheets (see Instruction F-1, "Documentation," in Appendix F).

- Decontaminate the sampler.

C.3.4.7 Storm water runoff sampling techniques.

C.3.4.7.1 Applicability. Grab and flow-weighted composite samples are required to complete NPDES storm-permit requirements.

C.3.4.7.2 Method summary and equipment. Samples of storm water runoff are taken into the sample containers directly, or a bucket and transferred to the appropriate sample bottle containers.

C.3.4.7.3 Grab sampling procedure. The sampling procedure is as follows:

- After rain begins to fall, record the date and time rain started to produce storm water runoff, facility number, outfall number, height of water in a measurement device (i.e., rain gauge), sample number, sample type, other items as directed on the NPDES storm water field sheet (see EPA/833/B-92/001).

- Lower the sample container or stainless steel or PTFE sampling bucket into the center of the runoff flow where turbulence is at a maximum. Hold the sample container so the opening faces upstream. Avoid stirring up bottom sediments and keep sample free of uncharacteristic floating debris.

- Allow the device to fill, using care not to overfill the bottle.

- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.

- Verify that a PTFE liner is present in the cap. Secure the cap tightly.

- Conduct visual observations as appropriate and record them in field log book.

- Label the sample bottle with an appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.

- Place filled sample containers on ice immediately along with the required trip blank, if analyzing for VOCs.

- Record the information in the field logbook and complete the chain-of-custody form and field sheets (See Instruction F-1, "Documentation," in Appendix F).

C.3.4.7.4 Flow-weighted composite sampling procedure. Flow-weighted composite sampling techniques are appropriate for most chemical parameters, with the exception of those noted as requiring grab sampling techniques within C.3.2.2 and 40 CFR 136. The aliquots for flow-weighted composite samples must be collected within the first 3 hours (or during the entire event if the storm is less than 3 hours). Equal aliquots may be collected at the time of sampling and then flow-proportioned and composited in the laboratory, or the aliquots taken may be based on the flow rate at the time of sample collection and composited in the field. Regulations require that a minimum of 15 minutes must separate the collection of each sample aliquot, and that a minimum frequency of three sample aliquots within each hour of discharge be maintained. To help meet regulatory requirements, suggest sample aliquots be collected at 20-minute intervals. Use the following procedure:

- After rain begins to fall, record the date and time rain started to produce storm water runoff, facility number, outfall number, height of water in the measurement device (i.e., rain gauge), sample number, sample type, other items as directed on the NPDES storm water field sheet (see EPA/833/B-92/001).
- Determine and record runoff flow at this time as noted within EPA/833/B-92/001. Determine appropriate volume for sample aliquot.
- Lower the sample container (for lab compositing) or stainless steel or PTFE sample aliquot measuring device (for onsite compositing) into the center of the runoff flow where turbulence is at a maximum. Record the time and water depth. Hold the sample container so the opening faces upstream. Avoid stirring up bottom sediments and keep sample free of uncharacteristic floating debris.
- Allow the device to fill with appropriate volumes based on flow observed, or suggest a minimum of 1000 mL be acquired for each aliquot (for lab compositing). NOTE: The laboratory should also be consulted to determine the overall sample volumes necessary for the required analyses to ensure that sufficient volumes of individual sample aliquots are collected to support the composite sample.
- Repeat the steps for bullets 2-4 for each aliquot of the composite sample, retaining each storm water sample aliquot in separate, labeled sample containers. As stated in Section C.3.4.7.4, regulations dictate a minimum frequency of three sample aliquots within each hour of the storm event for the first 3 hours or duration of the storm event, if less than 3 hours.
- If field compositing is performed and after the sample aliquots have been collected, combine appropriate volumes of sample aliquots into stainless steel or PTFE bucket to create the flow-weighted composite sample. Fill appropriate sample bottles with the composite sample mixture, using care not to overfill the bottle.
- Preserve the sample if necessary and verify that the pH is sufficient for the criteria.
- Verify that a PTFE liner is present in the cap. Secure the cap tightly.
- Conduct visual observations as appropriate and record them in field logbook.
- Label the sample bottle with an appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Record the information in the field logbook and complete the chain-of-custody form and field sheets (see Instruction F-1, "Documentation," in Appendix F).

C.3.4.8 Emerging and innovative sampling procedures.

C.3.4.8.1 Disadvantages of standard samplers. All of the standard samplers presented previously for the sampling of surface water disrupt equilibrium during the sampling event. This may lead to obtaining a sample that is not representative of the actual environmental conditions or contaminant concentrations. These routine sampling techniques also acquire a one-time sample, which reflects only environmental conditions at the time of sampling, and they are unable to assess episodic contamination. Additionally, there is little understanding of the correlation between routine surface water sample results and the concentrations of truly dissolved or bioavailable contaminants. Many of the Applicable, Relevant, and Appropriate Requirements (ARARs) for surface water, which are aquatic toxicity data or water quality criteria, are based on dissolved contamination concentrations. Therefore, the use of standard sampling techniques to generate data for comparison with these criteria may not be appropriate.

C.3.4.8.2 New sampling devices and procedures. New sampling devices and sampling procedures have been designed to minimize the disturbance to the medium during sampling to minimize any bias in the results. Recent studies have shown the application of semipermeable membrane devices (SPMDs) to the sampling of surface water bodies (Petty et al. 1995; Ellis et al. 1995). This type of sampler is designed to mimic the bioconcentration process by capturing only the dissolved/bioavailable contaminant concentrations and is an alternative to performing tissue analyses of various species or aquatic organisms. It is also unique in that it assesses episodic contamination, due to the residence time within the medium under investigation. Although the use of this technique may not be fully accepted by a data user or regulating authority without some initial redundancy to routine procedures, the advantages it offers are compelling. SPMDs are commercially available; easy to deploy, retrieve, and sample; and very low maintenance. They are also able to detect contaminants at lower concentrations than routine surface water samples due to their ability to concentrate the contaminants within the lipid phase, as well as extending residence times, which may further enhance contaminant detection at low levels.

C.3.4.8.3 SPMDs. SPMDs (Figures C-8 and C-9) are constructed of thin-walled nonporous polymer lay-flat tubes (of low-density polyethylene, polypropylene, PVC, or silicone) containing a large molecular weight (• 600 daltons) nonpolar liquid (of neutral lipids - such as triolein, or silicone fluids) as a sequestered medium. The SPMD is housed within a protective shroud to avoid damage to the SPMD during sampling events. The semipermeable membrane (i.e., high-density polyethylene) film has pore sizes of approximately 10 •, which effectively control the rate of dissolved contaminants uptake into the device. The SPMD capacity to sequester organic contaminants is dependent on the lipid/water partition coefficient K_{LW} for that organic target analyte. This K_{LW} value can be approximated from the value for the octanol/water partition coefficient K_{ow} for the target analyte. SPMDs may be suspended to a specified depth (e.g., 0.5 or 1 m) of the surface water body, secured by floats and anchors for a period of several days to weeks. In general, the rate of contaminant uptake increases as water temperature increases and decreases as the device is biofouled by aquatic organisms. If water is clear and photosensitive compounds are being evaluated, the SPMD should be shaded to reduce contaminant loss through degradation. Heterotrophic growth may be minimized by periodic treatment (dipping) of the SPMD into a biocide, and/or the protective shroud may be manufactured of materials (i.e., copper screen) that inhibit biofouling. Post sampling, the SPMDs are collected and placed in clean jars or cans on ice for cooling. Ship SPMD samples to the laboratory within 24 hours. Holding time studies for SPMDs have been sporadic and have not assessed all potential contaminants. However, one study determined that freezing of SPMDs caused no loss of herbicide concentrations during 6 months.

C.3.4.8.4 SPMD uses. SPMDs may be used to screen for polynuclear aromatic hydrocarbons (PAHs), organochlorine pesticides, polychlorinated biphenyls (PCBs), herbicides, methyl mercury complexes, alkylated selenides, etc. Unfortunately, the analytical chemistry and data reduction procedures used for SPMDs are more labor intensive than routine environmental samples. Generally, the analytical procedures involve the following: initial cleaning and integrity inspection of the membrane; spiking SPMD media with

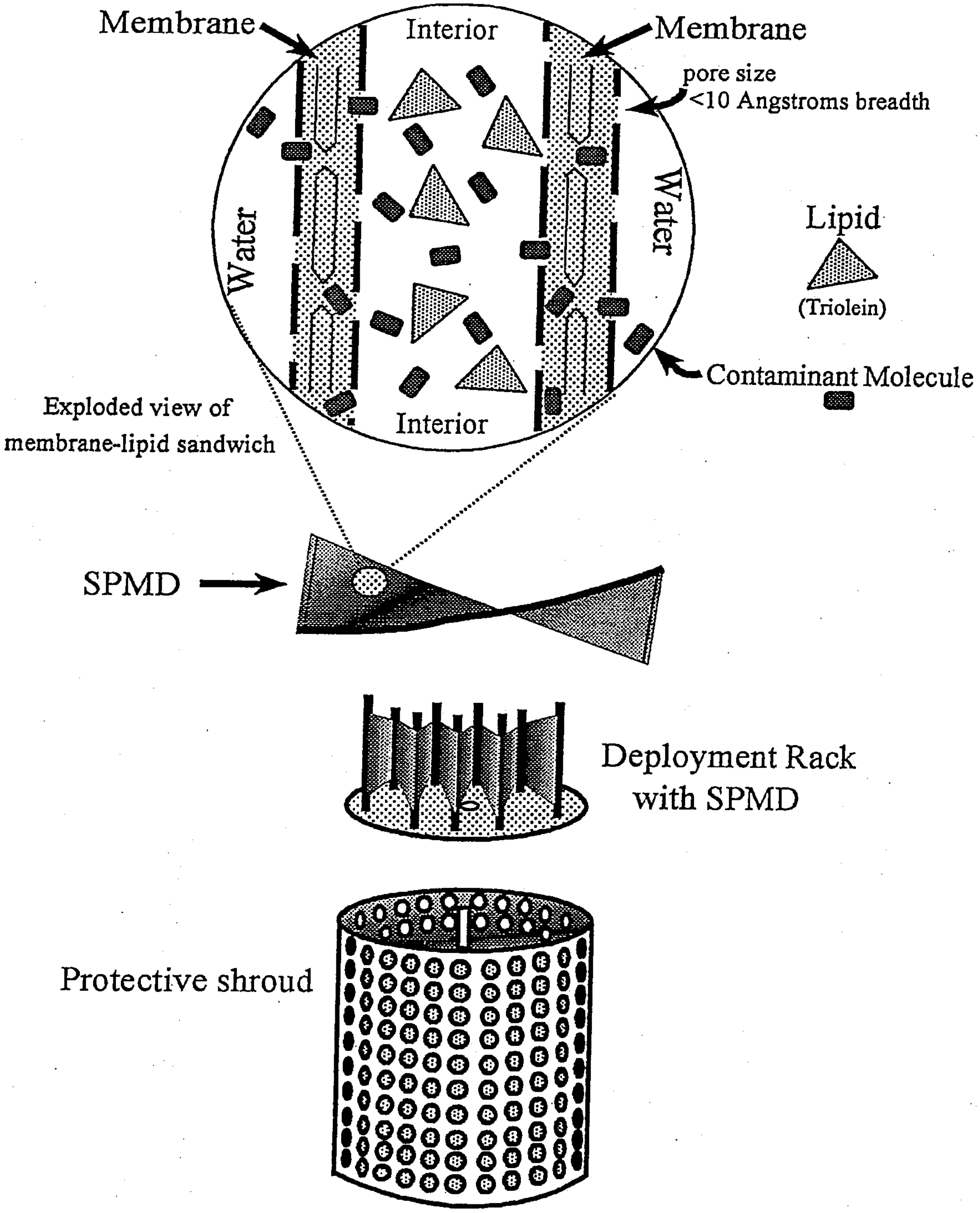


Figure C-8. Schematic of a semipermeable membrane device (SPMD)

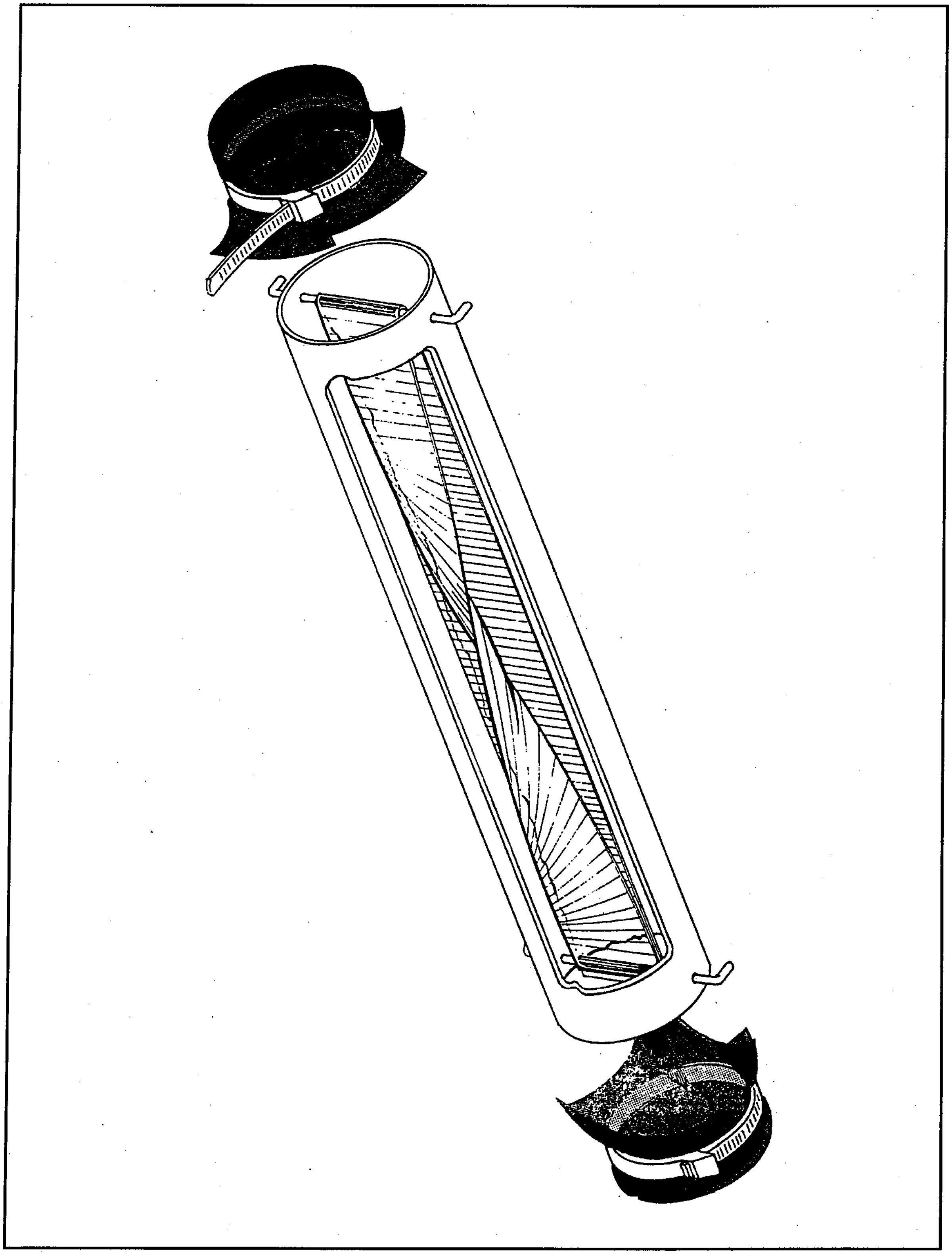


Figure C-9. Cutaway representation of an SPMD and protective shroud surrogates or internal standards; placing SPMD in an appropriate solvent (i.e., hexane) to perform dialysis; undergoing sulfur cleanup of dialysates (if applicable); performing size exclusion chromatography (i.e., gel permeation column); performing additional chromatographic cleanups (florisil, silica gel); and performing final solvent exchange (if applicable) and solvent reduction procedures. Finally the extract undergoes analysis by gas chromatograph or high-performance liquid chromatograph configured with appropriate detectors. Currently, a major disadvantage of SPMDs is that few environmental laboratories have any experience with dialysis procedures. Concentrations of contaminants from SPMD data are calculated with information from these partitioning coefficients, the uptake rate constant, and exposure times. Refer to Petty et al. (1995) and Ellis et al. (1995) for details on the mathematical model used for this calculation.

C.3.5 Decontamination procedures. All equipment that will enter the water must be decontaminated prior to its entry. The inside surface of pumps and tubing apparatus must be decontaminated by drawing the decontamination solution through the equipment. Sampling equipment should be decontaminated, as described in Instruction E-6 (Appendix E). The sampling equipment should be placed in plastic bags until immediately prior to use. Additional sampling devices may be needed onsite to ensure an adequate drying time. During transport and storage, sampling equipment and sample bottles must be physically separated from engines/ generators that are used to power some sampling equipment.

C.3.6 Field control samples requirements. Field control samples are collected by the sampling team to determine whether the data are of suitable quality. They include blanks, replicates, and/or background (upgradient) samples. QA samples are replicates sent to a referee (QA) laboratory and analyzed to evaluate the contractor's laboratory performance. QC samples are blind replicates collected by the sampling team for analysis by the primary laboratory. A detailed discussion of field control samples is presented in Instruction G-2 (Appendix G).

C.3.7 Documentation requirements. Bound field logbooks should be used for the maintenance of field records. Record all aspects of the site setup, sample collection, and handling as outlined above and in Instruction F-1 of Appendix F.

APPENDIX D

GROUNDWATER SAMPLING CHECKLIST

GROUNDWATER WELL SAMPLING CHECKLIST

SAMPLING PROCEDURE	**COMPLETED?**
PRE-SAMPLING	
PROPERTY OWNER CONTACTED	
LABORATORY CONTACTED 2 WEEKS PRIOR TO SAMPLING	
LABORATORY SAMPLE KIT, COOLER RECEIVED	
EQUIPMENT OBTAINED	
KEYS TO WELL LOCKS OBTAINED	
SAMPLING (EACH WELL)	
HEADSPACE READINGS COLLECTED	
DEPTH TO GROUNDWATER LEVEL COLLECTED (ALL WELLS MEASURED SAME DAY)	
WELLS PURGED	
SAMPLES COLLECTED	
DUPLICATE SAMPLE COLLECTED (MOST CONTAMINATED WELL)	
EQUIPMENT BLANK SAMPLE COLLECTED (ONE ONLY; AFTER SAMPLING A CONTAMINATED WELL)	
LABELS COMPLETED	
CHAIN OF CUSTODY COMPLETED	
CHAIN OF CUSTODY SEAL PLACED ON COOLER	
SAMPLES DELIVERED OR SHIPPED TO LABORATORY WITHIN 24 HOURS OF SAMPLE COLLECTION	
REPORT RECEIVED FROM LABORATORY	
LABORATORY REPORT FORWARDED TO USEPA AND MADEP WITHIN 60 DAYS OF SAMPLE DELIVERY/SHIPMENT	

Notes:
USEPA = United States Environmental Protection Agency
MADEP = Massachusetts Department of Environmental Protection

APPENDIX E

GROUNDWATER SAMPLING FORMS

CHAIN OF CUSTODY RECORD

HGL
HydroGeoLogic, Inc
Northway 10 Executive Park
313 Ushers Road
Ballston Lake, NY 12019

Client: ____________________

Project Name/No.: ____________________

Project Manager: ____________________

Sampler: ____________________

Phone: (518) 877-0390 Fax: (518) 877-0414

APPLICABLE REGULATION

- ☐ RCRA
- ☐ ECRA
- ☐ CERCLA
- ☐ NPDES
- ☐ CWA
- ☐ SDWA
- ☐ OTHER

					MATRIX				ANALYSIS REQUIRED								
SAMPLE IDENTIFICATION	DATE COLL.	TIME COLL.	GRAB	COMPOSITE	SOIL	WATER	OTHER	TOTAL NO. OF CONTAINERS									REMARKS OR SAMPLE LOCATION

Special Instructions

Possible Hazard Identification
☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal
☐ Return to Client ☐ Disposal by Lab ☐ Archive for ______ Months

Turn Around Time Required
☐ Normal ☐ Rush

QC Level
☐ I. ☐ II. ☐ III.

Project Specific (specify)

1. Relinquished by	Date	Time	1. Received by	Date	Time
2. Relinquished by	Date	Time	2. Received by	Date	Time
3. Relinquished by	Date	Time	3. Received by	Date	Time

Comments

HGL
HydroGeoLogic, Inc
Northway 10 Executive Park
313 Ushers Road
Ballston Lake, NY 12019
Phone: (518) 877-0390
Fax: (518) 877-0414

COOLER / SAMPLE RECEIPT FORM

Date cooler opened: ____________ By: ________________ HydroGeoLogic File No.: ____________
Date entered into LIMS: ____________ By: ________________ HydroGeoLogic Order No.: ____________

Cooler Identification: CAS cooler #: __________ / Client's Cooler / Box / Letter / Hand Delivered
Other: ______________________________

Cooler Size: Small / Medium / Large / NA

Delivered By: UPS / FedX / AirBrn / Pny Exp / Field S / Mail / Walk-in / Other ______________
Air Bill No.: ______________________________

Custody Seal: Present (intact or broken) Absent Seal No.: ______________
Seal matches Chain of Custody: Yes / No / NA

Type of Packing Material: BlueIce / Ice / Bubble / Foam / Paper / Peanuts / Vermiculite / NA

Cooler Temperature: (°C) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 ______________

Temp. By: Surface ________ Temp. Blank ________ Thermo. ID No.: ____________

Sample Receipt Discrepancies: ☐ No ☐ Yes (See detail below)

☐ Chain of Custody not present
 ☐ Information obtained from:
 Purchase Order / Letter received with samples
☐ Container label absent
☐ Chain of Custody incomplete
 ☐ Chain of Custody missing time sampled
  ☐ Time sampled obtained from container label
 ☐ Chain of Custody missing date sampled
  ☐ Date sampled obtained from container label
 ☐ Sample excluded from Chain of Custody: ________

☐ Broken or leaking containers: ______________
____
☐ Sample listed on Chain of Custody not received:
____
☐ Sample description on container label different from Chain of Custody: ______________
____
____
____
☐ Air bubbles in VOA vials: ______________

Detailed description/comments: ______________________________
____
____

Did Project manager contact client regarding cooler/sample receipt conditions: Yes / No
Who was contacted: ______________________ Remarks: ______________
____
____

Reviewed by Project Manager: ______________________ Date: ______________

HGL
HydroGeoLogic, Inc
Exceeding Expectations

DAILY QUALITY CONTROL REPORT

Date________________________

	S	M	T	W	Th	F	S
Weather							
Temp							
Wind							
Humidity							

USACE PROJECT MANAGER:
PROJECT:

CONTRACT NUMBER:

Equipment Onsite:

Work Performed:

Signature:

Date_______________________________

PROJECT:

CONTRACT
NUMBER:

Quality Control Activities (including field calibrations):

Health and Safety Level Activities:

Problems Encountered/Corrective Action Taken:

Special Notes

Signature: Title:

HGL HydroGeoLogic, Inc

FIELD SAMPLING REPORT

LOCATION: ________________________ PROJECT : __________________________

SITE: ______________________________

SAMPLE INFORMATION

MATRIX __________________________ SAMPLE ID: _________________________

SAMPLING METHOD _______________ DUP./REP. OF : _______________________

BEGINNING DEPTH ________________ MATRIX SPIKE/MATRIX SPIKE DUPLICATE
YES ( ) NO ( )

END DEPTH _______________________

GRAB ( ) COMPOSITE ( ) DATE: _____________ TIME: ___________

CONTAINER		PRESERVATIVE/ PREPARATION	EXTRACTION METHOD	ANALYTICAL METHOD	ANALYSIS
SIZE/TYPE	#				

NOTABLE OBSERVATIONS

PID READINGS	SAMPLE CHARACTERISTICS	MISCELLANEOUS
1st	COLOR:	
2nd	ODOR:	
	OTHER:	

pH ______ Temperature ________ Dissolved oxygen __________ Specific Conductivity__________

GENERAL INFORMATION

WEATHER: SUN/CLEAR _____ OVERCAST/RAIN _____ WIND DRIECTION ________ AMBIENT TEMP _______

SHIPMENT VIA: FED-X _____ HAND DELIVER ______ COURIER _______ OTHER ________

SHIPPED TO: ____

COMMENTS: ____

SAMPLER: ______________________________ OBSERVER: _________________________________

MATRIX TYPE CODES

DC=DRILL CUTTINGS	SL=SLUDGE
WG=GROUND WATER	SO=SOIL
LH=HAZARDOUS LIQUID WASTE	GS=SOIL GAS
SH=HAZARDOUS SOLID WASTE	WS=SURFACE WATER
SE=SEDIMENT	SW=SWAP\WIPE

SAMPLING METHOD CODES

B=BAILER	G=GRAB
BR=BRASS RING	HA=HAND AUGER
CS=COMPOSITE SAMPLE	H=HOLLOW STEM AUGER
C=CONTINUOUS FLIGHT AUGER	HP=HYDRO PUNCH
DT=DRIVEN TUBE	SS=SPLIT SPOON
W=SWAB\WIPE	SP=SUBMERSIBLE PUMP

HGL
HydroGeoLogic, Inc

GROUNDWATER FIELD SAMPLING DATA SHEET

Well Name.:	Project Name:	LOCID:
Sampler(s):	Project No.:	
Well Depth:	Date:	Time:
DTW (ft TOC):	Screen Interval:	
Well Diameter (in):	Placement of Pump (ft TOC):	
Type of Pump:		

Field Parameters

Time	Depth to Water (ft)	Flow Rate (gpm)	Total Volume (gal)	pH	Temp. (C)	Cond. (umhos/cm)	ORP	D.O. (mg/L)	Turb. (N.T.U.)	Description

Observations

Notes:
Signed/Sampler(s):

HTRW DRILLING LOG

		HOLE NO.
1. COMPANY NAME	2. DRILLING SUBCONTRACTOR	SHEET OF SHEETS
3. PROJECT	4. LOCATION	
5. NAME OF DRILLER	6. MANUFACTURER'S DESIGNATION OF DRILL	
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	8. HOLE LOCATION	
	9. SURFACE ELEVATION	
	10. DATE STARTED	11. DATE COMPLETED
12. OVERBURDEN THICKNESS	15. DEPTH GROUNDWATER ENCOUNTERED	
13. DEPTH DRILLED INTO ROCK	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	
14. TOTAL DEPTH OF HOLE	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES			
20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %
22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR		

ELEV a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREEING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE f	BLOW COUNTS g	REMARKS h

HTRW DRILLING LOG

HOLE NO.

PROJECT

INSPECTOR

SHEET
OF SHEETS

ELEV a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREEING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE f	BLOW COUNTS g	REMARKS h

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HydroGeoLogic, Inc

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STATIC GROUNDWATER ELEVATION LOG

Project Name: ______________________________

Project No.: ______________________________

Water Level Indicator ID#: ____________________ **PID Meter ID#:** ____________________

Well Identification	Date	Time	Static Depth to Water (from TOC)	Depth to Product (from TOC)	PID Reading	Comments

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Exceeding Expectations

Devens/Sudbury LTM Event
Daily Instrument and Calibration Log

Circle One:
Spring/Fall

Date:

Standard Value Standard Lot Number	pH4	pH7	pH10	SC 150 µS/cm (Low)	SC 1,000 µS/cm (High)	Zobell Solution	100% Sat. (%)	(mg/L)	Water 0.0mg/L
Instrument Serial #	pH4	pH7	pH10	SC 150 µS/cm	SC 1,000 µS/cm	ORP	D.O.	D.O.	D.O.
Pre Calibration									
Calibrated									
End of Day Drift									
Instrument Serial #	pH4	pH7	pH10	SC 150 µS/cm	SC 1,000 µS/cm	ORP	D.O.	D.O.	D.O.
Pre Calibration									
Calibrated									
End of Day Drift									
Instrument Serial #	pH4	pH7	pH10	SC 150 µS/cm	SC 1,000 µS/cm	ORP	D.O.	D.O.	D.O.
Pre Calibration									
Calibrated									
End of Day Drift									
Instrument Serial #	pH4	pH7	pH10	SC 150 µS/cm	SC 1,000 µS/cm	ORP	D.O.	D.O.	D.O.
Pre Calibration									
Calibrated									
End of Day Drift									
Instrument Serial #	pH4	pH7	pH10	SC 150 µS/cm	SC 1,000 µS/cm	ORP	D.O.	D.O.	D.O.
Pre Calibration									
Calibrated									
End of Day Drift									

HGL
HydroGeoLogic, Inc
Exceeding Expectations

SITE SAFETY BRIEFING FORM

Project Ft. Devens Groundwater Monitoring **Location** Ft. Devens, MA
Date **Time**
Type of Work Groundwater Sampling

SAFETY TOPICS PRESENTED

Protective Clothing/Equipment

Chemical Hazards VPH/EPH/Metals/PCBs/Pest

Physical Hazards Slip/Trip/Fall

Biological Hazards

Emergency Procedures Refer to Site Safety and Health Plan

Hospital/Clinic Deaconess-Nashoba Community Hospital **Phone** 978-772-0200
Hospital Address
200 Groton Road, Ayer
MA_1432
Special Equipment
Other Call 9-1-1 if emergency

ATTENDEES

Name (Printed)	Signature

Meeting Conducted by:

Site Safety Officer:

HGL
HydroGeoLogic, Inc
Exceeding Expectations

SITE SAFETY BRIEFING FORM

Project Sudbury Groundwater Monitoring **Location** Sudbury, MA
Date **Time**
Type of Work Groundwater Sampling

SAFETY TOPICS PRESENTED

Protective Clothing/Equipment

Chemical Hazards VOCs/Metals/Pesticides/Cyanide

Physical Hazards Slip/Trip/Fall

Biological Hazards Ticks, Hornets

Emergency Procedures Refer to Site Safety and Health Plan

Hospital/Clinic Umass Memorial Marlborough Hospital **Phone** 508-481-5000
Hospital Address 157 Union Street, Marlborough, MA
Special Equipment
Other Call 9-1-1 if emergency

ATTENDEES

Name (Printed)	Signature

Meeting Conducted by:

Site Safety Officer:

APPENDIX F

USEPA REGION 1 LOW STRESS (LOW FLOW) PURGING AND SAMPLING PROCEDURES

U.S. ENVIRONMENTAL PROTECTION AGENCY REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUNDWATER SAMPLES FROM MONITORING WELLS

Quality Assurance Unit
U.S. Environmental Protection Agency – Region 1
11 Technology Drive
North Chelmsford, MA 01863

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Prepared by: Charles Porfert 1/19/10
(Charles Porfert, Quality Assurance Unit) Date

Approved by: Gerard Sotolongo 1-19-10
(Gerard Sotolongo, Quality Assurance Unit) Date

Revision Page

Date	Rev #	Summary of changes	Sections
7/30/96	2	Finalized	
01/19/10	3	Updated	All sections

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USE OF TERMS

Equipment blank: The equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank needs only to include the pump in subsequent sampling rounds. If the pump and tubing are dedicated to the well, the equipment blank is collected prior to its placement in the well. If the pump and tubing will be used to sample multiple wells, the equipment blank is normally collected after sampling from contaminated wells and not after background wells.

Field duplicates: Field duplicates are collected to determine precision of the sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

Indicator field parameters: This SOP uses field measurements of turbidity, dissolved oxygen, specific conductance, temperature, pH, and oxidation/reduction potential (ORP) as indicators of when purging operations are sufficient and sample collection may begin.

Matrix Spike/Matrix Spike Duplicates: Used by the laboratory in its quality assurance program. Consult the laboratory for the sample volume to be collected.

Poteniometric Surface: The level to which water rises in a tightly cased well constructed in a confined aquifer. In an unconfined aquifer, the potentiometric surface is the water table.

QAPP: Quality Assurance Project Plan

SAP: Sampling and Analysis Plan

SOP: Standard operating procedure

Stabilization: A condition that is achieved when all indicator field parameter measurements are sufficiently stable (as described in the "Monitoring Indicator Field Parameters" section) to allow sample collection to begin.

Temperature blank: A temperature blank is added to each sample cooler. The blank is measured upon receipt at the laboratory to assess whether the samples were properly cooled during transit.

Trip blank (VOCs): Trip blank is a sample of analyte-free water taken to the sampling site and returned to the laboratory. The trip blanks (one pair) are added to each sample cooler that contains VOC samples.

SCOPE & APPLICATION

The goal of this groundwater sampling procedure is to collect water samples that reflect the total mobile organic and inorganic loads (dissolved and colloidal sized fractions) transported through the subsurface under ambient flow conditions, with minimal physical and chemical alterations from sampling operations. This standard operating procedure (SOP) for collecting groundwater samples will help ensure that the project's data quality objectives (DQOs) are met under certain low-flow conditions.

The SOP emphasizes the need to minimize hydraulic stress at the well-aquifer interface by maintaining low water-level drawdowns, and by using low pumping rates during purging and sampling operations. Indicator field parameters (e.g., dissolved oxygen, pH, etc.) are monitored during purging in order to determine when sample collection may begin. Samples properly collected using this SOP are suitable for analysis of groundwater contaminants (volatile and semi-volatile organic analytes, dissolved gases, pesticides, PCBs, metals and other inorganics), or naturally occurring analytes. This SOP is based on Puls, and Barcelona (1996).

This procedure is designed for monitoring wells with an inside diameter (1.5-inches or greater) that can accommodate a positive lift pump with a screen length or open interval ten feet or less and with a water level above the top of the screen or open interval (Hereafter, the "screen or open interval" will be referred to only as "screen interval"). This SOP is not applicable to other well-sampling conditions.

While the use of dedicated sampling equipment is not mandatory, dedicated pumps and tubing can reduce sampling costs significantly by streamlining sampling activities and thereby reducing the overall field costs.

The goal of this procedure is to emphasize the need for consistency in deploying and operating equipment while purging and sampling monitoring wells during each sampling event. This will help to minimize sampling variability.

This procedure describes a general framework for groundwater sampling. Other site specific information (hydrogeological context, conceptual site model (CSM), DQOs, etc.) coupled with systematic planning must be added to the procedure in order to develop an appropriate site specific SAP/QAPP. In addition, the site specific SAP/QAPP must identify the specific equipment that will be used to collect the groundwater samples.

This procedure does not address the collection of water or free product samples from wells containing free phase LNAPLs and/or DNAPLs (light or dense non-aqueous phase liquids). For this type of situation, the reader may wish to check: Cohen, and Mercer (1993) or other pertinent documents.

This SOP is to be used when collecting groundwater samples from monitoring wells at all Superfund, Federal Facility and RCRA sites in Region 1 under the conditions described herein. Request for modification of this SOP, in order to better address specific situations at individual wells, must include adequate technical justification for proposed changes. <u>All changes and modifications must be approved and included in a revised SAP/QAPP before implementation in field.</u>

BACKGROUND FOR IMPLEMENTATION

It is expected that the monitoring well screen has been properly located (both laterally and vertically) to intercept existing contaminant plume(s) or along flow paths of potential contaminant migration. Problems with inappropriate monitoring well placement or faulty/improper well installation cannot be overcome by even the best water sampling procedures. This SOP presumes that the analytes of interest are moving (or will potentially move) primarily through the more permeable zones intercepted by the screen interval.

Proper well construction, development, and operation and maintenance cannot be overemphasized. The use of installation techniques that are appropriate to the hydrogeologic setting of the site often prevent "problem well" situations from occurring. During well development, or redevelopment, tests should be conducted to determine the hydraulic characteristics of the monitoring well. The data can then be used to set the purging/sampling rate, and provide a baseline for evaluating changes in well performance and the potential need for well rehabilitation. Note: if this installation data or well history (construction and sampling) is not available or discoverable, for all wells to be sampled, efforts to build a sampling history should commence with the next sampling event.

The pump intake should be located within the screen interval and at a depth that will remain under water at all times. It is recommended that the intake depth and pumping rate remain the same for all sampling events. The mid-point or the lowest historical midpoint of the saturated screen length is often used as the location of the pump intake. For new wells, or for wells without pump intake depth information, the site's SAP/QAPP must provide clear reasons and instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected. If the depths to top and bottom of the well screen are not known, the SAP/QAPP will need to describe how the sampling depth will be determined and how the data can be used.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU, and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection may still take place provided the indicator field parameter criteria in this procedure are met. If after 2 hours of purging indicator field parameters have not stabilized, one of three optional courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization), c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may reflect a sampling bias and therefore, the data may not meet the data quality objectives of the sampling event).

It is recommended that low-flow sampling be conducted when the air temperature is above 32°F (0°C). If the procedure is used below 32°F, special precautions will need to be taken to prevent the groundwater from freezing in the equipment. Because sampling during freezing temperatures may adversely impact the data quality objectives, the need for water sample collection during months when these conditions are likely to occur should be evaluated during site planning and special sampling measures may need to be developed. Ice formation in the flow-through-cell will cause the monitoring probes to act erratically. A transparent flow-through-cell needs to be used to observe if ice is forming in the cell. If ice starts to form on the other pieces of the sampling equipment, additional problems may occur.

HEALTH & SAFETY

When working on-site, comply with all applicable OSHA requirements and the site's health/safety procedures. All proper personal protection clothing and equipment are to be worn. Some samples may contain biological and chemical hazards. These samples should be handled with suitable protection to skin, eyes, etc.

CAUTIONS

The following cautions need to be considered when planning to collect groundwater samples when the below conditions occur.

If the groundwater degasses during purging of the monitoring well, dissolved gases and VOCs will be lost. When this happens, the groundwater data for dissolved gases (e.g., methane, ethene, ethane, dissolved oxygen, etc.) and VOCs will need to be qualified. Some conditions that can promote degassing are the use of a vacuum pump (e.g., peristaltic pumps), changes in aperture along the sampling tubing, and squeezing/pinching the pump's tubing which results in a pressure change.

When collecting the samples for dissolved gases and VOCs analyses, avoid aerating the groundwater in the pump's tubing. This can cause loss of the dissolved gases and VOCs in the groundwater. Having the pump's tubing completely filled prior to sampling will avoid this problem when using a centrifugal pump or peristaltic pump.

Direct sun light and hot ambient air temperatures may cause the groundwater in the tubing and flow-through-cell to heat up. This may cause the groundwater to degas which will result in loss of VOCs and dissolved gases. When sampling under these conditions, the sampler will need to shade the equipment from the sunlight (e.g., umbrella, tent, etc.). If possible, sampling on hot days, or during the hottest time of the day, should be avoided. The tubing exiting the monitoring well should be kept as short as possible to avoid the sun light or ambient air from heating up the groundwater.

Thermal currents in the monitoring well may cause vertical mixing of water in the well bore. When the air temperature is colder than the groundwater temperature, it can cool the top of the water column. Colder water which is denser than warm water sinks to the bottom of the well and the warmer water at the bottom of the well rises, setting up a convention cell. "During low-flow sampling, the pumped water may be a mixture of convecting water from within the well casing and aquifer water moving inward through the screen. This mixing of water during low-flow sampling can substantially increase equilibration times, can cause false stabilization of indicator parameters, can give false indication of redox state, and can provide biological data that are not representative of the aquifer conditions" (Vroblesky 2007).

Failure to calibrate or perform proper maintenance on the sampling equipment and measurement instruments (e.g., dissolved oxygen meter, etc.) can result in faulty data being collected.

Interferences may result from using contaminated equipment, cleaning materials, sample containers, or uncontrolled ambient/surrounding air conditions (e.g., truck/vehicle exhaust nearby).

Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment and/or proper planning to avoid ambient air interferences. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

Clean and decontaminate all sampling equipment prior to use. All sampling equipment needs to be routinely checked to be free from contaminants and equipment blanks collected to ensure that the equipment is free of contaminants. Check the previous equipment blank data for the site (if they exist) to determine if the previous cleaning procedure removed the contaminants. If contaminants were detected and they are a concern, then a more vigorous cleaning procedure will be needed.

PERSONNEL QUALIFICATIONS

All field samplers working at sites containing hazardous waste must meet the requirements of the OSHA regulations. OSHA regulations may require the sampler to take the 40 hour OSHA health and safety training course and a refresher course prior to engaging in any field activities, depending upon the site and field conditions.

The field samplers must be trained prior to the use of the sampling equipment, field instruments, and procedures. Training is to be conducted by an experienced sampler before initiating any sampling procedure.

The entire sampling team needs to read, and be familiar with, the site Health and Safety Plan, all relevant SOPs, and SAP/QAPP (and the most recent amendments) before going onsite for the sampling event. It is recommended that the field sampling leader attest to the understanding of these site documents and that it is recorded.

EQUIPMENT AND SUPPLIES

A. Informational materials for sampling event

A copy of the current Health and Safety Plan, SAP/QAPP, monitoring well construction data, location map(s), field data from last sampling event, manuals for sampling, and the monitoring instruments' operation, maintenance, and calibration manuals should be brought to the site.

B. Well keys.

C. Extraction device

Adjustable rate, submersible pumps (e.g., centrifugal, bladder, etc.) which are constructed of stainless steel or Teflon are preferred. Note: if extraction devices constructed of other materials are to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

If bladder pumps are selected for the collection of VOCs and dissolved gases, the pump setting should be set so that one pulse will deliver a water volume that is sufficient to fill a 40 mL VOC vial. This is not mandatory, but is considered a "best practice". For the proper operation, the bladder pump will need a minimum amount of water above the pump; consult the manufacturer for the recommended submergence. The pump's recommended submergence value should be determined during the planning stage, since it may influence well construction and placement of dedicated pumps where water-level fluctuations are significant.

Adjustable rate, peristaltic pumps (suction) are to be used with caution when collecting samples for VOCs and dissolved gases (e.g., methane, carbon dioxide, etc.) analyses. Additional information on the use of peristaltic pumps can be found in Appendix A. If peristaltic pumps are used, the inside diameter of the rotor head tubing needs to match the inside diameter of the tubing installed in the monitoring well.

Inertial pumping devices (motor driven or manual) are not recommended. These devices frequently cause greater disturbance during purging and sampling, and are less easily controlled than submersible pumps (potentially increasing turbidity and sampling variability, etc.). This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

D. Tubing

Teflon or Teflon-lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics. Note: if tubing constructed of other materials is to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for metal and other inorganics analyses.

The use of 1/4 inch or 3/8 inch (inside diameter) tubing is recommended. This will help ensure that the tubing remains liquid filled when operating at very low pumping rates when using centrifugal and peristaltic pumps.

Silastic tubing should be used for the section around the rotor head of a peristaltic pump. It should be less than a foot in length. The inside diameter of the tubing used at the pump rotor head must be the same as the inside diameter of tubing placed in the well. A tubing connector is used to connect the pump rotor head tubing to the well tubing. Alternatively, the two pieces of tubing can be connected to each other by placing the one end of the tubing inside the end of the other tubing. The tubing must not be reused.

E. The water level measuring device

Electronic "tape", pressure transducer, water level sounder/level indicator, etc. should be capable of measuring to 0.01 foot accuracy. Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include check measurements with a water level "tape" at the start and end of each sampling event.

F. Flow measurement supplies

Graduated cylinder (size according to flow rate) and stopwatch usually will suffice.

Large graduated bucket used to record total water purged from the well.

G. Interface probe

To be used to check on the presence of free phase liquids (LNAPL, or DNAPL) before purging begins (as needed).

H. Power source (generator, nitrogen tank, battery, etc.)

When a gasoline generator is used, locate it downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate samples.

I. Indicator field parameter monitoring instruments

Use of a multi-parameter instrument capable of measuring pH, oxidation/reduction potential (ORP), dissolved oxygen (DO), specific conductance, temperature, and coupled with a flow-through-cell is required when measuring all indicator field parameters, except turbidity. Turbidity is collected using a separate instrument. Record equipment/instrument identification (manufacturer, and model number).

Transparent, small volume flow-through-cells (e.g., 250 mLs or less) are preferred. This allows observation of air bubbles and sediment buildup in the cell, which can interfere with the operation of the monitoring instrument probes, to be easily detected. A small volume cell facilitates rapid turnover of water in the cell between measurements of the indicator field parameters.

It is recommended to use a flow-through-cell and monitoring probes from the same manufacturer and model to avoid incompatibility between the probes and flow-through-cell.

Turbidity samples are collected before the flow-through-cell. A "T" connector coupled with a valve is connected between the pump's tubing and flow-through-cell. When a turbidity measurement is required, the valve is opened to allow the groundwater to flow into a container. The valve is closed and the container sample is then placed in the turbidimeter.

Standards are necessary to perform field calibration of instruments. A minimum of two standards are needed to bracket the instrument measurement range for all parameters except ORP which use a Zobell solution as a standard. For dissolved oxygen, a wet sponge used for the 100% saturation and a zero dissolved oxygen solution are used for the calibration.

Barometer (used in the calibration of the Dissolved Oxygen probe) and the conversion formula to convert the barometric pressure into the units of measure used by the Dissolved Oxygen meter are needed.

J. Decontamination supplies

Includes (for example) non-phosphate detergent, distilled/deionized water, isopropyl alcohol, etc.

K. Record keeping supplies

Logbook(s), well purging forms, chain-of-custody forms, field instrument calibration forms, etc.

L. Sample bottles

M. Sample preservation supplies (as required by the analytical methods)

N. Sample tags or labels

O. PID or FID instrument

If appropriate, to detect VOCs for health and safety purposes, and provide qualitative field evaluations.

P. Miscellaneous Equipment

Equipment to keep the sampling apparatus shaded in the summer (e.g., umbrella) and from freezing in the winter. If the pump's tubing is allowed to heat up in the warm weather, the cold groundwater may degas as it is warmed in the tubing.

EQUIPMENT/INSTRUMENT CALIBRATION

Prior to the sampling event, perform maintenance checks on the equipment and instruments according to the manufacturer's manual and/or applicable SOP. This will ensure that the equipment/instruments are working properly before they are used in the field.

Prior to sampling, the monitoring instruments must be calibrated and the calibration documented. The instruments are calibrated using U.S Environmental Protection Agency Region 1 *Calibration of Field Instruments (temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction [ORP], and turbidity),* January 19, 2010, or latest version or from one of the methods listed in 40CFR136, 40CFR141 and SW-846.

The instruments shall be calibrated at the beginning of each day. If the field measurement falls outside the calibration range, the instrument must be re-calibrated so that all measurements fall within the calibration range. At the end of each day, a calibration check is performed to verify that instruments remained in calibration throughout the day. This check is performed while the instrument is in measurement mode, not calibration mode. If the field instruments are being used to monitor the natural attenuation parameters, then a calibration check at mid-day is highly recommended to ensure that the instruments did not drift out of calibration. Note: during the day if the instrument reads zero or a negative number for dissolved oxygen, pH, specific conductance, or turbidity (negative value only), this indicates that the instrument drifted out of calibration or the instrument is malfunctioning. If this situation occurs the data from this instrument will need to be qualified or rejected.

PRELIMINARY SITE ACTIVITIES (as applicable)

Check the well for security (damage, evidence of tampering, missing lock, etc.) and record pertinent observations (include photograph as warranted).

If needed lay out sheet of clean polyethylene for monitoring and sampling equipment, unless equipment is elevated above the ground (e.g., on a table, etc.).

Remove well cap and if appropriate measure VOCs at the rim of the well with a PID or FID instrument and record reading in field logbook or on the well purge form.

If the well casing does not have an established reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook (consider a photographic record as well). All water level measurements must be recorded relative to this reference point (and the altitude of this point should be determined using techniques that are appropriate to site's DQOs.

If water-table or potentiometric surface map(s) are to be constructed for the sampling event, perform synoptic water level measurement round (in the shortest possible time) before any purging and sampling activities begin. If possible, measure water level depth (to 0.01 ft.) and total well depth (to 0.1 ft.) the day before sampling begins, in order to allow for re-settlement of any particulates in the water column. This is especially important for those wells that have not been recently sampled because sediment buildup in the well may require the well to be redeveloped. If measurement of total well depth is not made the day before, it should be measured after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe may not be necessary unless analytical data or field analysis signal a worsening situation. This SOP cannot be used in the presence of LNAPLs or DNAPLs. If NAPLs are present, the project team must decide upon an alternate sampling method. All project modifications must be approved and documented prior to implementation.

If available check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). If changes are made in the intake depth or extraction rate(s) used during previous sampling event(s), for either portable or dedicated extraction devices, record new values, and explain reasons for the changes in the field logbook.

PURGING AND SAMPLING PROCEDURE

Purging and sampling wells in order of increasing chemical concentrations (known or anticipated) are preferred.

The use of dedicated pumps is recommended to minimize artificial mobilization and entrainment of particulates each time the well is sampled. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

A. Initial Water Level

Measure the water level in the well before installing the pump if a non-dedicated pump is being used. The initial water level is recorded on the purge form or in the field logbook.

B. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the appropriate depth (may not be the mid-point of the screen/open interval). The Sampling and Analysis Plan/Quality Assurance Project Plan should specify the sampling depth (used previously), or provide criteria for selection of intake depth for each new well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well.

Pump tubing lengths, above the top of well casing should be kept as short as possible to minimize heating the groundwater in the tubing by exposure to sun light and ambient air temperatures. Heating may cause the groundwater to degas, which is unacceptable for the collection of samples for VOC and dissolved gases analyses.

C. Measure Water Level

Before starting pump, measure water level. Install recording pressure transducer, if used to track drawdowns, to initialize starting condition.

D. Purge Well

From the time the pump starts purging and until the time the samples are collected, the purged water is discharged into a graduated bucket to determine the total volume of groundwater purged. This information is recorded on the purge form or in the field logbook.

Start the pump at low speed and slowly increase the speed until discharge occurs. Check water level. Check equipment for water leaks and if present fix or replace the affected equipment. Try to match pumping rate used during previous sampling event(s). Otherwise, adjust pump speed until there is little or no water level drawdown. If the minimal drawdown that can be achieved exceeds 0.3 feet, but remains stable, continue purging.

Monitor and record the water level and pumping rate every five minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump to ensure stabilization of the water level. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" somewhat as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. If the initial water level is above the top of the screen do not allow the water level to fall into the well screen. The final purge volume must be greater than the stabilized drawdown volume plus the pump's tubing volume. If the drawdown has exceeded 0.3 feet and stabilizes, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are collected.

Avoid the use of constriction devices on the tubing to decrease the flow rate because the constrictor will cause a pressure difference in the water column. This will cause the groundwater to degas and result in a loss of VOCs and dissolved gasses in the groundwater samples.

Note: the flow rate used to achieve a stable pumping level should remain constant while monitoring the indicator parameters for stabilization and while collecting the samples.

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (e.g., bladder, peristaltic), and/or the use of dedicated equipment. For new monitoring wells, or wells where the following situation has not occurred before, if the recovery rate to the well is less than 50 mL/min., or the well is being essentially dewatered during purging, the well should be sampled as soon as the water level has recovered sufficiently to collect the volume needed for all anticipated samples. The project manager or field team leader will need to make the decision when samples should be collected, how the sample is to be collected, and the reasons recorded on the purge form or in the field logbook. A water level measurement needs to be performed and recorded before samples are collected. If the project manager decides to collect the samples using the pump, it is best during this recovery period that the pump intake tubing not be removed, since this will aggravate any turbidity problems. Samples in this specific situation may be collected without stabilization of indicator field parameters. Note that field conditions and efforts to overcome problematic situations must be recorded in order to support field decisions to deviate from normal procedures described in this SOP. If this type of problematic situation persists in a well, then water sample collection should be changed to a passive or no-purge method, if consistent with the site's DQOs, or have a new well installed.

E. Monitor Indicator Field Parameters

After the water level has stabilized, connect the "T" connector with a valve and the flow-through-cell to monitor the indicator field parameters. If excessive turbidity is anticipated or encountered with the pump startup, the well may be purged for a while without connecting up the flow-through-cell, in order to minimize particulate buildup in the cell (This is a judgment call made by the sampler). Water level drawdown measurements should be made as usual. If possible, the pump may be installed the day before purging to allow particulates that were disturbed during pump insertion to settle.

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, ORP, DO) at a frequency of five minute intervals or greater. The pump's flow rate must be able to "turn over" at least one flow-through-cell volume between measurements (for a 250 mL flow-through-cell with a flow rate of 50 mLs/min., the monitoring frequency would be every five minutes; for a 500 mL flow-through-cell it would be every ten minutes). If the cell volume cannot be replaced in the five minute interval, then the time between measurements must be increased accordingly. Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments followed by stabilization of indicator parameters. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings are within the following limits:

Turbidity (10% for values greater than 5 NTU; if three Turbidity values are less than 5 NTU, consider the values as stabilized),
Dissolved Oxygen (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),
Specific Conductance (3%),
Temperature (3%),
pH (± 0.1 unit),
Oxidation/Reduction Potential (±10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Samples for turbidity measurements are obtained before water enters the flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values measured within the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities. Record start and stop times and give a brief description of cleaning activities.

The flow-through-cell must be designed in a way that prevents gas bubble entrapment in the cell. Placing the flow-through-cell at a 45 degree angle with the port facing upward can help remove bubbles from the flow-through-cell (see Appendix B Low-Flow Setup Diagram). All during the measurement process, the flow-through-cell must remain free of any gas bubbles. Otherwise, the monitoring probes may act erratically. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must remain submerged in water at all times.

F. Collect Water Samples

When samples are collected for laboratory analyses, the pump's tubing is disconnected from the "T" connector with a valve and the flow-through-cell. The samples are collected directly from the pump's tubing. Samples must not be collected from the flow-through-cell or from the "T" connector with a valve.

VOC samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the pump's flow rate is too high to collect the VOC/dissolved gases samples, collect the other samples first. Lower the pump's flow rate to a reasonable rate and collect the VOC/dissolved gases samples and record the new flow rate.

During purging and sampling, the centrifugal/peristaltic pump tubing must remain filled with water to avoid aeration of the groundwater. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use the following procedure to collect samples: collect non-VOC/dissolved gases samples first, then increase flow rate slightly until the water completely fills the tubing, collect the VOC/dissolved gases samples, and record new drawdown depth and flow rate.

For bladder pumps that will be used to collect VOC or dissolved gas samples, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 mL VOC vial.

Use pre-preserved sample containers or add preservative, as required by analytical methods, to the samples immediately after they are collected. Check the analytical methods (e.g. EPA SW-846, 40 CFR 136, water supply, etc.) for additional information on preservation.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter (transparent housing preferred) is required, and the filter size (0.45 μm is commonly used) should be based on the sampling objective. Pre-rinse the filter with groundwater prior to sample collection. Make sure the filter is free of air bubbles before samples are collected. Preserve the filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in groundwater for human health or ecological risk calculations.

Label each sample as collected. Samples requiring cooling will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

G. Post Sampling Activities

If a recording pressure transducer is used to track drawdown, re-measure water level with tape.

After collection of samples, the pump tubing may be dedicated to the well for re-sampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth annually is usually sufficient after the initial low stress sampling event. However, a greater frequency may be needed if the well has a "silting" problem or if confirmation of well identity is needed.

Secure the well.

DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and then following sampling of each well. Pumps should not be removed between purging and sampling operations. The pump, tubing, support cable and electrical wires which were in contact with the well should be decontaminated by one of the procedures listed below.

The use of dedicated pumps and tubing will reduce the amount of time spent on decontamination of the equipment. If dedicated pumps and tubing are used, only the initial sampling event will require decontamination of the pump and tubing.

Note if the previous equipment blank data showed that contaminant(s) were present after using the below procedure or the one described in the SAP/QAPP, a more vigorous procedure may be needed.

Procedure 1

Decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump and tubing. The pump may be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

Optional - flush with isopropyl alcohol (pesticide grade; must be free of ketones {e.g., acetone}) or with methanol. This step may be required if the well is highly contaminated or if the equipment blank data from the previous sampling event show that the level of contaminants is significant.

Flush with distilled/deionized water. This step must remove all traces of alcohol (if used) from the equipment. The final water rinse must not be recycled.

Procedure 2

Steam clean the outside of the submersible pump.

Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the groundwater samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. Quality control samples include field duplicates, equipment blanks, matrix spike/matrix spike duplicates, trip blanks (VOCs), and temperature blanks.

FIELD LOGBOOK

A field log shall be kept to document all groundwater field monitoring activities (see Appendix C, example table), and record the following for each well:

Site name, municipality, state.

Well identifier, latitude-longitude or state grid coordinates.

Measuring point description (e.g., north side of PVC pipe).

Well depth, and measurement technique.

Well screen length.

Pump depth.

Static water level depth, date, time and measurement technique.

Presence and thickness of immiscible liquid (NAPL) layers and detection method.

Pumping rate, drawdown, indicator parameters values, calculated or measured total volume pumped, and clock time of each set of measurements.

Type of tubing used and its length.

Type of pump used.

Clock time of start and end of purging and sampling activity.

Types of sample bottles used and sample identification numbers.

Preservatives used.

Parameters requested for analyses.

Field observations during sampling event.

Name of sample collector(s).

Weather conditions, including approximate ambient air temperature.

QA/QC data for field instruments.

Any problems encountered should be highlighted.

Description of all sampling/monitoring equipment used, including trade names, model number, instrument identification number, diameters, material composition, etc.

DATA REPORT

Data reports are to include laboratory analytical results, QA/QC information, field indicator parameters measured during purging, field instrument calibration information, and whatever other field logbook information is needed to allow for a full evaluation of data usability.

Note: the use of trade, product, or firm names in this sampling procedure is for descriptive purposes only and does not constitute endorsement by the U.S. EPA.

REFERENCES

Cohen, R.M. and J.W. Mercer, 1993, *DNAPL Site Evaluation*; C.K. Smoley (CRC Press), Boca Raton, Florida.

Robert W. Puls and Michael J. Barcelona, *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*, April 1996 (EPA/540/S-95/504).

U.S. Environmental Protection Agency, 1992, *RCRA Ground-Water Monitoring: Draft Technical Guidance*; Washington, DC (EPA/530-R-93-001).

U.S. Environmental Protection Agency, 1987, *A Compendium of Superfund Field Operations Methods*; Washington, DC (EPA/540/P-87/001).

U.S Environmental Protection Agency, Region 1, *Calibration of Field Instruments (temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction [ORP], and turbidity),* January 19, 2010 or latest version.

U.S Environmental Protection Agency, EPA SW-846.

U.S Environmental Protection Agency, 40 CFR 136.

U.S Environmental Protection Agency, 40 CFR 141.

Vroblesky, Don A., Clifton C. Casey, and Mark A. Lowery, Summer 2007, Influence of Dissolved Oxygen Convection on Well Sampling, *Ground Water Monitoring & Remediation* 27, no. 3: 49-58.

APPENDIX A
PERISTALTIC PUMPS

Before selecting a peristaltic pump to collect groundwater samples for VOCs and/or dissolved gases (e.g., methane, carbon dioxide, etc.) consideration should be given to the following:

- The decision of whether or not to use a peristaltic pump is dependent on the intended use of the data.
- If the additional sampling error that may be introduced by this device is NOT of concern for the VOC/dissolved gases data's intended use, then this device may be acceptable.
- If minor differences in the groundwater concentrations could effect the decision, such as to continue or terminate groundwater cleanup or whether the cleanup goals have been reached, then this device should NOT be used for VOC/dissolved gases sampling. In these cases, centrifugal or bladder pumps are a better choice for more accurate results.

EPA and USGS have documented their concerns with the use of the peristaltic pumps to collect water sample in the below documents.

- "Suction Pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001, December 1987.
- "The agency does not recommend the use of peristaltic pumps to sample ground water particularly for volatile organic analytes" *RCRA Ground-Water Monitoring Draft Technical Guidance*, EPA Office of Solid Waste, November 1992.
- "The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and volatiles loss", *Low-flow (Minimal drawdown) Ground-Water Sampling Procedures*, by Robert Puls & Michael Barcelona, April 1996, EPA/540/S-95/504.
- "Suction-lift pumps, such as peristaltic pumps, can operate at a very low pumping rate; however, using negative pressure to lift the sample can result in the loss of volatile analytes", USGS Book 9 Techniques of Water-Resources Investigation, Chapter A4. (Version 2.0, 9/2006).

APPENDIX B

SUMMARY OF SAMPLING INSTRUCTIONS

These instructions are for using an adjustable rate, submersible pump or a peristaltic pump with the pump's intake placed at the midpoint of a 10 foot or less well screen or an open interval. The water level in the monitoring well is above the top of the well screen or open interval, the ambient temperature is above 32°F, and the equipment is not dedicated. Field instruments are already calibrated. The equipment is setup according to the diagram at the end of these instructions.

1. Review well installation information. Record well depth, length of screen or open interval, and depth to top of the well screen. Determine the pump's intake depth (e.g., mid-point of screen/open interval).

2. On the day of sampling, check security of the well casing, perform any safety checks needed for the site, lay out a sheet of polyethylene around the well (if necessary), and setup the equipment. If necessary a canopy or an equivalent item can be setup to shade the pump's tubing and flow-through-cell from the sun light to prevent the sun light from heating the groundwater.

3. Check well casing for a reference mark. If missing, make a reference mark. Measure the water level (initial) to 0.01 ft. and record this information.

4. Install the pump's intake to the appropriate depth (e.g., midpoint) of the well screen or open interval. Do not turn-on the pump at this time.

5. Measure water level and record this information.

6. Turn-on the pump and discharge the groundwater into a graduated waste bucket. Slowly increase the flow rate until the water level starts to drop. Reduce the flow rate slightly so the water level stabilizes. Record the pump's settings. Calculate the flow rate using a graduated container and a stop watch. Record the flow rate. Do not let the water level drop below the top of the well screen.

If the groundwater is highly turbid or colored, continue to discharge the water into the bucket until the water clears (visual observation); this usually takes a few minutes. The turbid or colored water is usually from the well being disturbed during the pump installation. If the water does not clear, then you need to make a choice whether to continue purging the well (hoping that it will clear after a reasonable time) or continue to the next step. Note, it is sometimes helpful to install the pump the day before the sampling event so that the disturbed materials in the well can settle out.

If the water level drops to the top of the well screen during the purging of the well, stop purging the well, and do the following:

> Wait for the well to recharge to a sufficient volume so samples can be collected. This may take awhile (pump maybe removed from well, if turbidity is not a problem). The project manager will need to make the decision when samples should be collected and the reasons recorded in the site's log book. A water level measurement needs to be performed and recorded before samples are collected. When samples are being collected, the water level must not drop below the top of the screen or open interval. Collect the samples from the pump's tubing. Always collect the VOCs and dissolved gases samples first. Normally, the samples requiring a small volume are collected before the large volume samples are collected just in case there is not sufficient water in the well to fill all the sample containers. All samples must be collected, preserved, and stored according to the analytical method. Remove the pump from the well and decontaminate the sampling equipment.

If the water level has dropped 0.3 feet or less from the initial water level (water level measure before the pump was installed); proceed to Step 7. If the water level has dropped more than 0.3 feet, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are be collected.

7. Attach the pump's tubing to the "T" connector with a valve (or a three-way stop cock). The pump's tubing from the well casing to the "T" connector must be as short as possible to prevent the groundwater in the tubing from heating up from the sun light or from the ambient air. Attach a short piece of tubing to the other end of the end of the "T" connector to serve as a sampling port for the turbidity samples. Attach the remaining end of the "T" connector to a short piece of tubing and connect the tubing to the flow-through-cell bottom port. To the top port, attach a small piece of tubing to direct the water into a calibrated waste bucket. Fill the cell with the groundwater and remove all gas bubbles from the cell. Position the flow-through-cell in such a way that if gas bubbles enter the cell they can easily exit the cell. If the ports are on the same side of the cell and the cell is cylindrical shape, the cell can be placed at a 45-degree angle with the ports facing upwards; this position should keep any gas bubbles entering the cell away from the monitoring probes and allow the gas bubbles to exit the cell easily (see Low-Flow Setup Diagram). Note,

make sure there are no gas bubbles caught in the probes' protective guard; you may need to shake the cell to remove these bubbles.

8. Turn-on the monitoring probes and turbidity meter.

9. Record the temperature, pH, dissolved oxygen, specific conductance, and oxidation/reduction potential measurements. Open the valve on the "T" connector to collect a sample for the turbidity measurement, close the valve, do the measurement, and record this measurement. Calculate the pump's flow rate from the water exiting the flow-through-cell using a graduated container and a stop watch, and record the measurement. Measure and record the water level. Check flow-through-cell for gas bubbles and sediment; if present, remove them.

10. Repeat Step 9 every 5 minutes or as appropriate until monitoring parameters stabilized. Note at least one flow-through-cell volume must be exchanged between readings. If not, the time interval between readings will need to be increased. Stabilization is achieved when three consecutive measurements are within the following limits:

Turbidity (10% for values greater than 5 NTUs; if three Turbidity values are less than 5 NTUs, consider the values as stabilized),
Dissolved Oxygen (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),
Specific Conductance (3%),
Temperature (3%),
pH (± 0.1 unit),
Oxidation/Reduction Potential (±10 millivolts).

If these stabilization requirements do not stabilize in a reasonable time, the probes may have been coated from the materials in the groundwater, from a buildup of sediment in the flow-through-cell, or a gas bubble is lodged in the probe. The cell and the probes will need to be cleaned. Turn-off the probes (not the pump), disconnect the cell from the "T" connector and continue to purge the well. Disassemble the cell, remove the sediment, and clean the probes according to the manufacturer's instructions. Reassemble the cell and connect the cell to the "T" connector. Remove all gas bubbles from the cell, turn-on the probes, and continue the measurements. Record that the time the cell was cleaned.

11. When it is time to collect the groundwater samples, turn-off the monitoring probes, and disconnect the pump's tubing from the "T" connector. If you are using a centrifugal or peristaltic pump check the pump's tubing to determine if the tubing is completely filled with water (no air space).

All samples must be collected and preserved according to the analytical method. VOCs and dissolved gases samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

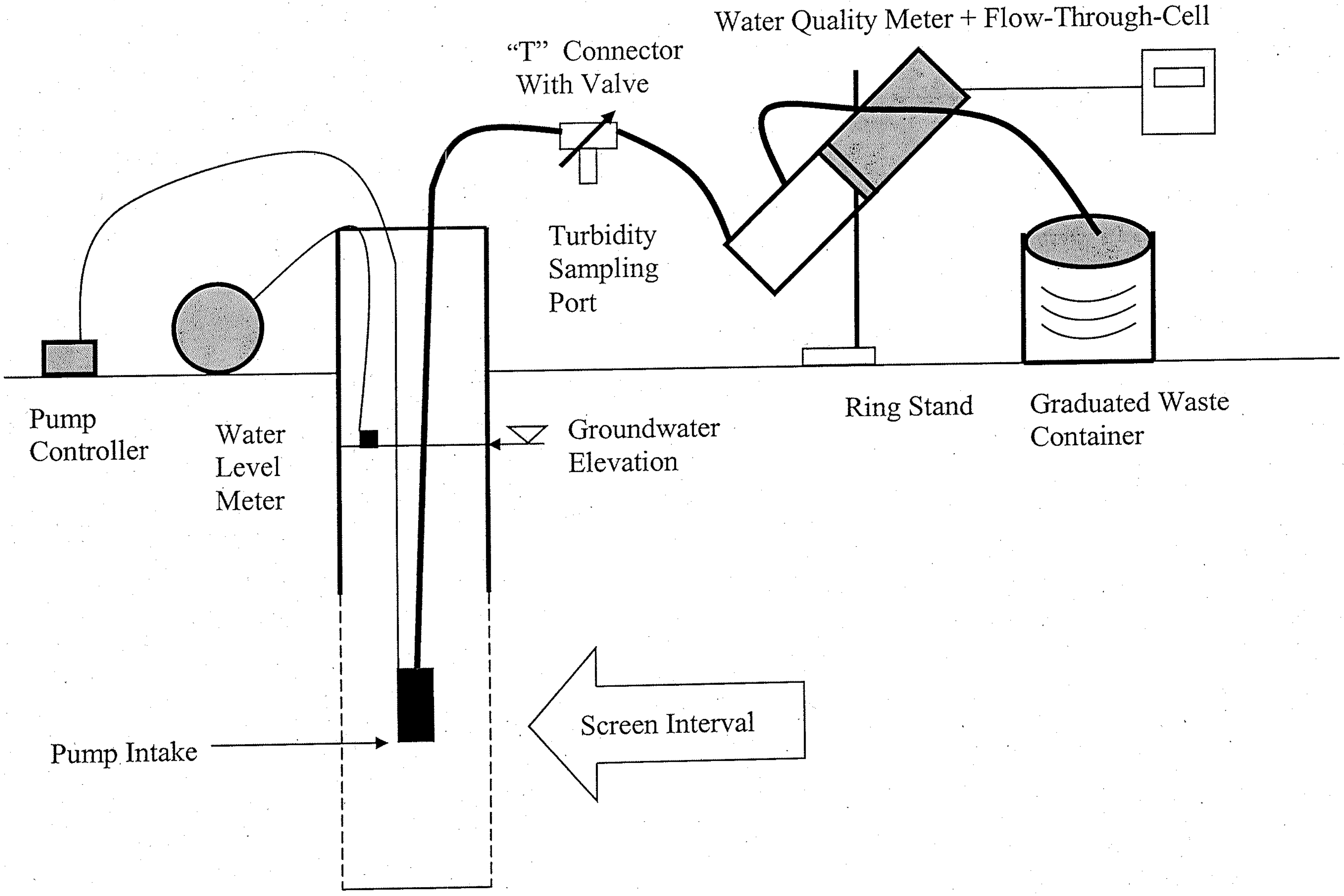
If the pump's tubing is not completely filled with water and the samples are being collected for VOCs and/or dissolved gases analyses using a centrifugal or peristaltic pump, do the following:

> All samples must be collected and preserved according to the analytical method. The VOCs and the dissolved gases (e.g., methane, ethane, ethene, and carbon dioxide) samples are collected last. When it becomes time to collect these samples increase the pump's flow rate until the tubing is completely filled. Collect the samples and record the new flow rate.

12. Store the samples according to the analytical method.

13. Record the total purged volume (graduated waste bucket). Remove the pump from the well and decontaminate the sampling equipment.

Low-Flow Setup Diagram



APPENDIX C
EXAMPLE (Minimum Requirements)
WELL PURGING-FIELD WATER QUALITY MEASUREMENTS FORM

Location (Site/Facility Name)____________________

Well Number__________ Date__________

Field Personnel____________________

Sampling Organization____________________

Identify MP____________________

Depth to ______/______ of screen
(below MP) top bottom

Pump Intake at (ft. below MP)__________

Purging Device; (pump type)__________

Total Volume Purged __________

Clock Time 24 HR	Water Depth below MP ft	Pump Dial[1]	Purge Rate ml/min	Cum. Volume Purged liters	Temp. °C	Spec. Cond.[2] µS/cm	pH	ORP[3] mv	DO mg/L	Turb-idity NTU	Comments
Stabilization Criteria					3%	3%	±0.1	± 10 mv	10%	10%	

1. Pump dial setting (for example: hertz, cycles/min, etc).
2. µSiemens per cm(same as µmhos/cm)at 25 °C.
3. Oxidation reduction potential (ORP)

APPENDIX G

SEPTEMBER 2007 ADDENDUM FOR REAL PROPERTY MASTER PLAN LONG RANGE COMPONENT FOR DEVENS RESERVE FORCES TRAINING AREA

REAL PROPERTY MASTER PLAN
LONG RANGE COMPONENT
FOR
DEVENS RESERVE FORCES TRAINING AREA

ADDENDUM – SEPTEMBER 2007

This addendum applies to Chapter 4.C. (Land Use Policies and Constraints) and Chapter 5.E. (Environmental Concerns) of the *Real Property Master Plan, Long Range Component for Devens Reserves Forces Training Area, June 1999.* The addendum provides supplemental information on Land-Use Controls (LUCs) established under BRAC and CERCLA programs that are applicable to the following areas:

Area A (Main Cantonment)

The CERCLA remedy for the former AAFES Gas Station located on Queenstown Street is addressed in the Record of Decision (ROD) for Area of Contamination (AOC) 43G. The remedy is based on Army retention of this area and continued restricted access to groundwater; however, any proposed actions that affect this property must consider the following ROD requirements and site environmental conditions:

- Assure that the Property is not used for residential purposes and prohibit the use of groundwater beneath the site. If the Army changes the land-use within the AOC, then additional assessment and/or possible remedial action may be needed based upon the possible resultant changed risk factors.

- If the Army transfers this property by lease or deed, an Environmental Baseline Assessment (EBS) will be conducted to ensure that the remedy remains protective by incorporating all necessary environmental protection provisions within the Finding of Suitability to Transfer (FOST) and the property transfer deed.

- Any intrusive construction work must consider that residual soil and groundwater contamination has been documented for AOC 43G and that such actions should be coordinated with the DPW, the BRAC Environmental Office and the BRAC Clean-up Team (BCT).

Area C (Range & Training Area)

The CERCLA remedy for the South Post range and training areas is addressed in the ROD for the South Post Impact Area (SPIA) and AOCs 25, 26, 27 and 41. The "no action" remedy is based on Army retention of the South Post; however, any proposed actions that affect this property must consider the following ROD requirements:

- If the Army should close or transfer or change the use of this property, an Environmental Baseline Survey (EBS) will be conducted, and the "no action" decision in the ROD will be re-examined in light of the changed use and risk factors resulting from this closure/transfer.

- The Army will not develop new drinking water sources within the SPIA monitored area.

Area F (3700 Area – Barnum Road Maintenance Yards)

The CERCLA remedy for the former Cannibalization Yard and TDA Maintenance Yard is addressed in the ROD for AOCs 44 and 52, respectively. The remedy is based on Army retention of this property; however, any proposed actions that affect this property must consider the following ROD requirements:

- Assure the Property is not used for residential purposes. If the Army transfers this property by lease or deed, an EBS will be conducted to ensure that the remedy remains protective by incorporating all necessary environmental protection provisions within the FOST and the property transfer deed.

- Maintain the existing paved areas and storm water collection systems to prevent long-term worker exposure to residual oil contaminated soils 2-5 feet BGS associated with AOC 44/52 remedy.

- Assure that Soil Management Plans and Health and Safety Plans are prepared and executed prior to subsurface excavations.

- Any intrusive construction work must consider that residual soil contamination has been documented for AOC 44/52 and that such actions should be coordinated with the DPW, the BRAC Environmental Office and the BCT.

Area G (3800 Area – RTS Maintenance)

The CERCLA remedy for the former Moore Army Airfield is addressed in the ROD for AOC 50. Active remediation and monitoring of the AOC 50 chlorinated solvent plume, which is under building 3813 is ongoing. Treatment transects and associated monitoring wells are located in the RTC vehicle storage area and on the Southwest Corner of Building 3813 former hanger, along the axis of the plume through Army retained Parcel H. Any proposed actions that affect this property must consider the following ROD requirements:

- Provide continued access to treatment transects and monitoring wells and access to install additional injection or monitoring wells, if necessary.

- Coordinate construction plans with the BCT to facilitate ongoing remediation and future access to plume areas

- No groundwater extraction or injection for any purpose

- Coordinate construction plans for modifications to storm water systems with the BCT including engineered storm water management plans and hydrologic/ mounding studies. (Continue use of existing storm water system to direct storm water away from the plume)

APPENDIX H

ANNUAL LAND USE CONTROL CHECKLISTS

Annual Land Use Control Plan Checklist

This checklist has been developed from the USEPA guidance document Comprehensive Five Year Review Guidance dated June 2001 (OSWER No. 9355.7-03B-P) and from Section 4.0 of the 2007 Draft Long-Term Monitoring Plan, Devens, Massachusetts. The Checklist was modified to site-specific conditions as recommended by the guidance document. The checklist will be completed annually and submitted with the AOC 43G annual long-term monitoring report. The checklist will also be used to assist in compiling information for the five-year review.

I. Site Information

Site Name:	Fort Devens AOC 43G	**Name:** **Affiliation:** **Date:**
Location:	Harvard, MA	Weather:

Remedy Includes:

- Removal of Waste Oil, Gasoline USTs
- Intrinsic Bioremediation
- Long-Term Monitoring
- Institutional Controls

Inspectors: ______________________________

Participants: ______________________________

Site Map Attached:

II Documentation & Records

Item	Check One	Comments
Any related notices filed with Town of Harvard, MA?	Yes ☐ No ☐	
Any related Department of Public Works permits found?	Yes ☐ No ☐	
Any related zoning permits or variances found?	Yes ☐ No ☐	
Any related Conservation Commission findings, proposals or notices of intent found?	Yes ☐ No ☐	

III Physical On-site Inspection

Item	Check One	Comments
Any evidence of development present in the area of the remedy?	Yes ☐ No ☐	
Is there evidence of damage to the remedy?	Yes ☐ No ☐	
Any groundwater extraction wells present?	Yes ☐ No ☐	
Is there sufficient access to the site for monitoring?	Yes ☐ No ☐	
Any signs of increased exposure potential?	Yes ☐ No ☐	

IV Interview

Name of Interviewer:

Name of Interviewee:

Date:

Position:

Owner ☐

Manager ☐

Other: Please Specify

Location:

Site ☐

Office ☐

Phone: ☐

Telephone #

Item	**Check One**	**Comments**
Is interviewee familiar with the land use controls imposed upon the property & documentation of these controls?	Yes ☐ No ☐	
Are there any extraction wells at the property?	Yes ☐ No ☐	
Are there any proposed plans for property sale, future development, construction or demolition activities at the property?	Yes ☐ No ☐	
Are there any issues with site access for monitoring?	Yes ☐ No ☐	

V Response Actions

Item	**Check One**	**Comments**
Were violations of the LUC's present?	Yes ☐ No ☐	
Are there Response Actions necessary based on the violations?	Yes ☐ No ☐	
Are modifications/ terminations of LUC's necessary?	Yes ☐ No ☐	
Have Enforcement Actions been taken during this reporting period?	Yes ☐ No ☐	

***If any of the responses above are "Yes", please provide comments**

Annual Certification

Name: ______________________

Affiliation: ______________________

Signature: ______________________

Date: ______________________

Annual Land Use Control Plan Checklist

This checklist has been developed from the USEPA guidance document Comprehensive Five Year Review Guidance dated June 2001 (OSWER No. 9355.7-03B-P) and from Section 4.0 of the 2007 Draft Long-Term Monitoring Plan, Devens, Massachusetts. The Checklist was modified to site-specific conditions as recommended by the guidance document. The checklist will be completed annually and submitted with the AOCs 32and 43A annual long-term monitoring report. The checklist will also be used to assist in compiling information for the five-year review.

I. Site Information

Site Name:	Fort Devens AOCs 32 and 43A	**Name:** **Affiliation:** **Date:**
Location:	Ayer, MA	Weather:

Remedy Includes:

Source Removal via Excavation and Off-Site Disposal or Treatment
Long-Term Monitoring
Institutional Controls

Inspectors: ______________________

Participants: ______________________

Site Map Attached:

II Documentation & Records

Item	Check One	Comments
Any related notices filed with Devens Enterprise Commission?	Yes ☐ No ☐	
Any related Department of Public Works permits found?	Yes ☐ No ☐	
Any related zoning permits or variances found?	Yes ☐ No ☐	
Any related Conservation Commission findings, proposals or notices of intent found?	Yes ☐ No ☐	

III Physical On-site Inspection

Item	Check One	Comments
Any evidence of new construction or excavation present in the area of the remedy?	Yes ☐ No ☐	
Is there evidence of damage to the remedy?	Yes ☐ No ☐	
Any groundwater extraction wells present?	Yes ☐ No ☐	
Is there sufficient access to the site for monitoring?	Yes ☐ No ☐	
Any signs of increased exposure potential?	Yes ☐ No ☐	

IV Interview

Name of Interviewer:

Name of Interviewee:

Date:

Position:

Owner ☐

Manager ☐

Other: Please Specify

Location:

Site ☐

Office ☐

Phone: ☐

Telephone #

Item	Check One	Comments
Is interviewee familiar with the land use controls imposed upon the property & documentation of these controls?	Yes ☐ No ☐	
Are there any extraction wells at the property?	Yes ☐ No ☐	
Are there any proposed plans for property sale, future development, construction or demolition activities at the property?	Yes ☐ No ☐	
Are there any issues with site access for monitoring?	Yes ☐ No ☐	

V Response Actions

Item	Check One	Comments
Were violations of the LUC's present?	Yes ☐ No ☐	
Are there Response Actions necessary based on the violations?	Yes ☐ No ☐	
Are modifications/ terminations of LUC's necessary?	Yes ☐ No ☐	
Have Enforcement Actions been taken during this reporting period?	Yes ☐ No ☐	

***If any of the responses above are "Yes", please provide comments**

Annual Certification

Name: ____________________

Affiliation: ____________________

Signature: ____________________

Date: ____________________

Annual Land Use Control Plan Checklist

This checklist has been developed from the USEPA guidance document Comprehensive Five Year Review Guidance dated June 2001 (OSWER No. 9355.7-03B-P) and from Section 4.0 of the 2007 Draft Long-Term Monitoring Plan, Devens, Massachusetts. The Checklist was modified to site-specific conditions as recommended by the guidance document. The checklist will be completed annually and submitted with the AOC 57 annual long-term monitoring report. The checklist will also be used to assist in compiling information for the five-year review.

I. Site Information

Site Name:	Fort Devens AOC 57	**Name:**
☐	Area 2	**Affiliation:**
☐	Area 3	**Date:**
Location:	Harvard, MA	Weather:

Remedy Includes:

Source Removal via Excavation and Off-Site Disposal or Treatment
Wetlands Protection
Long-Term Monitoring
Institutional Controls

Inspectors: ________________________________

Participants: ________________________________

Site Map Attached:

II Documentation & Records

Item	Check One	Comments
Any related notices filed with Devens Enterprise Commission?	Yes ☐ No ☐	
Any related Department of Public Works permits found?	Yes ☐ No ☐	
Any related zoning permits or variances found?	Yes ☐ No ☐	
Any related Conservation Commission findings, proposals or notices of intent found?	Yes ☐ No ☐	

III Physical On-site Inspection

Item	Check One	Comments
Any evidence of construction or excavation present in the area of the remedy?	Yes ☐ No ☐	
Is there evidence of damage to the remedy?	Yes ☐ No ☐	
Any groundwater extraction wells present?	Yes ☐ No ☐	
Is there sufficient access to the site for monitoring?	Yes ☐ No ☐	
Any signs of increased exposure potential?	Yes ☐ No ☐	

IV Interview

Name of Interviewer:

Name of Interviewee:

Date:

Position:

Owner ☐

Manager ☐

Other: Please Specify

Location:

Site ☐

Office ☐

Phone: ☐

Telephone #

Item	Check One	Comments
Is interviewee familiar with the land use controls imposed upon the property & documentation of these controls?	Yes ☐ No ☐	
Are there any extraction wells at the property?	Yes ☐ No ☐	
Are there any proposed plans for property sale, future development, construction or demolition activities at the property?	Yes ☐ No ☐	
Are there any issues with site access for monitoring?	Yes ☐ No ☐	

V Response Actions

Item	Check One	Comments
Were violations of the LUC's present?	Yes ☐ No ☐	
Are there Response Actions necessary based on the violations?	Yes ☐ No ☐	
Are modifications/ terminations of LUC's necessary?	Yes ☐ No ☐	
Have Enforcement Actions been taken during this reporting period?	Yes ☐ No ☐	

***If any of the responses above are "Yes", please provide comments**

Annual Certification

Name: ______________________________

Affiliation: ______________________________

Signature: ______________________________

Date: ______________________________

Annual Land Use Control Plan Checklist

This checklist has been developed from the USEPA guidance document Comprehensive Five Year Review Guidance dated June 2001 (OSWER No. 9355.7-03B-P) and from Section 4.0 of the 2007 Draft Long-Term Monitoring Plan, Devens, Massachusetts. The Checklist was modified to site-specific conditions as recommended by the guidance document. The checklist will be completed annually and submitted with the AOC 69W annual long-term monitoring report. The checklist will also be used to assist in compiling information for the five-year review.

I. Site Information

Site Name:	Fort Devens AOC 69W	**Name:** **Affiliation:** **Date:**
Location:	Ayer, MA	Weather:

Remedy Includes:

Source Removal via Excavation and Off-Site Disposal or Treatment
Long-Term Monitoring
Institutional Controls

Inspectors: ______________________________

Participants: ______________________________

Site Map Attached:

II Documentation & Records

Item	Check One	Comments
Any related notices filed with Devens Enterprise Commission?	Yes ☐ No ☐	
Any related Department of Public Works permits found?	Yes ☐ No ☐	
Any related zoning permits or variances found?	Yes ☐ No ☐	
Any related Conservation Commission findings, proposals or notices of intent found?	Yes ☐ No ☐	

III Physical On-site Inspection

Item	Check One	Comments
Any evidence of penetrations or repaved cut marks present in the ESMA?	Yes ☐ No ☐	
Is there evidence of damage to the remedy?	Yes ☐ No ☐	
Any groundwater extraction wells present?	Yes ☐ No ☐	
Is there sufficient access to the site for monitoring?	Yes ☐ No ☐	
Any signs of increased exposure potential?	Yes ☐ No ☐	

IV Interview

Name of Interviewer:

Name of Interviewee:

Date:

Position:

Owner ☐

Manager ☐

Other: Please Specify

Location:

Site ☐

Office ☐

Phone: ☐

Telephone #

Item	Check One	Comments
Is interviewee familiar with the land use controls imposed upon the property & documentation of these controls?	Yes ☐ No ☐	
Are there any extraction wells at the property?	Yes ☐ No ☐	
Are there any proposed plans for property sale, future development, construction or demolition activities at the property?	Yes ☐ No ☐	
Any excavations, planned or emergency, that may have extended to soils below two feet in depth in ESMA?	Yes ☐ No ☐	
Are there any issues with site access for monitoring?	Yes ☐ No ☐	

V Response Actions

Item	Check One	Comments
Were violations of the LUC's present?	Yes ☐ No ☐	
Are there Response Actions necessary based on the violations?	Yes ☐ No ☐	
Are modifications/ terminations of LUC's necessary?	Yes ☐ No ☐	
Have Enforcement Actions been taken during this reporting period?	Yes ☐ No ☐	

***If any of the responses above are "Yes", please provide comments**

Annual Certification

Name: ____________________

Affiliation: ____________________

Signature: ____________________

Date: ____________________

Annual Land Use Control Plan Checklist

This checklist has been developed from the USEPA guidance document Comprehensive Five Year Review Guidance dated June 2001 (OSWER No. 9355.7-03B-P) and from Section 4.0 of the 2007 Draft Long-Term Monitoring Plan, Devens, Massachusetts. The Checklist was modified to site-specific conditions as recommended by the guidance document. The checklist will be completed annually and submitted with the DCL annual long-term monitoring report. The checklist will also be used to assist in compiling information for the five-year review.

I. Site Information

Site Name:	Fort Devens DCL	**Name:** **Affiliation:** **Date:**
Location:	Harvard, MA	Weather:

Remedy Includes:

- Source Removal via Excavation and Off-Site Disposal/Treatment or Consolidation in DCL
- Long-Term Monitoring
- Institutional Controls

Inspectors: ____________________

Participants: ____________________

Site Map Attached:

II Documentation & Records

Item	Check One	Comments
Any related notices filed with Devens Enterprise Commission?	Yes ☐ No ☐	
Any related Department of Public Works permits found?	Yes ☐ No ☐	
Any related zoning permits or variances found?	Yes ☐ No ☐	
Any related Conservation Commission findings, proposals or notices of intent found?	Yes ☐ No ☐	

III Physical On-site Inspection

Item	Check One	Comments
Any evidence of development present in the area of the remedy?	Yes ☐ No ☐	
Is there evidence of damage to the remedy?	Yes ☐ No ☐	
Any groundwater extraction wells present?	Yes ☐ No ☐	
Is there sufficient access to the site for monitoring?	Yes ☐ No ☐	
Any signs of increased exposure potential?	Yes ☐ No ☐	

IV Interview

Name of Interviewer:		
Name of Interviewee:		
Date:		
Position: Owner ☐ Manager ☐ Other: Please Specify Environmental Services Representative		
Location: Site ☐ Office ☐ Phone: ☐ Telephone #		
Item	**Check One**	**Comments**
Is interviewee familiar with the land use controls imposed upon the property & documentation of these controls?	Yes ☐ No ☐	
Are there any extraction wells at the property?	Yes ☐ No ☐	
Are there any proposed plans for property sale, future development, construction or demolition activities at the property?	Yes ☐ No ☐	
Are there any issues with site access for monitoring?	Yes ☐ No ☐	

V Response Actions

Item	**Check One**	**Comments**
Were violations of the LUC's present?	Yes ☐ No ☐	
Are there Response Actions necessary based on the violations?	Yes ☐ No ☐	
Are modifications/ terminations of LUC's necessary?	Yes ☐ No ☐	
Have Enforcement Actions been taken during this reporting period?	Yes ☐ No ☐	

***If any of the responses above are "Yes", please provide comments**

Annual Certification

Name: ______________________

Affiliation: ______________________

Signature: ______________________

Date: ______________________

Annual Land Use Control Plan Checklist

This checklist has been developed from the USEPA guidance document Comprehensive Five Year Review Guidance dated June 2001 (OSWER No. 9355.7-03B-P) and from Section 4.0 of the 2007 Draft Long-Term Monitoring Plan, Devens, Massachusetts. The Checklist was modified to site-specific conditions as recommended by the guidance document. The checklist will be completed annually and submitted with the SPIA annual long-term monitoring report. The checklist will also be used to assist in compiling information for the five-year review.

I. Site Information

Site Name:	Fort Devens SPIA	**Name:** **Affiliation:** **Date:**
Location:	Lancaster, MA	Weather:

Remedy Includes:
No Action

Inspectors: ______________________________

Participants: ______________________________

Site Map Attached:

II Documentation & Records

Item	Check One	Comments
Any related notices filed with Town of Lancaster, MA?	Yes ☐ No ☐	
Any related Department of Public Works permits found?	Yes ☐ No ☐	
Any related zoning permits or variances found?	Yes ☐ No ☐	
Any related Conservation Commission findings, proposals or notices of intent found?	Yes ☐ No ☐	

III Physical On-site Inspection

Item	Check One	Comments
Any evidence of development present in the SPIA?	Yes ☐ No ☐	
Is there evidence of damage to the remedy?	Yes ☐ No ☐	
Any new groundwater extraction wells present?	Yes ☐ No ☐	
Is there sufficient access to the site for monitoring?	Yes ☐ No ☐	
Any signs of increased exposure potential?	Yes ☐ No ☐	

IV Interview

Name of Interviewer:

Name of Interviewee:

Date:

Position:

Owner ☐

Manager ☐

Other: Please Specify

Location:

Site ☐

Office ☐

Phone: ☐

Telephone #

Item	**Check One**	**Comments**
Is interviewee familiar with the land use controls imposed upon the property & documentation of these controls?	Yes ☐ No ☐	
Are there any extraction wells at the property?	Yes ☐ No ☐	
Are there any proposed plans for property sale, future development, construction or demolition activities at the property?	Yes ☐ No ☐	
Are there any issues with site access for monitoring?	Yes ☐ No ☐	

V Response Actions

Item	**Check One**	**Comments**
Were violations of the LUC's present?	Yes ☐ No ☐	
Are there Response Actions necessary based on the violations?	Yes ☐ No ☐	
Are modifications/ terminations of LUC's necessary?	Yes ☐ No ☐	
Have Enforcement Actions been taken during this reporting period?	Yes ☐ No ☐	

***If any of the responses above are "Yes", please provide comments**

Annual Certification

Name: ______________________

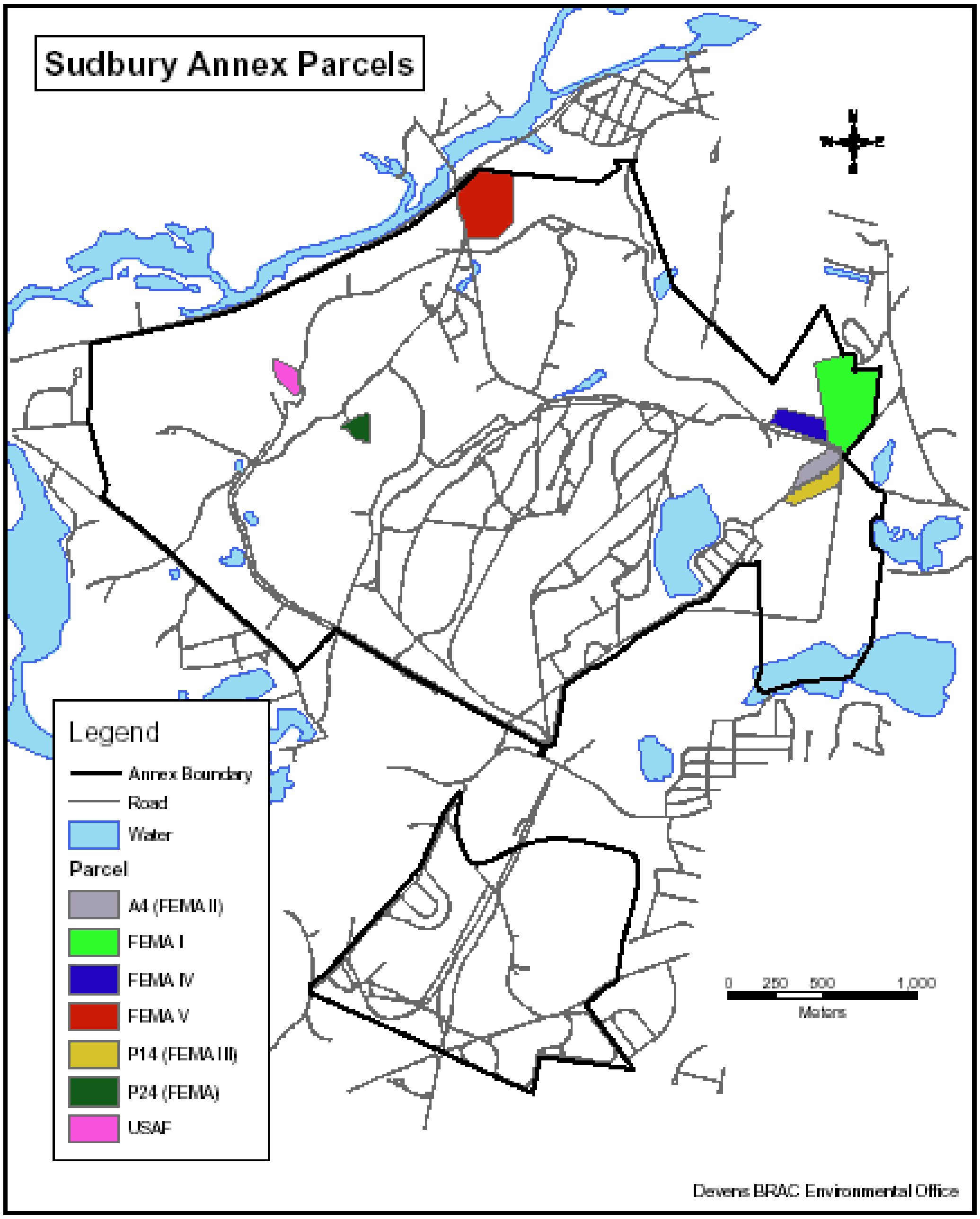
Affiliation: ______________________

Signature: ______________________

Date: ______________________

Table D.1
Checklist for Review of *insert year* Annual Report

	1 – *insert year* Annual Report Aspect Reviewed	Summary	OK?
(a)	Changes to the use of the site?		
(b)(i)	Containment System Intact?		
(b)(ii)	Monitoring System Operational?		
(c)	Site Free of Disruptions Deeper than 4 feet?		
(d)(i)	Monitoring Wells Intact (vs. Negatively Affected)?		
(d)(ii)	Water Table Unaffected (vs. Negatively Affected)?		



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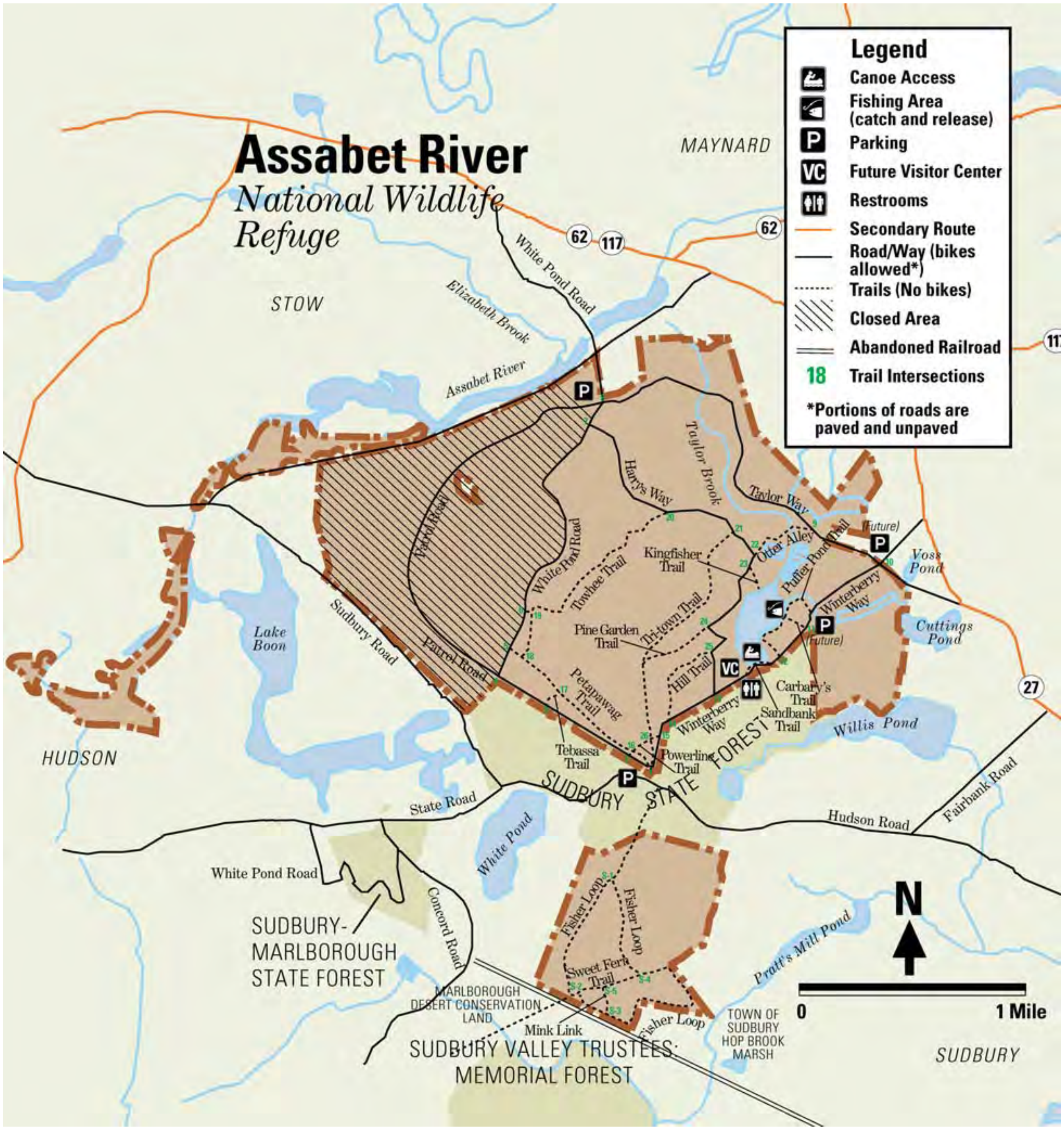
Contract No.: W912WJ-10-D-0003
Revised: 5/27/2011

Figure D.1
Sudbury Annex
Parcel Owners

Table D.2
Checklist for Review of AOC P31/P58 Protectiveness Assessment

	2 – AOC P31/P58 Protectiveness Assessment: Aspect Reviewed	**Summary**	**OK?**
(a)	Changes to the use of the site?		
(b)(i)	Containment System Intact?		
(b)(ii)	Monitoring System Operational?		
(c)	Site Free of Disruptions Deeper than 4 feet?		
(d)(i)	Monitoring Wells Intact (vs. Negatively Affected)?		
(d)(ii)	Water Table Unaffected (vs. Negatively Affected)?		



https://hglcentral.hgl.com/sites/projectsites/SO1/Active/SO1002/Post Award/Deliverables/LTMMP
Project: W912WJ-10-D-0003
Revised: 11/25/2013 VR

Figure D.2 Former Sudbury Training Annex: Assabet River NWR Layout

Table D.3
Checklist for USFWS Interview

	USFWS Interview Checklists	Summary	OK ?
1	Changes to the use of the site?		
2	Approved conditional exemptions, amendments and/or releases		
3	Unauthorized uses and activities		
4	Review of corrective action to resolve unauthorized uses and activities		
5	Overall effectiveness of the institutional controls		
6	Status of anticipated future redevelopment or other construction or demolition activities		

Table D.4
Checklist for FEMA Interview

	FEMA Interview Checklist	Summary	OK?
1	Changes to the use of the site?		
2	Approved conditional exemptions, amendments and/or releases		
3	Unauthorized uses and activities		
4	Review of corrective action to resolve unauthorized uses and activities		
5	Overall effectiveness of the institutional controls		
6	Status of anticipated future redevelopment or other construction or demolition activities		

Table D.5
Checklist for USAF Interview

	B.3 – USAF Interview Checklist	Summary	OK?
1	Changes to the use of the site?		
2	Approved conditional exemptions, amendments and/or releases		
3	Unauthorized uses and activities		
4	Review of corrective action to resolve unauthorized uses and activities		
5	Overall effectiveness of the institutional controls		
6	Status of anticipated future redevelopment or other construction or demolition activities		

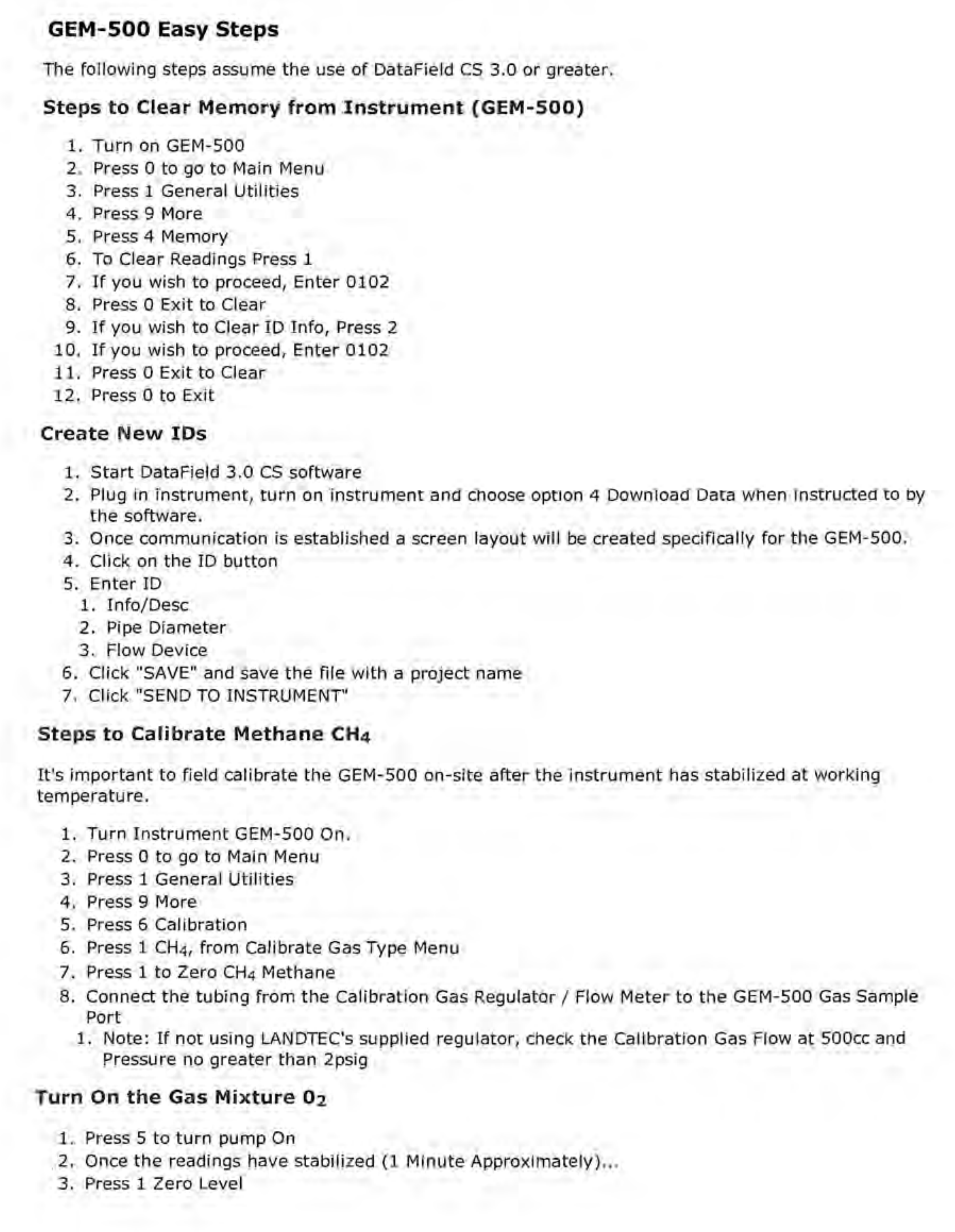
Table D.6
Checklist for Stow Board of Health Interview

	B.4 – Stow BOH Interview Checklist	Summary	OK?
1	Changes to the use of the site?		
2	Approved conditional exemptions, amendments and/or releases		
3	Unauthorized uses and activities		
4	Review of corrective action to resolve unauthorized uses and activities		
5	Overall effectiveness of the institutional controls		
6	Status of anticipated future redevelopment or other construction or demolition activities		

APPENDIX I

LANDTEC GEM-500 CALIBRATION PROCEDURE

Appendix I – Landtec GEM-500 Procedures



GEM-500 Easy Steps

The following steps assume the use of DataField CS 3.0 or greater.

Steps to Clear Memory from Instrument (GEM-500)

1. Turn on GEM-500
2. Press 0 to go to Main Menu
3. Press 1 General Utilities
4. Press 9 More
5. Press 4 Memory
6. To Clear Readings Press 1
7. If you wish to proceed, Enter 0102
8. Press 0 Exit to Clear
9. If you wish to Clear ID Info, Press 2
10. If you wish to proceed, Enter 0102
11. Press 0 Exit to Clear
12. Press 0 to Exit

Create New IDs

1. Start DataField 3.0 CS software
2. Plug in instrument, turn on instrument and choose option 4 Download Data when instructed to by the software.
3. Once communication is established a screen layout will be created specifically for the GEM-500.
4. Click on the ID button
5. Enter ID
   1. Info/Desc
   2. Pipe Diameter
   3. Flow Device
6. Click "SAVE" and save the file with a project name
7. Click "SEND TO INSTRUMENT"

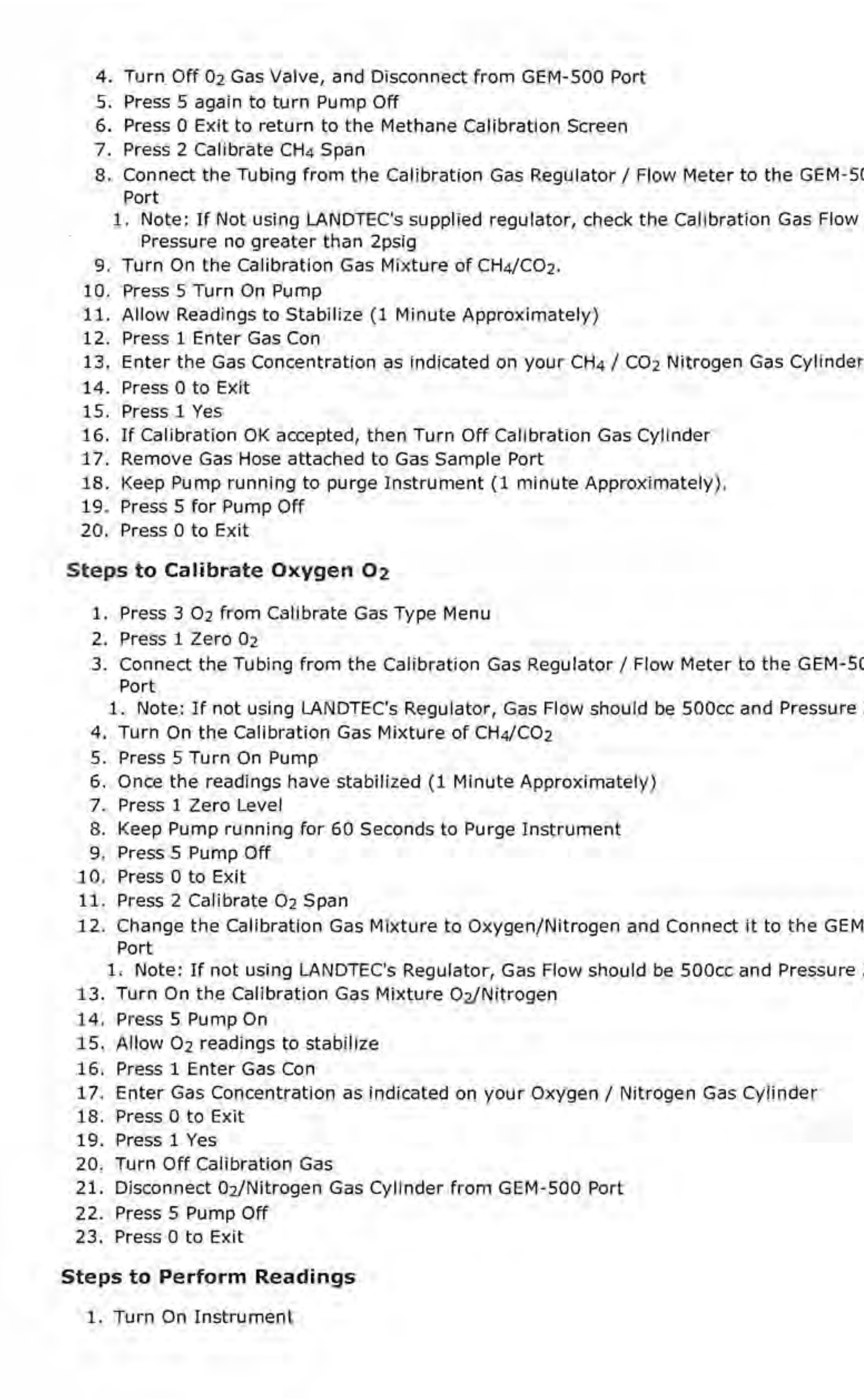
Steps to Calibrate Methane CH_4

It's important to field calibrate the GEM-500 on-site after the instrument has stabilized at working temperature.

1. Turn Instrument GEM-500 On.
2. Press 0 to go to Main Menu
3. Press 1 General Utilities
4. Press 9 More
5. Press 6 Calibration
6. Press 1 CH_4, from Calibrate Gas Type Menu
7. Press 1 to Zero CH_4 Methane
8. Connect the tubing from the Calibration Gas Regulator / Flow Meter to the GEM-500 Gas Sample Port
   1. Note: If not using LANDTEC's supplied regulator, check the Calibration Gas Flow at 500cc and Pressure no greater than 2psig

Turn On the Gas Mixture 0_2

1. Press 5 to turn pump On
2. Once the readings have stabilized (1 Minute Approximately)...
3. Press 1 Zero Level



4. Turn Off 0$_2$ Gas Valve, and Disconnect from GEM-500 Port
5. Press 5 again to turn Pump Off
6. Press 0 Exit to return to the Methane Calibration Screen
7. Press 2 Calibrate CH$_4$ Span
8. Connect the Tubing from the Calibration Gas Regulator / Flow Meter to the GEM-500 Gas Sample Port
   1. Note: If Not using LANDTEC's supplied regulator, check the Calibration Gas Flow at 500cc and Pressure no greater than 2psig
9. Turn On the Calibration Gas Mixture of CH$_4$/CO$_2$.
10. Press 5 Turn On Pump
11. Allow Readings to Stabilize (1 Minute Approximately)
12. Press 1 Enter Gas Con
13. Enter the Gas Concentration as indicated on your CH$_4$ / CO$_2$ Nitrogen Gas Cylinder
14. Press 0 to Exit
15. Press 1 Yes
16. If Calibration OK accepted, then Turn Off Calibration Gas Cylinder
17. Remove Gas Hose attached to Gas Sample Port
18. Keep Pump running to purge Instrument (1 minute Approximately).
19. Press 5 for Pump Off
20. Press 0 to Exit

Steps to Calibrate Oxygen O$_2$

1. Press 3 O$_2$ from Calibrate Gas Type Menu
2. Press 1 Zero 0$_2$
3. Connect the Tubing from the Calibration Gas Regulator / Flow Meter to the GEM-500 Gas Sample Port
   1. Note: If not using LANDTEC's Regulator, Gas Flow should be 500cc and Pressure 2psig
4. Turn On the Calibration Gas Mixture of CH$_4$/CO$_2$
5. Press 5 Turn On Pump
6. Once the readings have stabilized (1 Minute Approximately)
7. Press 1 Zero Level
8. Keep Pump running for 60 Seconds to Purge Instrument
9. Press 5 Pump Off
10. Press 0 to Exit
11. Press 2 Calibrate O$_2$ Span
12. Change the Calibration Gas Mixture to Oxygen/Nitrogen and Connect it to the GEM-500 Sample Port
    1. Note: If not using LANDTEC's Regulator, Gas Flow should be 500cc and Pressure 2psig
13. Turn On the Calibration Gas Mixture O$_2$/Nitrogen
14. Press 5 Pump On
15. Allow O$_2$ readings to stabilize
16. Press 1 Enter Gas Con
17. Enter Gas Concentration as indicated on your Oxygen / Nitrogen Gas Cylinder
18. Press 0 to Exit
19. Press 1 Yes
20. Turn Off Calibration Gas
21. Disconnect 0$_2$/Nitrogen Gas Cylinder from GEM-500 Port
22. Press 5 Pump Off
23. Press 0 to Exit

Steps to Perform Readings

1. Turn On Instrument

2. Press 0 to go to Main Menu
3. Press 2 Read Gas Levels
4. Press 1 Read using ID?
5. Press 1 (If you want to Scroll)
6. Press 2 (If you want to Enter Manually)
7. (If you Scroll), Press UP or Down Arrows and #2 to Select
8. Press 1 to Read
9. Press 5 Pump On
10. Allow Readings on left side of the screen to become stable
11. Press 5 Pump Off
12. To record Temperature and Probe Depth, Press 2 More
13. Press 1 to Enter Temperature
14. After Entering Temperature, Press 0 to Exit
15. Press 3 to Zero Pressure
    1. Note: Disconnect hose before zeroing, Then Press any key
16. Press 1 to Zero Pressures
17. Press 0 to Exit
    1. Note: Reconnect hose. Allow the Instrument to read
18. Press 2 Continue
19. If the Flow needs to be changed adjust the control valve on the Well head.
20. Press 6 to Store
21. Press 1 or 6 to scroll Up or Down Comments
22. To select a Comment, Press 2
23. Press 0 to Store
24. If you want to go to Next ID then,
25. Press 4 to go to Next ID
26. Press 2 to Purge
    1. Note: Warning: Disconnect Hose from the Well
27. Press 1 to Begin Purging
28. Press 0 to Back
29. Press 0 to Exit Purge
30. Press 1 for Next ID
31. Begin Reading Process Again!

Steps to Download Readings to Datafield

1. Start DataField 3.0CS software
2. Plug in instrument, turn on instrument and choose option 4 Download Data when instructed to by the software.
3. Once communication is established a screen layout will be created specifically for the GEM-500 instrument.
4. Click on the readings button
5. Click on the button labeled "Load From Instrument"
6. The readings will be transferred from the GEM to the computer.
7. Click on the Save File button to save the readings from Datafield 3.0CS to a file.
    1. Hint: be sure to end the file name with a .CSV (this will assist with opening the file in Excel)