MONITORING SURVEY AT THE RHODE ISLAND SOUND DISPOSAL SITE OCTOBER 2021

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Note on units of this report: As a scientific data summary, information and data are presented in the metric system. However, given the prevalence of English units in the dredging industry of the United States, conversions to English units are provided for general information in Section 1.0. A table of common conversions can be found in Appendix A.

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LIST OF ACRONYMS

aRPD	apparent redox potential discontinuity
ASCII	American Standard Code for Information Interchange
CAD	confined aquatic disposal
CI	confidence interval
cm	centimeter
CMECS	Coastal and Marine Ecological Classification Standard
CTD	conductivity, temperature, and depth
DAMOS	Disposal Area Monitoring System
dB	decibels
DQM	Dredging Quality Management
FGDC	Federal Geographic Data Committee
ft	feet
GIS	Geographic information system
GNSS	Global Navigation Satellite System
INSPIRE	INSPIRE Environmental
kHz	kilohertz
km	kilometer
m	meter
MBES	multibeam echosounder
mi	mile
MLLW	Mean Lower Low Water
MMS	Mobile Mapping Suite
NAD83	North American Datum of 1983
NAE	USACE, New England Division
NEF	Nikon Electronic Format
NOAA	National Oceanic and Atmospheric Association
NOS	National Ocean Service

LIST OF ACRONYMS (CONTINUED)

ODMDS	Ocean Dredged Material Disposal Site
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PRHMDP	Providence River and Harbor Maintenance Dredging Project
PSD	Photoshop Document
PV	Plan View
QAPP	Quality Assurance Project Plan
RISDS	Rhode Island Sound Disposal Site
RMS	Root Mean Square
RTK	Real Time Kinematic
R/V	research vessel
SBET	Smoothed Best Estimate of Trajectory
SMMP	Site Management and Monitoring Plan
SOP	Standard Operating Procedures
SPI	Sediment Profile Imaging
TIF	tagged image file
TOC	total organic carbon
USACE	U.S. Army Corps of Engineers
USEPA/EPA	U.S. Environmental Protection Agency
VDATUM	Vertical Datum Transformation
yd	yard

EXECUTIVE SUMMARY

INSPIRE Environmental (INSPIRE) conducted a monitoring survey at the Rhode Island Sound Disposal Site (RISDS) in October 2021 that encompassed three objectives over four targeted survey areas. A confirmatory investigation was conducted at RISDS to assess the recent targeted dredged material placement events in the active, northern portion of the site. An off-target release of dredged material outside of the RISDS boundary by a scow transiting from New Bedford Lower Harbor to RISDS ('short dump') was investigated by collecting multibeam bathymetric data and adaptive SPI/PV imagery. Lastly, two potential new reference areas were assessed for hard bottom distribution and physical characteristics by collecting multibeam bathymetric data and Pogo PV imagery.

Overall, at the northern active area of RISDS, seafloor elevation increases were observed at expected locations based on disposal event records, confirming that dredged material was placed at targeted locations. Dredged material from four dredging projects was placed since the previous survey in 2020 at three general areas in the northern portion of RISDS. These areas included two distinct mounds in the northeast of RISDS, which received material from New Bedford Lower Harbor, and a broad plateau area to the southwest of the high-relief north-central mound, which received material from Port of Davisville and Quonset Business Park. The two deposit features in the northeast corner of RISDS were initially documented during the 2020 survey and have increased in elevation by up to 4 m since 2020. The broad plateau area to the southwest of the high-relief north-central mound increased in elevation by up to 1 m since the 2020 survey.

The slope on the northern side of the high-relief north-central mound experienced a decrease in elevation by as much as 0.75 m since the 2020 acoustic survey. Previous reports have documented that this mound experienced a rapid increase in elevation between 2013 and 2015, followed by self-weight consolidation resulting in a decreased in elevation between 2020 and 2015 by as much as 1.4 m. It is possible that self-weight consolidation is continuing at this high-relief mound. The location of the decreased elevation on the northern slope of the mound may suggest some sediment transport preferentially winnowing this exposed portion of the topographic feature.

A short dump of dredged material was successfully identified outside of the RISDS boundaries along the scow's transit path using a combination of reconnaissance multibeam data collection and adaptive SPI/PV. Discerning the short-dump dredged material from the native sediments was challenging in both the acoustic data and the SPI/PV imagery because of a similarity in sediment types (soft sediments with some organic enrichment). The observed feature that was most diagnostic of dredged material was the presence of coastal bivalve shells on the sediment surface. This clue provided the basis for identifying the dredged material composition in the sediment column observed in SPI, which was only slightly different in texture and color to the ambient native sediments. The scow was transiting when the material was released and as a result the material was deposited in a relatively thin layer on the seafloor; as a result the acoustic data covering the area of the short dump detected only a slight anomaly. Reconnaissance multibeam data collection in combination with adaptive SPI/PV was an effective and efficient approach to investigate the actual location and general extent of dredged material on the seafloor resulting from the short-dump event.

Several areas at RISDS are composed of dredged material-derived hard bottom; following the 2020 survey it was recommended that a new reference area representative of native hard bottom in the region be identified to serve as a more comparable reference to these hard bottom habitats. During this 2021 survey, two candidate areas were investigated based on a desktop review that indicated potential hard bottom at water depths similar to RISDS. Hard bottom was found at both candidate areas. It was recommended that the western candidate area be adopted as a new reference area for RISDS based on gravel sizes, gravel percent cover, and overall distribution of hard bottom habitat.

Results from the 2021 surveys led to the following recommendations:

R1: Future dredged material placement should continue to avoid the large, high-relief north-central mound

R2: Future dredged material placement planning at RISDS should consider placing dredged material at locations with similar seafloor characteristics (i.e., place similar materials together).

R3: The use of reconnaissance acoustic data and adaptive SPI/PV collection proved effective in identifying and documenting the extent of dredged material resulting from a short dump (off-target disposal) and is recommended for similar investigations in the future. Useful data to support short-dump investigations includes scow transit track lines, characteristics of the native sediment versus the dredged material, and the expected disposal footprint size given the water depth and nature of the material (for this survey the size was ~50-100 m across).

R4: Given the relatively consistent distribution of hard bottom, the observed gravel sizes, and the proportion of gravel relative to soft sediments, the western potential new reference area is recommended as a new reference area representative of native hard bottom habitat in the vicinity of RISDS.

1.0 INTRODUCTION

INSPIRE Environmental (INSPIRE) conducted a monitoring survey at the Rhode Island Sound Disposal Site (RISDS) in October 2021 as part of the U.S. Army Corps of Engineers (USACE) New England District (NAE) Disposal Area Monitoring System (DAMOS) Program. DAMOS is a comprehensive monitoring and management program designed and conducted to address environmental concerns surrounding the placement of dredged material at aquatic disposal sites throughout the New England region. An introduction to the DAMOS Program and RISDS, including brief descriptions of previous dredged material disposal and site monitoring activities, is provided below.

1.1 Overview of the DAMOS Program

The DAMOS Program features a tiered management protocol designed to ensure that any potential adverse environmental impacts associated with dredged material disposal are promptly identified and addressed (Germano et al. 1994). For over 40 years, the DAMOS Program has collected and evaluated dredged material disposal site data throughout New England. Based on these data, patterns of physical, chemical, and biological responses of seafloor environments to dredged material disposal activity have been documented (Fredette and French 2004).

DAMOS monitoring surveys fall into two general categories: confirmatory studies and focused studies. The data collected and evaluated during these studies provide answers to strategic questions in determining next steps in the disposal site management process. DAMOS monitoring results guide the management of disposal activities at existing sites, support planning for use of future sites, and evaluate the long-term status of historical sites (Wolf et al. 2012).

Confirmatory studies are designed to test hypotheses related to expected physical and ecological response patterns following placement of dredged material on the seafloor at established, active disposal sites. Two primary goals of DAMOS confirmatory monitoring surveys are to document the physical location and stability of dredged material placed into the aquatic environment and to evaluate the biological recovery of the benthic community following placement of dredged material. Several survey techniques are employed in order to characterize these responses to dredged material placement. Sequential acoustic monitoring surveys (including bathymetric, acoustic backscatter, and side-scan sonar data collection) are performed to characterize the height and spread of discrete dredged material deposits or mounds created at open water sites as well as the accumulation/consolidation of dredged material into confined aquatic disposal cells.

Sediment Profile and Plan View Imaging (SPI/PV) surveys are performed in confirmatory studies to provide further physical characterization of the material and to support evaluation of seafloor (benthic) habitat conditions and recovery over time. Each type of data collection activity is conducted periodically at disposal sites, and the conditions found after a defined period of disposal activity are compared with the long-term data set at specific sites to determine the next step in the disposal site management process (Germano et al. 1994).

Focused studies are periodically undertaken within the DAMOS Program to evaluate candidate sites, as baseline surveys at new sites, to evaluate inactive or historical disposal sites, and to contribute to the development of dredged material management and monitoring techniques. Focused DAMOS monitoring surveys may also feature additional types of data collection activities as deemed appropriate to achieve specific survey objectives, such as grab or core sampling of sediment for physical/chemical/biological analyses, sub-bottom profiling, or video imaging.

The 2021 RISDS effort was a confirmatory survey with additional focused studies to provide a baseline assessment for a potential new reference area and to assess seafloor conditions at a location outside of RISDS boundary where dredged material was accidentally released (short-dump location).

1.2 Introduction to the Rhode Island Sound Disposal Site

RISDS is located south of Narragansett Bay and approximately 16.7 kilometers (km) (10.4 miles [mi]) south of Point Judith, Rhode Island (Figure 1-1). The site is defined as an 1,800 × 1,800-meter (m) (5,900 × 5,900-feet [ft]) area on the seafloor centered at 41°13.850' N, 71°22.817' W (NAD 83). RISDS was selected as an open-water disposal site in 2001 (USACE 2001), began receiving dredged material from the Providence River and Harbor Maintenance Dredging Project (PRHMDP) in 2003 (Carey et al. 2015), and was formally designated as an Ocean Dredged Material Disposal Site (ODMDS) by the U.S. Environmental Protection Agency (EPA) in 2004 (40 CFR Part 228).

The underlying topography of RISDS features a broad topographic depression with water depths ranging from 34 to 39 m (111 to 128 ft). Native sediments at RISDS range from glacially derived till to soft, silty sand (USEPA 2004). RISDS features a berm rising 1 to 4 m above the seafloor along the western side, a mound in the northern area rising up to 12 m (~40.0 ft) above the seafloor, and several smaller low-relief areas rising 1 to 2 m (~3.0 - 6.5 ft) above the seafloor located throughout the site. The western berm, the northern mound, and the low-relief areas were formed by dredged material placement activities, as described below.

1.3 Historical Dredged Material Disposal Activity

Recorded placement of dredged material at RISDS began in 2003 through 2005 with the placement of 4 million cubic meters (m^3) (5 million cubic yards [yd^3]) of dredged material from the PRHMDP (Table 1-1). This dredged material was composed primarily of two different types of sediment; (1) maintenance material from the navigation channel, and (2) underlying native material generated from the excavation of confined aquatic disposal (CAD) cells beneath Providence River. The underlying native material was composed primarily of glacial sediments and was placed mainly along the western boundary of RISDS to create a continuous ridge or berm of sediment (SAIC 2004). This berm was created to enhance the capacity of the natural bottom depression located in the southeastern quadrant of the disposal site and to limit the lateral spread of disposed unconsolidated sediment. The maintenance material dredged from the channel and additional material from non-federal projects was directed to a series of disposal points across the site to create a relatively even deposit.

From 2008 through 2015, a total of 866,100 m^3 (1,132,800 yd^3) of dredged material was placed at and near the northern mound area of RISDS from three projects (Table 1-1). Most of this dredged material (76%) came from the New Bedford Harbor CAD cell construction project and consisted primarily of glacial till and clay. In addition, dredged material from the Port of Davisville that consisted of primarily fine sand was placed at RISDS along with a relatively small amount of material from Great Harbor in Woods Hole, MA.

Between 2017 and 2020, approximately 366,000 m^3 (479,000 yd^3) of dredged material was placed at RISDS, originating from the Town of Harwich, Quonset Business Park, Port of Davisville, and New Bedford Lower Harbor (Table 1-1). This material was placed at the northern mound, an area to the southwest of the northern mound, and at two locations in the northeast corner of RISDS.

1.4 Previous RISDS Monitoring Events

Numerous acoustic, SPI/PV, and other surveys were conducted prior to, during, and immediately following the major Providence River dredging project (1997-2005; Table 1-2; Carey et al. 2015). Four additional RISDS monitoring surveys were conducted in 2009, 2013, 2015, and 2020. In 2009, a SPI/PV survey was conducted to continue the assessment of benthic recolonization status following placement of sediment from Providence River.

In 2013, an acoustic survey and a combined SPI/PV and sediment grab sampling survey confirmed the persistence of the western berm created previously through dredged material disposal activity. Stage 3 successional stage was present at all RISDS stations, although lower abundances of deep deposit-feeding infauna compared to the reference areas, likely contributed to the significantly shallower aRPD depths measured in 2013.

In 2015, an acoustic survey was conducted over the north-central portion of the site and confirmed targeted placement of dredged material to the northeast of the existing western berm. Between the 2013 and 2015 surveys, up to 11 m of material accumulated on the northern mound. The 2015 survey report recommended that future material be spread more widely to increase the spatial extent of the berm (Sturdivant and Carey 2017).

In 2020, a combined confirmatory and focused survey was conducted in preparation for increased use of RISDS as part of the planned Providence Harbor maintenance dredging project and to support updates to the Site Management and Monitoring Plan (SMMP). Seafloor elevation changes confirmed the placement of material in the northern area of RISDS. Hard bottom habitat consisting of cobble and smaller gravels encrusted with bryozoa and hydroids was documented at several locations at RISDS, including in a central area (referred to in previous reports as RISDS-C) and at the pinnacle of the high-relief northern mound. These hard bottom habitats were derived from dredged material placement and are generally not comparable to the native soft bottom habitats that occur at the three RISDS reference areas. One of the objectives of the 2021 survey was to identify and conduct a baseline assessment for a potential new reference area with more comparable seafloor conditions to the hard bottom areas at RISDS. Two candidate locations were surveyed to determine potential use as an additional reference area for RISDS (discussed further in Section 1.6).

1.5 Recent Dredged Material Disposal Activity

Since the 2020 survey, approximately 495,000 m^3 (647,000 yd^3) of dredged material have been placed at RISDS (Table 1-1). This material originated from both federal and permitted (non-federal) dredging projects and was directed to the northern portion of RISDS (Figure 1-2). In addition, a short dump of dredged material occurred northeast of RISDS in 2020, which was assessed during the 2021 survey and reported herein (Figure 1-3).

A detailed record of dredged material disposal activity at RISDS since the last survey (June 15, 2020 to February 11, 2021), including the origin and volume of dredged material, and the placement coordinates, is provided in Appendix B.

1.6 2021 Survey Objectives and Motivation for Approach

The 2021 RISDS survey encompassed several objectives and four separate survey areas (Figure 1-3). A confirmatory investigation was conducted at RISDS to assess the recent targeted dredged material placement events in the active, northern portion of the site. A 2020 short dump of dredged material, located northeast of RISDS, was investigated by collecting multibeam bathymetric data and SPI/PV imagery. Two potential new reference areas, initially identified based on a desktop review of existing data, were assessed for hard bottom distribution and characteristics by collecting multibeam bathymetric data and PV imagery.

The overall objectives of the 2021 RISDS survey were to conduct confirmatory and focused investigations designed to address the following:

- characterize the seafloor topography and surficial features over the active portion of RISDS, potential new reference area locations, and the short-dump location by completing a multibeam bathymetric survey;
- assess seafloor conditions by conducting an adaptive SPI/PV survey at the short-dump location; and
- assess surficial sediments by collecting “Pogo” PV imagery at two potential new reference area locations.

Table 1-1.

Estimated Volume of Dredged Material Placed at RISDS
from April 2003 to Feb 2021

Project	Disposal Dates	Volume (m³)	Volume (yd³)
Providence River and Harbor Maintenance Dredging	04/2003 to 01/2005	4,062,000	5,312,000
National Marine Fisheries Service at Great Harbor, Woods Hole, MA - Maintenance Dredging	11/2008 to 01/2009	866,100	1,132,800
Port of Davisville, Quonset Point, RI - Improvement Dredging	01/2012 to 01/2013		
New Bedford Harbor CAD Cell Construction Material	05/20/2013 to 08/25/2013*		
New Bedford Harbor CAD Cell Construction Material	08/28/2013 to 07/19/2015*		
Town of Harwich, Quonset Business Park, Port of Davisville, New Bedford Lower Harbor	11/2017 to 6/2020	366,000	479,000
New Bedford Lower Harbor, Quonset Business Park, Port of Davisville, Block Island Federal Navigation Project	06/14/2020 to 02/11/2021	494,900	647,300
Total		**5,789,000**	**7,571,100**

*Acoustic surveys performed 08/27/2013 and 10/14/2015

Table 1-2.

Overview of DAMOS Survey Activities in Rhode Island Sound since 1997

Date	Purpose of Survey	Acoustic Surveys	SPI Stations	Additional Studies	Reference
June 1997	Evaluation of potential disposal sites		18		SAIC 1997[a]
Nov 1999	Characterize benthic resources and sediment at potential dredged material disposal sites		35		SAIC 2000[b]
Sept 2001	Rhode Island regional long-term dredged material disposal site evaluation		RISDS - 9 REF Areas - 9		Battelle 2002
Feb 2003	Baseline bathymetric survey in support of PRHMDP	Multibeam 4000 x 3800 m			SAIC 2004
July 2003	First post-disposal monitoring survey	Single-beam 1900 x 1900 m			SAIC 2004
Sept 2003	Second post-disposal monitoring survey	Single-beam 1900 x 1900 m Towed Side-scan sonar 2900 x 2900 m[c]			SAIC 2004
Oct 2003	Assessment of surface sediment composition within RISDS and surrounding Area W		11	Towed video 8 transects	SAIC 2004
Apr 2004 Sept 2004	Track and assess suspended sediment plume			ADCP OBS drogues, water analysis	SAIC 2005a SAIC 2005b
Feb 2004 May 2004 Sept 2004 Aug 2005	Post-disposal monitoring in support of PRHMDP	Single-beam 1900 x 1900 m			ENSR 2008

Table 1-2. continued

Date	Purpose of Survey	Acoustic Surveys	SPI Stations	Additional Studies	Reference
July 2005	Assess benthic recolonization status		RISDS – 30 (RISDS-A thru -E, BE[d]) Ref Areas - 15	Infauna Analysis	ENSR 2007
Aug 2005 Sept 2005 Nov 2005	Assess post-disposal lobster abundance			Lobster trapping	Valente et al. 2007
Oct 2009	Assess benthic recolonization status		RISDS – 30 (RISDS-A thru -E, BE[d]) Ref Areas - 15		ENSR 2007
Aug 2013	Assess full-site seafloor topography Assess benthic recolonization status	Multibeam 2,000 x 2,000 m	RISDS – 15 (RISDS-B, -C and -D) Ref Areas - 15	Infauna Analysis	Carey et al. 2015
Oct 2015	Post-disposal monitoring in support of New Bedford Harbor CAD Cell Construction	Multibeam 600 x 1,000 m			Sturdivant and Carey 2017
May/June 2020	Assess full-site seafloor topography Assess benthic recolonization status Support SMMP update	Multibeam 2,000 x 2,000 m RISDS 600 x 600 m Ref areas	RISDS – 21 (RISDS-A, -B, -C, -D, -E, -N, -NW) Ref Areas - 15	Infaunal Analysis Grain Size PCBs, PAHs, Metals, TOC	USACE 2021
October 2021		Multibeam 1,000 x 1,800 m RISDS 1,000 x 1,000 m at two potential references areas 600 x 600 m at short-dump survey area	57 adaptive SPI/PV at short-dump survey area 54 Pogo PV at two potential new reference areas		current study

Notes:
a - Dimensions of site 69b and 69a were different from current configuration. b - Dimensions of site 69b and 69a were consistent with current boundaries.
c - Area W was 2900 x 2900 m with RISDS included in the southeast quadrant. d - BE refers to the berm area.

2.0 METHODS

INSPIRE led the 2021 confirmatory and focused investigations at RISDS. The acoustic data collection was conducted by Substructure, Inc. 07-08 October 2021 onboard the 31-ft R/V *Orion*. The adaptive SPI/PV and Pogo PV surveys were conducted by INSPIRE onboard 55-ft R/V *Jamie Hanna* on 08 October 2021.

2.1 Acoustic Survey

The acoustic survey featured use of a multibeam echosounder (MBES) to collect bathymetric, acoustic backscatter, and side-scan sonar measurements over a 1,000 x 1,800-m area of RISDS, a 600 x 600-m area centered around the short-dump point location coordinates, and two 1,000 x 1,000-m areas over potential new reference areas (Figure 2-1). Fishing gear observations were made during the acoustic survey to quantify fishing activity in and around RISDS.

2.1.1 Navigation and Onboard Data Acquisition

During survey operations, vessel navigation and orientation data were controlled by an Applanix 320 POSMV on the R/V *Orion* that received Real Time Kinematic (RTK) differential Global Navigation Satellite System (GNSS) correctors from a local Trimble R10 base station (established over a temporary survey mark at the Point Judith Coast Guard Station) via a dedicated NTRIP caster network (Table 2-1). During survey operations, the POSMV vessel navigation, heading, and motion data were logged within the QPS QINSy hydrographic survey software, and the raw POSMV observables were continuously recorded throughout the survey period to enable post-processing using the Applanix POSPac Mobile Mapping Suite (MMS) software. The POSPac post-processed horizontal position error Root Mean Square (RMS) was consistently below 1.5 centimeters (cm) and the vertical error RMS was below 2.0 cm.

Bathymetric, acoustic backscatter (snippets), and side-scan sonar (Truepix) data were acquired using an R2Sonic 2024 MBES as detailed in the Program Quality Assurance Project Plan (QAPP; INSPIRE 2020a) and in the standard operating procedures (SOP) for acoustic surveys (INSPIRE 2020b). This 200-450 kilohertz (kHz) system forms 256 0.5- to 1-degree beams (frequency dependent) distributed equiangularly or equidistantly across up to a 160-degree swath. For this survey, the sonar frequency was set to 300 kHz and a sonar swath opening of 100 - 110 degrees was used, resulting in swath coverage approximately 2.4 - 2.8 times the water depth.

Corrections of sounding depth and position (range and azimuth) for refraction due to water column speed of sound differences were applied using a series of twelve conductivity, temperature, and depth (CTD) profiles acquired during the two days of survey operations. The CTD profiles were generally consistent across the survey period, and the profiles were applied directly within the survey program during data acquisition. The observed speed of sound differences resulted in very minor outer beam differences that had no effect on the useable swath of the multibeam data.

Table 2-1.

Navigation and Data Acquisition Equipment

Measurement	Equipment
Vessel Navigation and Motion	Applanix 320 POSMV
Local GNSS Base Station	Trimble R10 dual-frequency GNSS
MBES	R2Sonic 2024
Sound Velocity	Valeport Mini SVS and YSI Castaway

2.1.2 Acoustic Survey Planning

The MBES survey was designed to provide high-resolution bathymetry at the RISDS survey area to characterize the seafloor topography and surficial features over the active portion of the site. Survey efforts at the short-dump location and at two potential reference areas were designed to provide lower resolution data sufficient to generally characterize surficial grain size while maximizing efficiency of time offshore.

2.1.3 Acoustic Data Collection

The acoustic survey within the active disposal area of RISDS was executed to provide close to 200-percent coverage by running a series of east-west oriented lines spaced at 40-m intervals across the required survey area (Figure 2-1). Adequate survey coverage was confirmed by closely monitoring the 0.5-m real-time sounding grid. In addition, four perpendicular north-south oriented cross-check sounding lines (cross-lines) were acquired across the site. Over the short dump survey area and at the two potential new reference areas, the north-south main line spacing was increased to 100-m intervals and included two east-west oriented cross-lines in each area.

2.1.4 Bathymetric Data Processing

Bathymetric data were processed using Applanix POSPac MMS, QPS Qimera, and HYPACK HYSWEEP® software. Processing components are described below and included:

- Post-processing of real-time POSMV solution with POSPac MMS using POSMV raw observables and local base station Trimble R10 GNSS data;
- Application of POSPac Smoothed Best Estimate of Trajectory (SBET) file to raw multibeam data files;
- Conversion of the SBET ellipsoidal height reference to Mean Lower Low Water (MLLW) via Geoid Model 12B and published NAVD88 to MLLW offset for the survey area from the National Oceanic and Atmospheric Administration's (NOAA) VDatum application;
- Comparison of SBET height reference to the NOAA Newport, RI tide observations;
- Application of speed of sound profiles to account for differences in the water column during the survey period;
- Removal of spurious points associated with water column interference or system errors;
- Development of a grid surface representing depth solutions;
- Statistical estimation of sounding solution uncertainty; and
- Generation of data visualization products.

The combined uncertainties associated with all system elements, including calibrations, tide corrections, and refraction caused by water column stratification were quantified by comparing primary survey transects with perpendicular cross-line transects.

Comparisons were made using the Qimera Cross Check program to show the observed differences by beam angle between the 0.5-m grid surface (computed from the primary survey transects) and the cross-line survey point data. This comparison used a 45-degree swath opening for both main and cross-lines which was consistent with the swath opening used for final grid development. This resulted in approximately 2.1 million mainstay versus cross-check comparison points, with a mean difference of 0.023 m, a standard deviation of 0.038 m, and a mean 95% RMS (2-sigma) confidence limit uncertainty of 0.099 m. Mean elevation differences across the swaths ranged from -1.99 m to 1.47 m with the greatest differences observed in the outer beams farther from nadir. This comparison indicates negligible tide bias with only slightly increased outer swath uncertainty associated with minor refraction impacts. This analysis shows compliance with USACE accuracy recommendations and National Ocean Service (NOS) standards. Note that the NOS standard for this project depth (Special Order) specifies a 95th percentile confidence interval (95% CI) of ±0.370 m at the maximum survey depth (39.0 m).

Reduced bathymetric data were exported in ASCII text format at a resolution of 1 m x 1 m with fields for easting, northing, and MLLW elevation (meters). All data were projected to the NAD 1983 Rhode Island State Plane Coordinate System meters. A variety of data visualizations were generated using a combination of HYPACK, QPS Fledermaus, and ESRI ArcGIS Pro. Visualizations and data products included:

- ASCII data files of all processed soundings including MLLW depths and elevations;
- 3-dimensional surface maps of the seabed created using 5x vertical exaggeration and artificial illumination to highlight fine-scale features not visible on contour layers (delivered in grid and TIF formats); and
- An acoustic relief map of the survey area created using 5x vertical exaggeration, delivered in georeferenced TIF format.

2.1.5 Backscatter Data Processing

MBES backscatter data were processed using the QPS Fledermaus GeoCoder Toolkit implementation of the GeoCoder algorithms, originally developed by NOAA's Center for Coastal and Ocean Mapping Joint Hydrographic Center. GeoCoder uses beam-angle varying gain algorithms to normalize the MBES snippet beam time-series data across the full swath. The resulting backscatter intensity data for RISDS were exported in ASCII format with fields for easting, northing, and backscatter intensity (in decibel [dB] units) at a grid resolution of 1-m and as a seamless 1-m backscatter mosaic in GeoTIF format. A Gaussian filter was applied to backscatter data to minimize nadir artifacts and the filtered data were used to develop backscatter visualization draped over hillshaded relief.

2.1.6 Side-Scan Sonar Data Processing

MBES pseudo side-scan sonar (TruePix) data were processed using Chesapeake Technology SonarWiz software. The TruePix data (16-bit QINSy QPD files) were imported into SonarWiz and each transect was manually bottom- and far-field tracked. Slant-range corrections and nadir filters were applied to the bottom-tracked data, and then empirical gain normalization was applied across the full dataset to create a seamless side-scan sonar mosaic. The side-scan sonar mosaic was exported at a 0.5-m resolution in GeoTIF format to complement the MBES backscatter mosaic.

2.1.7 Acoustic Data Analysis

The processed bathymetric grids were converted to rasters, and bathymetric contour lines and acoustic relief models were generated and displayed using ArcGIS. The backscatter mosaics and filtered backscatter grid were combined with acoustic relief models in ArcGIS to facilitate visualization of relationships between acoustic datasets. This is done by rendering images and color-coded grids with sufficient transparency to allow the three-dimensional acoustic relief model to be visible underneath.

Golden Software Surfer software was used to calculate elevation change grids between the 2021 bathymetric dataset and previous DAMOS surveys. Elevation change grids (1-m cells) were calculated by subtracting the earlier survey depth estimates from the 2021 survey depth estimates at each point throughout the grid. The resulting elevation changes were contoured and displayed using ArcGIS.

2.2 Sediment Profile and Plan View Imaging Survey

The adaptive SPI/PV and Pogo PV surveys were conducted by INSPIRE personnel onboard the 55-ft R/V *Jamie Hanna* on 08 October 2021. SPI and PV imaging are monitoring techniques used to provide data on the physical characteristics of the seafloor and the status of the benthic biological community. SPI and PV imagery were collected at the short-dump survey area to locate the dredged material on the seafloor within the context of surrounding native sediments. PV imagery was collected at two potential new reference areas to characterize the hard bottom habitat.

2.2.1 Navigation and Onboard Data Acquisition

Navigation for the adaptive SPI/PV and Pogo PV surveys was carried out by INSPIRE. A Hemisphere VS330 GNSS compass with dual antennas using WAAS differential correctors was used to accurately record vessel heading as well as position accuracy to within a meter. During operations, HYPACK® 2018 software received positional data and transmitted a visual display to the helm, guiding the captain to maneuver the vessel to each sampling station. The GNSS was interfaced to HYPACK® software via laptop serial ports to provide a method to record actual sampling locations. Throughout the survey, the HYPACK® data acquisition system received GNSS positioning data. The incoming data stream was digitally integrated and stored on the PC's hard drive. Actual SPI/PV sampling locations were recorded using this system.

At each station, the vessel was positioned based on the adaptive sampling plan and the camera was deployed. Single paired SPI and PV images were collected at each station at the short-dump survey area and a single PV image was collected at each station at the two potential new reference areas. When the camera contacted the seafloor, the SPI/PV technicians signaled via handheld radio that the camera was on the bottom. The navigator recorded the time and position of the camera electronically in HYPACK as well as the written field log. After all stations were sampled, the navigator exported all recorded positional data into a Microsoft Excel© spreadsheet. The spreadsheet included the station name, date, time, depth, and position of every SPI/PV pair or PV image collected.

2.2.2 SPI and PV Survey Planning

At the short-dump survey area, the adaptive SPI/PV sampling approach enabled flexible sampling to optimize spatial coverage and to locate and identify any evidence of dredged material on the seafloor. Preliminary acoustic data informed initial target locations for image collection. The scientists then reviewed the SPI/PV images in real-time onboard the vessel to direct further image collection. At the short-dump survey area, the SPI/PV survey included 57 adaptive SPI/PV stations, where one paired SPI/PV image was collected and analyzed at each station (Figure 2-2).

At each of the two potential new reference areas, Pogo PV stations were initially planned along transects that traversed location coordinates documented to have hard bottom (McMullen et al. 2011; Poppe et al. 2014). At the two potential new reference areas, a total of 54 Pogo PV stations were sampled; 29 stations at the western potential reference area and 26 stations at the eastern potential reference area (Figure 2-3).

During adaptive SPI/PV and Pogo PV sampling, the camera system is raised and lowered while the vessel is slowly moving in order to collect multiple sediment profile and/or plan view images in rapid succession. This approach allows for high spatial density of imaging to maximize coverage over an area.

The adaptive SPI/PV and Pogo PV station locations are provided in Appendix C. The methodology for data acquisition and analysis for these images was consistent with the sampling methods described in detail in the Project QAPP (INSPIRE 2020a) and INSPIRE SPI/PV SOP (INSPIRE 2019).

2.2.3 Sediment Profile Image Collection

The SPI technique involves deploying an underwater camera system to photograph a cross-section of the sediment–water interface. In the 2021 survey at RISDS, high-resolution SPI images were acquired using a Nikon® D7100 digital single-lens reflex camera mounted inside an Ocean Imaging® Model 3731 pressure housing system. The pressure housing sat atop a wedge-shaped steel prism with a plexiglass front faceplate and a back mirror. The mirror was mounted at a 45-degree angle to reflect the profile of the sediment–water interface. The camera lens looked down at the mirror, which reflected the image from the faceplate. The prism had an internal strobe mounted inside at the back of the wedge to provide illumination for the image; this chamber was filled with distilled water, so the camera always had an optically clear path. The descent of the prism into the sediment was controlled by a hydraulic piston. As the prism penetrated the seafloor, a trigger activated a time-delay circuit that fired an internal strobe to obtain a cross-sectional image of the upper 15–20 cm of the sediment column (Figure 2-4). The camera remained on the seafloor for approximately 20 seconds to ensure that a successful image had been obtained.

Test exposures of a Color Calibration Target were made on deck at the beginning and end of the 2021 survey to verify that all internal electronic systems consistently met design specifications and to provide a color standard against which final images could be checked to ensure proper color balance. Details of the camera settings for each digital image are available in the associated parameters file embedded in each electronic image file. For this survey, the ISO-equivalent was set at 640, shutter speed was 1/250, f-stop was f11, and storage was in compressed raw Nikon Electronic Format (NEF) files (approximately 30 MB each). All camera settings and any setting changes were recorded in the field log.

Each time the camera system was brought onboard, the frame counter was checked to ensure that the images had been obtained. In addition, a prism penetration depth indicator on the camera frame was checked to verify that the optical prism had actually penetrated the bottom to a sufficient depth. If images were missed or the penetration depth was insufficient, the camera frame stop collars were adjusted and/or weights were added or removed, prior to collecting additional images. Frame counts, time of image acquisition, and camera settings were recorded in the field log for each image.

Each image was assigned a unique time stamp in the digital file attributes by the camera's data logger and cross-checked with the time stamp in the navigational system's computer data file. In addition, the field crew kept redundant written sample logs. Images were downloaded periodically to verify successful sample acquisition and/or to assess what type of sediment/depositional layer was present at a particular station. Digital image files were renamed with the appropriate station names after downloading as a further quality assurance step.

2.2.4 Plan View Image Collection

An Ocean Imaging® Model DSC24000 PV underwater camera system with two Ocean Imaging® Model 400-37 Deep Sea Scaling lasers was attached to the sediment profile camera frame and used to collect plan view images of the seafloor surface. The PV system consisted of a Nikon D-7100 encased in an aluminum housing, a 24 VDC autonomous power pack, a 500 W strobe, and a bounce trigger. A weight was attached to the bounce trigger with a stainless-steel cable so that the weight hung below the camera frame; the scaling lasers projected two red dots that are separated by a constant distance (26 cm) regardless of the field of view of the PV system. The field of view can be varied by increasing or decreasing the length of the trigger wire and, thereby, the camera height above the bottom when the picture is taken. As the SPI/PV camera system was lowered to the seafloor, the weight attached to the bounce trigger contacted the seafloor prior to the camera frame reaching the seafloor and triggered the PV camera (Figure 2-4).

During setup and testing of the PV camera, the positions of lasers on the PV camera were checked and calibrated to ensure separation of 26 cm. Test images were also captured to confirm proper camera settings for site conditions. Details of the camera settings for each digital image are available in the associated parameters file embedded in each electronic image file; for this survey, the ISO-equivalent was set at 640. The additional camera settings used were as follows: shutter speed 1/30, f18, white balance set to flash, color mode set to

Adobe RGB, sharpening set to none, noise reduction off, and storage in compressed raw NEF files (approximately 30 MB each). Images were checked periodically throughout the survey to confirm that the initial camera settings were still resulting in the highest quality images possible. All camera settings and any setting changes were recorded in the field log.

Prior to field operations, the internal clock in the digital PV system was synchronized with the GNSS and the SPI camera. For each PV image, a time stamp was recorded in the digital file and redundant time notes were made in the field and navigation logs. Throughout the survey, PV images were downloaded at the same time as the SPI images and evaluated to confirm image acquisition and image clarity.

The ability of the PV system to collect usable images was dependent on the clarity of the water column. Water conditions at RISDS allowed use of a 0.8-m trigger wire, resulting in a mean image width of 0.7 m and a mean field of view of 0.4 m^2.

2.2.5 Image Conversion and Calibration

Following completion of field operations, quality control checks were conducted of the field log, image date/time stamps were verified, and project-specific filenames were generated. After these procedures, the NEF raw image files were color calibrated in Adobe Camera Raw® by synchronizing the raw color profiles to the Color Calibration Target that was photographed prior to field operations with the SPI camera. The raw SPI and PV images were then converted to high-resolution Photoshop Document (PSD) format files, using a lossless conversion file process and maintaining an Adobe RGB (1998) color profile. The PSD images were then calibrated and analyzed in Adobe Photoshop®. Length and area measurements were recorded as number of pixels and converted to scientific units using the calibration information. Detailed results of all SPI and PV image analyses are presented in Appendices D (short dump) and E (reference areas).

2.2.6 SPI and PV Data Analysis

Computer-aided analysis of the resulting images provided a set of standard measurements to allow comparisons between different locations and different surveys. The DAMOS Program has successfully used this technique for over 30 years to map the distribution of disposed dredged material and to monitor benthic recolonization at disposal sites (Germano et al. 2011).

Measured parameters for SPI and PV images were recorded in Microsoft Excel© spreadsheets. These data were subsequently checked by one of INSPIRE's senior scientists as an independent quality assurance/quality control review before final interpretation was performed. Spatial distributions of SPI and PV parameters were mapped using ESRI ArcGIS 10.5. Map backgrounds use ESRI Oceans streaming layer to provide spatial context.

2.2.6.1 Sediment Profile Image Analysis Parameters

The parameters discussed here were assessed and/or measured and recorded for each SPI image (Appendix D). The presence of dredged material below the sediment–water interface, distinguishable from other sediment layers, was recorded. If the dredged material layer extended below the depth of prism penetration it was noted. If the dredged material was buried, it was also noted. The lack of a distinct dredged material layer is not an indication that dredged material was not present as non-native material may have very similar characteristics as the native material.

2.2.6.2 Plan View Image Analysis Parameters

The PV images provided a much larger field of view than the SPI images and provided valuable information about the landscape ecology and sediment topography in the area where the pinpoint "optical core" of the sediment profile was taken (Figure 2-5). If coastal bivalve shells were observed in the PV imagery of the short-dump survey area, the data could be corroborated with evidence of potential dredged material in the sediment column detected in SPI imagery.

For each PV image collected at the short-dump survey area, analysts calculated the image size and field of view and the following were recorded: dredged material presence; dredged material notes, which included the presence of coastal bivalve(s) shells; and brief descriptive comments (Appendix D).

For each PV image collected at the two potential new reference areas, analysts calculated image size and field of view and the following Coastal and Marine Ecological Classification Standard (CMECS) parameters were recorded: CMECS Substrate Group, CMECS Substrate Subgroup, and Minimum and Maximum Gravel Size Categories (Appendix E).

The substrate analysis made use of CMECS, a framework that enables a comprehensive characterization of any environment using standardized parameters and definitions (Federal Geographic Data Committee [FGDC] 2012). CMECS Substrate Group and Subgroup are conceptually explained in Figure 2-6. CMECS Substrate Group is determined by the proportion of gravel present (Folk 1954). CMECS Substrate Subgroup further refines Substrate Group when gravel cover is >80%; the predominant gravel size class informs the Subgroup (Figure 2-6). At the two potential new reference areas, since no SPI imagery was collected, where gravel was <5% cover, Sand was the most resolved CMECS Substrate classification; SPI imagery is required to incorporate the proportion of sand to mud (silt/clay) and the grain size major mode (Wentworth 1922) into the CMECS Substrate Subgroup (Figure 2-6). However, further resolution of Sand was not necessary to meet the objectives of the survey at the two potential new reference areas.

3.0 RESULTS

Bathymetric, backscatter, and side-scan sonar data were collected at the northern portion of RISDS, at the short-dump survey area, and at two potential new reference areas (reference area west and reference area east). Overview maps showing all survey areas and respective data layers were created for spatial comparison (Figures 3-1, 3-2, 3-3, and 3-4). In addition, SPI/PV images were collected at the short-dump survey area and PV images were collected at the two potential new reference areas. Results are organized by survey location and presented below.

3.1 RISDS Acoustic Survey

3.1.1 Existing Bathymetry

The 2021 multibeam bathymetric data were rendered as an acoustic relief model to provide a detailed representation of the topography of the survey area (Figure 3-5). Across the 2021 RISDS survey area depths ranged from 26.7 m to 38.2 m, with a mean depth of 36.7 m. In the north-central portion of the survey area, a large mound was observed to be approximately 10 m above the surrounding seafloor at a water depth of 26 m. A berm near the western edge of the site was documented to be 1-2 m above the surrounding seafloor and extended southward 350-400 m from the mound to the survey boundary.

Two distinct mounds in the northeast portion of the site rose 3-4 m above the surrounding seafloor and had diameters of approximately 150 m each. Recent placement events occurred in this area (Figure 3-6) and appeared to have increased the size of the two northeast mounds in footprint and relief above the surrounding seafloor (Figure 3-7).

Dredged material was recently placed to the southwest of the large north-central mound in RISDS (Figure 3-6). The placement of this material resulted in distinct topographic features covering an area measuring 500 m x 250 m (Figures 3-5 and 3-6). This area was characterized by small-scale relief patterns, including hummocks and craters. These seafloor patterns are indicative of dredged material deposits that occurred throughout the area and ranged from one to ten meters across and approximately 50 cm in height.

3.1.2 Acoustic Backscatter and Side-Scan Sonar

Acoustic backscatter provides an indication of the nature of surficial sediment present in the survey area (e.g., sediment texture). Filtered backscatter was draped over a hillshaded relief model to visualize surficial topography in conjunction with acoustic returns (Figure 3-8). Stronger backscatter returns are indicative of coarser-grained, rougher, or harder sediment relative to surrounding sediments and are shown in orange and yellow on the map. Weaker backscatter returns are indicative of finer-grained, smoother, or softer sediment relative to surrounding sediments and are shown in blue on the map. Compared to backscatter data, side-scan sonar data are more responsive to minor surface textural features and slope than backscatter results and can reveal additional information about topographic and textural properties of the seafloor (Figure 3-9).

Stronger backscatter returns were predominantly observed on the north-central mound, along the western berm, and on the two mounds in the northeast (Figure 3-8). Additional areas along the southern and northeastern border of the survey area had stronger backscatter returns as well. Moderately high backscatter returns were observed over the topographically rough area southwest of the large north-central mound where recent material was placed. Stronger backscatter return patterns were often seen co-located with craters and small topographic features seen in the bathymetric relief data, particularly along the southwest apron of the north-central mound and the two northeast mounds. This co-location provides support for the characterization of these features as formed by dredged material placement. Weaker backscatter returns, suggesting finer-grained or softer sediments, were observed throughout the rest of the site and typically associated with smoother topographic features devoid of bathymetric relief.

The side-scan sonar imagery derived from MBES showed similar large-scale patterns as seen in the backscatter mosaic, including higher returns on the mounds, the western berm, and in areas with craters and small topographic features (Figure 3-9). The side-scan sonar mosaic provided additional resolution which was useful in discerning small-scale surface features such as craters, linear features, and more natural bedforms. For example, linear features of higher return in the central portion of the survey area are clearly visible in the side-scan sonar mosaic. Small-scale bedforms are visible in the far southeast corner of the surveyed area, likely derived from natural hydrodynamic forces.

3.1.3 Comparison with Previous Bathymetry

The 2021 bathymetric data were quantitatively compared to the 2020 bathymetric data to assess elevation changes since the 2020 survey (Figure 3-7). Bottom depths measured during the 2020 survey were subtracted from those measured during the 2021 survey to obtain an elevation change map of each survey point throughout the combined study area. Positive values (represented as shades of yellow and green in the elevation change maps) computed between surveys indicated elevations have increased (i.e., sediment accumulation). Negative elevation change (represented in shades of blue and purple) computed between surveys indicated areas that elevation has decreased (i.e., compaction, redistribution, smoothing).

Since 2020, substantial positive elevation changes were observed over two discrete areas within the acoustic survey extent, which corresponded to where dredged material was reportedly placed (Figures 3-7 and 3-10). The first area was in the northeast quadrant where two placement mounds have increased in elevation since 2020 by approximately three to four meters, and with elevation increases of approximately 0.5 to 1.0 m on the aprons of these mounds. The spatial extent where increased elevation was documented between these two mounds measured approximately 400 m x 250 m.

The second area that exhibited positive elevation change was to the southwest of the north-central mound (Figures 3-7 and 3-10). This broad plateau feature measured approximately 500 m x 500 m and experienced widespread positive elevation changes of 0.5 m to 1.0 m since 2020. Toward the center of this area, positive changes of up to ~2 m were observed.

Since 2020, negative seafloor elevation change was documented across an approximately 30 by 100-m strip along the northwest side of the north-central mound peak where seafloor elevation decreased by approximately 0.25 m to 0.75 m (Figure 3-7, shown in blue and purple). This was the most concentrated location of negative seafloor elevation change within the survey extent. A few other areas were documented to have experienced a negative change in seafloor elevation, but these locations were sparsely distributed throughout RISDS and limited in spatial area.

3.2 Short-Dump Survey Area

3.2.1 Acoustic Survey

Depths at the short-dump survey area ranged from 36.6 m to 39.0 m – averaging 37.9 m – indicating a relatively flat, low-relief seafloor (Figure 3-11). Bedforms associated with sediment transport were observed in the western half of the area. A slight depression with relatively low acoustic returns was observed in the south-eastern quadrant of the survey area directly adjacent to the short-dump point coordinates (Figure 3-12). A distinct circular area bounded by higher backscatter returns oriented southwest to northeast and measuring approximately 150 m x 50 m was observed to the west of the trough and was considered a potential signature of the short-dump placement event during preliminary, field analyses of the backscatter and side-scan sonar mosaics (Figure 3-12).

3.2.2 Sediment Profile and Plan View Imaging

An adaptive SPI/PV approach was adopted during field collection at the short-dump survey area to optimize the potential of capturing dredged material on the seafloor. SPI/PV stations were planned in the field based on review of preliminary acoustic data collected the previous day. Three general areas were sampled: (1) the reported short-dump point coordinates, including transects around this point; (2) an area to the north of the short-dump point coordinates; and (3) an area to the southwest of the short-dump point coordinates (Figure 2-2).

Initially, SPI/PV imagery was collected at the exact coordinates reported for the short-dump release through the USACE Dredging Quality Management (DQM) system records. SPI/PV imagery revealed very soft sediments with some degree of organic matter enrichment. However, there was no conclusive evidence of dredged material presence at the reported short-dump location (Figures 3-13 and 3-14A). Two SPI/PV transects were then sampled through the short-dump point coordinates with a focus on sampling the area of relatively lower acoustic returns to the southeast (Figure 3-12). Again, the benthic habitat was characterized by very soft sediment and there was no conclusive evidence of dredged material found along these sampled transects (Figures 3-13 and 3-14B). The very fine sand to silt/clay observed in the SPI was generally well mixed through the sediment column with no discrete sediment layering at any of the stations in this area.

SPI/PV imagery was then collected in an area north of the short-dump point coordinates where acoustic returns were relatively strong (Figures 3-12 and 3-14C). No evidence of dredged material was detected in this area (Figure 3-13).

SPI/PV imagery was collected at a location approximately 100 m to the southwest of the short-dump point coordinates. In this area, a relatively small and obscure anomaly was observed in the backscatter and side-scan data that appeared circular. Here, SPI/PV imagery revealed evidence of dredged material (Figures 3-13 and 3-15). Scattered coastal bivalve shells were observed on the sediment surface at several stations (Figure 3-15). These bivalve shells included the bay scallop (*Argopecten irradians*), the eastern oyster (*Crassostrea virginica*), and potentially razor clam (*Ensis directus*). All of these bivalve species are found in coastal waters, bays, and estuaries and do not naturally occur in offshore environments such as the short-dump survey area. In addition to the presence of these coastal shells, dredged material was evidenced in SPI by the presence of light gray and dark black silt/clay, distinct from the ambient light brown sands present in this area (Figure 3-15).

3.3 Potential New Reference Areas

3.3.1 Acoustic Survey

Reconnaissance acoustic data were collected at two potential new reference areas identified as potentially representative of hard bottom habitat based on reports from U.S. Geological Survey Open-File Reports (McMullen et al. 2011; Poppe et al. 2014). Depths at the eastern and western potential new reference areas ranged from 32.6 m to 37.8 m and 34.6 m to 38.0 m, respectively, with mean depths of 36.5 m in both areas (Figure 3-16).

The western potential new reference area was almost entirely composed of relatively strong backscatter returns, indicating potentially coarser-grained or rougher materials on the seafloor throughout the site (Figure 3-17). A few large surficial structures – most likely boulders or other debris – can be seen in the side-scan sonar mosaic in the eastern half of this survey area (Figure 3-18).

At the eastern potential new reference area, relatively weaker backscatter returns were observed throughout the northern and southern portions of the survey extent. A large seafloor feature measuring approximately 250 m x 900 m extended across the center of the survey area (Figures 3-17 and 3-18). This feature had stronger backscatter and side-scan sonar returns whereas the surrounding seafloor had relatively weak acoustic returns. This suggests the feature was predominantly comprised of coarser-grained or harder materials compared to the surrounding seafloor, which was likely finer or softer in nature (Figures 3-17 and 3-18). Discrete striations consistent with sediment transport features were seen in the western half of the area.

3.3.2 Plan View Imaging

PV imagery was collected using a Pogo approach along transects approximately 400 m in length at each of the two potential new reference areas (Figure 2-3). PV imagery was analyzed using the standard CMECS framework including Substrate Group and Subgroup, which consider the relative contribution of soft sediments to hard substrata and the size distribution of any dominant hard substrata present (Figure 2-6).

At the western potential new reference area, CMECS Substrate Subgroup classifications ranged from Sand (<5% cover of gravel) to Cobble (>80% cover of cobble-sized gravel) (Table 3-1; Figures 3-19 and 3-20). The spatial distribution, percent cover, and size of gravels varied along the western reference area Pogo PV transect. Several stations in the southern portion of the transect had little to no hard bottom or gravel (Substrate Subgroup Sand) (Figures 3-19, 3-20, and 3-21). Pebble/Granule (>80% cover of pebbles/granules) or Gravelly Sand (5-30% cover gravel) occurred along the central portion of the transect, where cobble-sized gravels were documented as the maximum gravel sizes observed in PV (Figures 3-19, 3-20, and 3-21). Gravels were more consistently documented at higher proportions in the northern half of the transect (Sandy Gravel, 30-80% gravels). In general, where gravels were documented at the western potential new reference area, a relatively high level of siltation was observed, with fine material draped over the gravels (Figure 3-21).

At the eastern potential new reference area, CMECS Substrate Subgroup classifications ranged from Sand (<5% cover of gravel) to Boulder (>80% cover of boulder-sized gravel) (Figure 3-19). There was no gravel present at the eight southern-most stations along the Pogo PV transect (Figures 3-19 and 3-20). The stations in the central and northern portions of the transect consisted of higher gravel content, generally >30% gravel cover (CMECS Substrate Subgroups Sandy Gravel, Pebble/Granule, Cobble, and Boulder). Where Sandy Gravel (30-80% gravel cover) was observed, cobble-sized gravel was frequently observed as the maximum gravel size (Figures 3-19 and 3-20). In general, where gravels were documented at the eastern potential new reference area, there was less siltation observed compared with the western potential new reference area (Figures 3-21 and 3-22).

3.4 Fishing Gear Observations

Surface marker buoys of fishing gear were observed visually during the acoustic survey; the senior hydrographer reported that generally sparse lobster gear (surface buoys) was observed. No coordinates were collected during the visual observation.

Table 3-1.

Number of Stations Detailing CMECS Substrate Groups and Substrate Subgroups at the Potential New Reference Areas based on Plan View Image Results

Area	CMECS Substrate Group				
	Gravel	Gravel Mixes	Gravelly	Sand	Total
Potential Reference Area - East	5	9	4	8	**26**
Potential Reference Area - West	4	7	7	10	**28**

Area	CMECS Substrate Subgroup						
	Boulder	Cobble	Pebble/Granule	Sandy Gravel	Gravelly Sand	Sand	Total
Potential Reference Area - East	2	1	2	9	4	8	**26**
Potential Reference Area - West	0	1	3	7	7	10	**28**

4.0 DISCUSSION

The objectives of the 2021 survey were to conduct a confirmatory investigation at the active northern portion of RISDS, to investigate a short-dump location, and to assess the benthic habitat at two potential new reference areas. High-resolution acoustic measurements were collected to characterize seafloor topography and surficial features over the active portion of RISDS. At the short-dump location, adaptive SPI/PV and Pogo PV sampling were used to assess the presence of dredged material. At the two potential new reference areas, reconnaissance level acoustic measurements and Pogo PV sampling were used to assess seafloor conditions.

4.1 RISDS - Seafloor Topography and Distribution of Dredged Material

Bathymetric measurements in the northern portion of RISDS confirmed the persistence of several prominent topographic features and the locations of recently placed dredged material (Figure 3-5). These features included the western berm, the high-relief north central mound, the broad plateau to the southwest of the north central mound, and two smaller mounds in the northeast corner of RISDS. Between the June 2020 and October 2021 surveys, dredged material was placed in three general areas at RISDS: the two mounds in the northeast of RISDS and the broad plateau area to the southwest of the high-relief central mound (Figure 3-6). Each of these areas increased in elevation over this time period due to disposal activity (Figure 3-10).

Since 2020, dredged material had reportedly not been placed on the western berm or on the north central mound peak, and acoustic measurements confirmed that these areas had not received significant dredged material (e.g., Figure 3-9). The peak of the high-relief north central mound was measured to be approximately ten meters above the surrounding seafloor (and at a water depth of approximately 27 meters). The northern slope of the north central mound decreased in elevation by as much as 0.75 m since the 2020 survey (Figure 3-9). A previous report documented up to 11 m of dredged material was placed on this mound between 2013 and 2015 (Sturdivant and Carey 2017). This dredged material placement was followed by self-weight consolidation resulting in a decrease in elevation by as much as 1.4 m between 2015 and 2020 (USACE 2021). It appears likely that self-weight consolidation is continuing along the northern slope of the north central mound. The particular location of the decreased elevation on the northern slope of the mound may suggest some sediment transport preferentially winnowing this exposed portion of the topographic feature.

Dredged material sourced from New Bedford Lower Harbor was reportedly placed at the two discrete mounds in the northeast corner of RISDS between June and October 2020 (Figure 3-10). This placement was confirmed by acoustic measurements (e.g., Figures 3-6 through 3-8) and by a depth difference analysis (Figure 3-7). In the northeast of RISDS, two prominent circular mounds, that had previously been observed during the 2020 survey, increased in height by as much as 4 m. The two mounds were observed to rise approximately three to four meters above the surrounding seafloor (Figure 3-5; to a water depth of approximately 33 meters). There were some distinct topographic features likely resulting from dredged material deposition including a few large craters visible in the bathymetric hillshaded model (Figure 3-5). The acoustic backscatter and side-scan sonar data revealed higher returns across both of these mounds relative to the surrounding seafloor (Figures 3-8 and 3-9). These observations are consistent with, and serve to confirm, the presence of recently placed dredged material on the two northeast mounds.

During the 2020-2021 season, dredged material sourced from the Port of Davisville and Quonset Business Park was placed in a wide plateau area southwest of the north central peak at RISDS (Figure 3-10). The 2021 acoustic data revealed evidence of dredged material placement activity in this area including numerous small-scale topographic features visible across the seafloor including hummocks, craters, and small deposits. These features were apparent in the multibeam bathymetric hillshaded relief model and appeared as variable backscatter returns, likely a result of the small-scale roughness of the seafloor in this area (Figures 3-5 and 3-8). This dredged material placement activity resulted in an increase in seafloor elevation by approximately 1 m over a relatively broad area southwest of the north central peak.

There were several dredged material placement events since 2020 that were off target, but within RISDS boundaries. In particular, two dredged material placement events with material sourced from New Bedford Lower Harbor occurred about 250 m south of the two northeast mounds. These two events resulted in two crater features on the seafloor distinguishable in the bathymetric hillshaded acoustic relief model and the filtered backscatter data (Figures 3-6 and 3-8). These features are described in more detail in Section 4.2 as they served as a useful reference for considering the spatial scale of a discrete disposal event on the seafloor when assessing the short-dump acoustic signature.

4.2 Short-Dump Location

On June 18, 2020, dredged material was inadvertently placed outside of the RISDS boundary by a scow transiting from New Bedford Lower Harbor to RISDS. One of the objectives of the 2021 survey was to attempt to locate and identify the dredged material on the seafloor associated with this short-dump event. Reconnaissance acoustic data were collected in combination with SPI/PV imagery in an area at and surrounding the reported point coordinates where the dredged material was released. The dredged material was successfully identified on the seafloor in an area approximately 50 meters to the southwest of the reported coordinates. The process of identifying short-dump dredged material involved applying iterative and adaptive sampling techniques during the survey. The approach and measurement techniques applied may be useful to support future short-dump investigations at RISDS and other dredged material disposal sites and are described below.

The short-dump event occurred in an area where the native benthic habitat was composed of very soft sediments (silt/clay to fine sand) with some degree of natural organic enrichment (Figure 3-14). The dredged material from New Bedford Lower Harbor was similar in physical characteristics to the native sediments, characterized predominantly as soft sediments. Because of this similarity in sediment types, discerning the dredged material from the native sediments was challenging using either the acoustic measurements or the SPI/PV imagery. The observed feature that proved to be most diagnostic of the dredged material was the presence of coastal bivalve shells on the sediment surface (Figure 3-15). Since the dredged material was only slightly different in texture and color compared to the ambient native sediments, the coastal bivalves provided a crucial clue (Figure 3-15).

The scow was transiting during the time of release and thus the material was deposited as a relatively thin layer over an area to the southwest along the scow's heading of where the hull initially opened according to the DQM record. A slight anomaly was detected in the backscatter and side-scan sonar data at this location and this ultimately led INSPIRE investigators to the location where the dredged material was identified on the seafloor (Figure 3-12). The size and shape of the acoustic anomaly detected at the short-dump area aligned well with two acoustic signatures observed within the RISDS boundary that were associated with two discrete off-target dredged material placement events from the same dredging project as the short-dump (Figure 4-1). These two circular features measured about 50 to 75 m across, which was similar to the scale of the short-dump acoustic anomaly. The shape of the acoustic feature at the short-dump location was more oblong than the two within the disposal site, likely a result of the fact that the scow was actively transiting while the short-dump dredged material was being released.

During the 2021 field event, acoustic data collection and the initial SPI/PV stations were focused around a single set of DQM coordinates of the reported scow release point. Inferences about the scow's likely heading from New Bedford Harbor helped the SPI/PV field team identify the acoustic anomaly to the southwest of the DQM coordinates in the data collected on the previous day and direct subsequent SPI/PV stations to that area. During future short-dump investigations, it will be useful to review the complete trackline of the transiting scow and ideally collect the acoustic dataset further in advance of the SPI/PV survey to more efficiently plan sampling stations.

Adaptive SPI/PV was an effective and efficient tool to investigate the actual location and general extent of dredged material on the seafloor resulting from the short-dump event. Adaptive SPI/PV provided rapid and real-time information about the presence or absence of dredged material at each station during field operations. Without this SPI/PV ground truth data, the slight acoustic anomaly identified in the multibeam data would not have provided sufficient evidence that dredged material was present. The grab sampling approach that was initially scoped to meet the objective of this survey, would likely not have been sufficient to confirm dredged material presence. Sediment grab sampling for grain size analysis would have limited the ability to definitively detect dredged material, particularly because of the similarity in sediment type between the dredged material and the native sediments. Grab sampling would also have limited the adaptive strategy of the investigation because grain size data would not be assessed in real time but rather require analytical lab results. It is possible that sediment grab samples would have captured the coastal bivalve shells on the surface, however the PV imagery provided a wider field of view than the surface area of a single grab, increasing the chance of observing these important and diagnostic features on the seafloor. In summary, the reconnaissance SPI/PV approach, utilized in an adaptive manner, was found to provide far more useful information in a timely manner than a grab sampling approach and would be the recommended tool for future short-dump investigations.

4.3 Potential New Reference Areas

Several areas throughout RISDS consist of hard bottom habitat derived from dredged material placement activities. Hard bottom habitat at RISDS occurs in several areas including: (1) areas along the western berm characterized by glacial till (Valente et al. 2012; ENSR 2007); (2) an area in the central portion of RISDS (previously referred to as 'RISDS-

C' or 'Mound C') composed of Gravelly Sand and Pebble/Granule (CMECS Substrate Subgroups) (USACE 2021); and (3) at the pinnacle of the high-relief mound in the north-central portion of RISDS where cobbles, pebble, and granules are prevalent (USACE 2021) (Figure 4-2). Following the comprehensive 2020 SPI/PV survey, it was recommended that a new reference area be identified because the three current RISDS reference areas are all composed of soft sediments and are thus not comparable to hard bottom habitat at RISDS (USACE 2021). Selecting a new reference area that is representative of natural hard bottom communities in the vicinity of RISDS would allow for direct comparisons between the benthic characteristics at these dredged material-derived hard bottom areas within RISDS and native hard bottom in the region.

The 2021 survey aimed to identify a new reference area with similar water depths and physical characteristics as the hard bottom areas found at RISDS. Two areas were surveyed within the vicinity of RISDS as potential candidates for the new reference area. These two areas were initially selected based on a desktop review, which indicated potential hard bottom at water depths within the range of 30 to 40 m (Poppe et al. 2014; McMullen et al. 2011). The 2021 survey confirmed hard bottom at both candidate areas (Figures 3-19, 3-20, and 3-21). However, there were slight differences between the two candidate areas in terms of the gravel sizes, the gravel contribution relative to soft sediments, and degree of sedimentation, as discussed below.

Although hard bottom (i.e., gravel) was documented at both the western and eastern potential new reference areas, the western area was determined to be the better candidate to serve as a new reference area for RISDS. This recommendation is largely based on the observed gravel sizes in each area and the larger-scale heterogeneity of the seafloor in the eastern surveyed area. Generally, the western potential new reference area had more consistent and less patchy hard bottom habitat compared with the eastern area as inferred by the acoustic data (Figures 3-17 and 3-18). Both potential new reference areas had similar distribution of CMECS Substrate Subgroups, meaning the relative proportion of gravel to soft sediments was similar between the two areas at each PV station (Table 3-1). However, the size of the gravels at the western potential new reference area were generally smaller than those found at the eastern area and more similar to those documented at the hard bottom areas at RISDS (USACE 2021) (Figure 4-3). Boulders were observed at two PV stations sampled at the eastern potential new reference area but not at the western area. Boulders are not common in the hard bottom habitats at RISDS; these areas are typically derived from glacial till, composed of a mixture of small cobble and pebbles/granules. Although sedimentation of fine material was more commonly observed in the western potential new reference area compared to the eastern area, similar conditions are found at the RISDS hard bottom areas (Figure 4-3). The recommended location for the new reference area representative of hard bottom in the vicinity of RISDS would be a 600-m diameter circle centered in the middle of the 2021 surveyed western potential reference area (Figure 4-4).

5.0 CONCLUSIONS AND RECOMMENDATIONS

The overall findings of the 2021 surveys were:

- At the northern active area of RISDS, seafloor elevation increases since 2020 were observed at expected locations based on disposal event records, confirming that dredged material was placed at targeted locations;
- Using a combination of acoustic and adaptive SPI/PV data collection, a short dump of dredged material was located and identified at a location approximately 50 m to the southwest of the coordinates where the material was reportedly released;
- Coastal bivalve shells on the seafloor were diagnostic of dredged material presence at the short-dump location;
- Representative hard bottom habitat was observed at both the eastern and western potential new reference areas;
- The gravel sizes and percent cover of gravel at the western potential new reference area were more similar to those found at hard bottom areas at RISDS;

Results from the 2021 surveys led to the following recommendations:

R1: Future dredged material placement should continue to avoid the large, high-relief north-central mound

R2: Future dredged material placement planning at RISDS should consider placing dredged material at locations with similar seafloor characteristics (i.e., place similar materials together).

R3: The use of reconnaissance acoustic data and adaptive SPI/PV collection proved effective in identifying and documenting the extent of dredged material resulting from a short dump (off-target disposal) and is recommended for similar investigations in the future. Useful data to support short-dump investigations includes scow transit track lines, characteristics of the native sediment versus the dredged material, and the expected disposal footprint size given the water depth and nature of the material (for this survey the size was ~50-100 m across).

R4: Given the relatively consistent distribution of hard bottom, the observed gravel sizes, and the proportion of gravel relative to soft sediments, the western potential new reference area is recommended as a new reference area representative of native hard bottom habitat in the vicinity of RISDS.

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