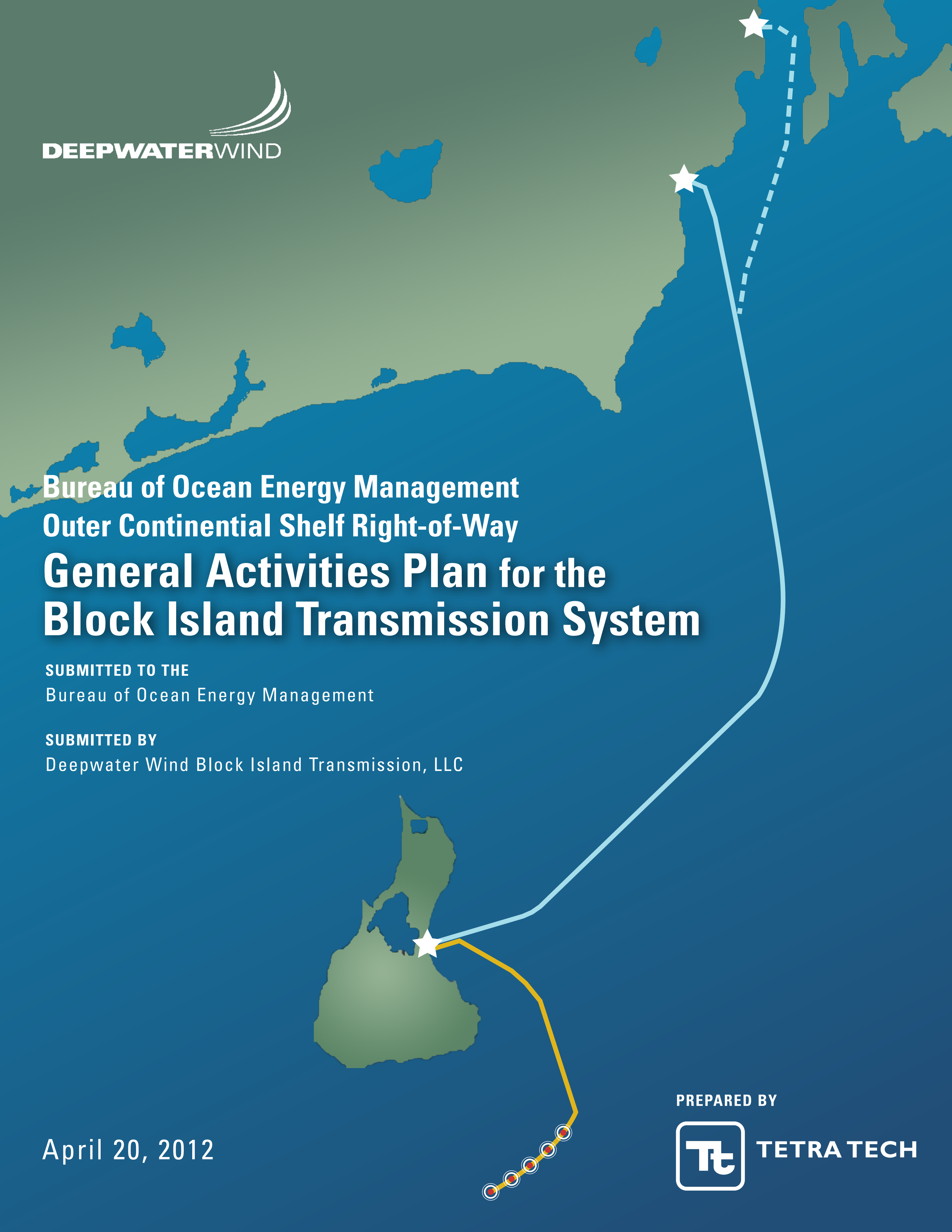

DEEPWATERWIND

Bureau of Ocean Energy Management
Outer Continental Shelf Right-of-Way

General Activities Plan for the Block Island Transmission System

SUBMITTED TO THE
Bureau of Ocean Energy Management

SUBMITTED BY
Deepwater Wind Block Island Transmission, LLC

April 20, 2012

PREPARED BY

TETRA TECH

BUREAU OF OCEAN ENERGY MANAGEMENT
OUTER CONTINENTAL SHELF RIGHT-OF-WAY

GENERAL ACTIVITIES PLAN
for the
BLOCK ISLAND TRANSMISSION SYSTEM

Submitted by:

DEEPWATER WIND BLOCK ISLAND TRANSMISSION, LLC

DEEPWATERWIND®

CLEAN ENERGY IS JUST OVER THE HORIZON

APRIL 20, 2012

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ACRONYMS AND ABBREVIATIONS

AC	alternating current
BIPCO	Block Island Power Company
BITS	Block Island Transmission System
BIWF	Block Island Wind Farm
BOEM	Bureau of Ocean Energy Management
CFR	Code of Federal Regulations
CRMC	Rhode Island Coastal Resources Management Council
CRMP	Rhode Island Coastal Resources Management Program
CVA	Certified Verification Agent
CZMA	Coastal Zone Management Act
Deepwater Wind	Deepwater Wind Block Island Transmission, LLC
DP	dynamic position
EFH	essential fish habitat
EPAct	Energy Policy Act of 2005
ESA	Endangered Species Act
GAP	General Activities Plan
GGARCH	Guidelines for Providing Geological and Geophysical, Hazards, and Archaeological
HDD	horizontal directional drill
HSE	Health, Safety and Environmental
ICPC	International Cable Protection Committee
IMO	International Maritime Organization
kV	kilovolt
LNM	local notice to mariners
MBTA	Migratory Bird Treaty Act
MMPA	Marine Mammal Protection Act
MW	megawatt(s)
NATHPO	National Association of Tribal Historic Preservation Officers'
National Grid	The Narragansett Electric Company d/b/a National Grid
NEPA	National Environmental Policy Act

ACRONYMS AND ABBREVIATIONS (CONT'D)

NHPA	National Historic Preservation Act
NOAA	National Oceanographic and Atmospheric Administration
NOAA Fisheries	National Oceanic Atmospheric Administration, National Marine Fisheries Service
NRHP	National Register of Historic Places
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
OSHA	Occupational Safety & Health Administration
OTDR	optical time domain reflectometer
Project	Block Island Transmission System
RI Ocean SAMP	RI Ocean Special Area Management Plan
RIDEM	Rhode Island Department of Environmental Management
RIHPHC	RI Historical Preservation & Heritage Commission
ROV	remotely operated vehicle
ROW	right-of-way
RUE	Rights-of-Use
SCADA	Supervisory Control and Data Acquisition
SPI	sediment profile and plan view imagery
STCW	Standards of Training, Certification, and Watchkeeping
TSS	traffic separation schemes
URI	University of Rhode Island
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USEPA	U.S. Environmental Protection Agency
WTG	wind turbine generator

1.0 INTRODUCTION

In accordance with the Outer Continental Shelf Lands Act (OCSLA) (43 USC 1331 et seq.), the Energy Policy Act of 2005 (EPAct, P.L. 109-58), and implementing regulations in 30 Code of Federal Regulations (CFR) Parts 250, 285, and 290, the United States Department of Interior, Bureau of Ocean Energy Management (BOEM) may grant leases, easements and rights-of-way (ROWs) for renewable energy activities on the Outer Continental Shelf (OCS).

Deepwater Wind Block Island Transmission, LLC (Deepwater Wind), a wholly owned indirect subsidiary of Deepwater Wind Holdings, LLC, submits this General Activities Plan (GAP) for the Block Island Transmission System (BITS or Project), a proposed bi-directional submarine transmission cable between Block Island and the Rhode Island mainland. The BITS cable route traverses both state and federal waters of Rhode Island Sound. Deepwater Wind has requested a ROW Grant for the portion of the BITS line on the OCS. The BITS will serve two purposes: (i) exporting excess power from a proposed offshore wind energy project located in Rhode Island state waters southeast of Block Island; and (ii) supplying electrical power from the existing distribution grid on the Rhode Island mainland to Block Island.

The ROW Grant award process is set forth in 30 CFR 285.305 through 285.310. Table 1 contains a summary of the information that must be included in a GAP, as specified in §285.645, and where this information is included in the GAP. At least one paper copy and one electronic copy of this document have been submitted to BOEM.

Table 1 Summary of Information Requirements for a GAP

Information	Including:	Location in GAP
	§285.645(a)	
1) Geotechnical. The results from the geotechnical survey with supporting data.	A description of all relevant seabed and engineering data and information to allow for the design of the foundation for that facility. You must provide data and information on the depths below which the underlying conditions will not influence the integrity or performance of the structure. This could include a series of sampling locations (borings and in situ tests) as well as laboratory testing of soil samples, but may consist of a minimum of one deep boring with samples.	Appendix A, Marine Site Characterization Study Section 3.1, Geology, Sediments, and Shallow Hazards
2) Shallow hazards. The results from the shallow hazards survey with supporting data.	A description of information sufficient to determine the presence of the following features and their likely effects on your proposed facility, including: (i) Shallow faults; (ii) Gas seeps or shallow gas; (iii) Slump blocks or slump sediments; (iv) Hydrates; or (v) Ice scour of seabed sediments.	Appendix A, Marine Site Characterization Study Section 3.1, Geology, Sediments, and Shallow Hazards
3) Archaeological resources. The results from the archaeological survey with supporting data, if required.	(i) A description of the results and data from the archaeological survey; and (ii) A description of the historic and prehistoric archaeological resources, as required by the National Historic Preservation Act (NHPA) (16 USC 470 et seq.), as amended.	Appendix C, Marine Cultural Report Section 3.3, Archaeological Resources
4) Geological Survey. The results from the geological survey with supporting data.	A report that describes the results of a geological survey that includes descriptions of: (i) Seismic activity at your proposed site; (ii) Fault zones; (iii) The possibility and effects of seabed subsidence; and (iv) The extent and geometry of faulting attenuation effects of geologic conditions near your site.	Appendix A, Marine Site Characterization Study Section 3.1, Geology, Sediments, and Shallow Hazards
5) Biological Survey. The results from the biological survey with supporting data.	A description of the results of a biological survey, including the presence of live bottoms, hard bottoms, and topographic features, and surveys of other marine resources such as fish populations (including migratory populations), sea turtles, and sea birds.	Appendix B, Benthic Survey Report Section 3.2, Biological Resources
	§285.645(b)	
1) Contact information.	The name, address, e-mail address, and phone number of an authorized representative.	Section 2.1, Authorized Representative and Operator
2) The site assessment or technology testing concept.	A discussion of the objectives; description of the proposed activities, including the technology you will use; and the proposed schedule from start to completion.	Section 1.0, Introduction Section 2.3, Description of Proposed Facility Section 2.7, Schedule This GAP is being submitted for a submarine cable ROW; site assessment or technology testing does not apply.

Information	Including:	Location in GAP
3) Designation of operator, if applicable.	As provided in §285.405.	Section 2.1, Authorized Representative and Operator
4) ROW, Rights-of-Use (RUE), or limited lease grant stipulations, if known.	A description of the measures you took, or will take, to satisfy the conditions of any lease stipulations related to your proposed activities.	To be provided upon issuance of ROW grant.
5) A location plat.	The surface location and water depth for all proposed and existing structures, facilities, and appurtenances located both offshore and onshore.	Figure 1 – Location Plat
6) General structural and project design, fabrication, and installation.	Information for each type of facility associated with your project.	Section 2.3, Description of Proposed Facility Section 2.4, Construction Figures 4 through 7
7) Deployment activities.	A description of the safety, prevention, and environmental protection features or measures that you will use.	Section 2.4, Construction Section 2.9, Health, Safety, and Environmental Protection Measures
8) A list of solid and liquid wastes generated.	Disposal methods and locations.	The BITS will not generate solid or liquid wastes. A marine debris awareness and elimination plan for cable laying vessels will be incorporated into the environmental compliance plan during installation.
9) A listing of chemical products used (only if volume exceeds U.S. Environmental Protection Agency [USEPA] Reportable Quantities).	A list of chemical products used; the volume stored on location; their treatment, discharge, or disposal methods used; and the name and location of the onshore waste receiving, treatment, and/or disposal facility. A description of how these products would be brought onsite, the number of transfers that may take place, and the quantity that will be transferred each time.	The BITS will not involve the use of reportable quantities of chemical products.
10) Reference information.	A list of any document or published source that you cite as part of your plan. You may reference information and data discussed in other plans you previously submitted or that are otherwise readily available to BOEM.	Section 5.0, References
11) Decommissioning and site clearance procedures.	A discussion of methodologies.	Section 2.6, Decommissioning
12) Air quality information.	As described in § 285.659 of this section.	Appendix D, Air Emissions Analysis Section 3.4, Air Quality
13) A listing of all federal, state, and local authorizations or approvals required to conduct site assessment activities on your lease.	A statement indicated whether such authorization or approval has been applied for or obtained.	Section 2.8, Permits and Approvals Table 6 – Summary of Environmental Permits, Approvals, and Consultations for the BITS

Information	Including:	Location in GAP
14) A list of agencies and persons with whom you have communicated, or with whom you will communicate, regarding potential impacts with your proposed activities.	Contact information and issues discussed.	Section 2.8, Permits and Approvals Table 7 – Summary of Relevant and Recent Agency Consultation
15) Financial assurance information.	Statements attesting that the activities and facilities proposed in your GAP are or will be covered by an appropriate bond or other approved security as required in §§ 285.520 and 285.521.	Section 4.0, Financial Assurance
16) Other information.	Additional information as requested by BOEM.	Shapefiles are included in the digital Appendix E, Digital Appendix.
	§285.645(c)	
1) The construction and operation concept.	A discussion of the objectives, description of the proposed activities, and tentative schedule from start to completion.	Section 1.0, Introduction Section 2.4, Construction Section 2.5, Operations and Maintenance Section 2.7, Schedule Table 5 – Schedule of Project Activities
2) All cables and pipelines, including cables on project easements.	The location, design, installation methods, testing, maintenance, repair, safety devices, exterior corrosion protection, inspections, and decommissioning.	Section 2.4, Construction Section 2.5, Operations and Maintenance Section 2.6, Decommissioning Figures 1 through 7
3) A description of the deployment activities.	Safety, prevention, and environmental protection features or measures that you will use.	Section 2.4, Construction Section 2.9, Health, Safety, and Environmental Protection Measures
4) A general description of the operating procedures and systems.	(i) Under normal conditions; and (ii) In the case of accidents or emergencies, including those that are natural or manmade.	Section 2.9, Health, Safety, and Environmental Protection Measures
5) Certified Verification Agent (CVA) nominations for reports required in subpart G of this part.	CVA nominations for reports in subpart G of this part, as required by § 285.706, or a request for a waiver under § 285.705(c).	To be provided as a separate filing.
6) Construction schedule.	A reasonable schedule of construction activity showing significant milestones leading to the commencement of activities.	Section 2.7, Schedule Table 5 – Schedule of Activities
7) Other information.	Additional information as required by BOEM.	n/a

2.0 DESCRIPTION OF PROPOSED ACTIVITY

Deepwater Wind is proposing to develop and construct the BITS, a 34.5-kilovolt (kV) alternating current (AC) bi-directional submarine transmission cable from Block Island to the Rhode Island mainland. The submarine transmission cable will traverse state and federal submerged lands in Rhode Island Sound. This section describes the activities associated with the BITS that will be conducted on the OCS under the ROW Grant, including the location and design of the proposed submarine cable, construction, operation and maintenance, and conceptual decommissioning plans.

2.1 Authorized Representative and Operator

Deepwater Wind will develop and construct the BITS. The contact information for the BITS authorized representative is provided in Table 2.

Table 2 Authorized Representative

Name	Role	Address	E-Mail	Phone
Aileen Kenney	Director of Permitting	56 Exchange Terrace, Suite 101 Providence RI 02903	akenney@dwwind.com	401-648-0607
Jeff Grybowski	Chief Administrative Officer	56 Exchange Terrace, Suite 101 Providence RI 02903	jgrybowski@dwwind.com	401-648-0611

Deepwater Wind will likely transfer ownership of the BITS prior to energizing the transmission line to The Narragansett Electric Company d/b/a National Grid (National Grid), an electricity and gas company serving Rhode Island.

2.2 Location

The portion of the BITS located in federal waters consists of approximately 9 mi (14.5 km) on OCS Official Protraction Diagram Blocks 6711, 6761, 6810, and 6811. Deepwater Wind has requested a ROW Grant from BOEM for the 200-ft (61-m) wide BITS route corridor on the OCS (Figure 2). Table 3 identifies the OCS Blocks and Aliquots within which the 200-ft corridor lies.

Table 3 Requested ROW Grant Area

BOEM OCS Block	Aliquots
6711	H, L, P
6761	D,H, K, L, N, O
6810	A, B, E
6811	G, H, K, L

The proposed BITS route considers environmental and engineering constraints that affect the selection of a submarine transmission cable route. Such constraints include hard sediments, bottom hazards and disposal sites, obstructions, shipwrecks, cables and pipelines, and sensitive habitats (Figure 3). Deepwater Wind selected the BITS route and associated 200-ft (61-m) wide corridor based on the results of screening level environmental and engineering surveys conducted in 2009, as well as detailed geophysical, geotechnical, benthic habitat, and archaeological surveys that were completed in 2011. The results of the site-specific marine route surveys are discussed in Sections 3.1 through 3.3 of this GAP and included as Appendices A through C.

The Quonset Point port facility in North Kingstown, in Washington County, Rhode Island, will be used during the construction of the Project for equipment staging and as a laydown yard. The BITS will be monitored remotely during the operation phase using Project-specific Supervisory Control and Data Acquisition (SCADA) System.

2.3 Description of Proposed Facility

2.3.1 Submarine Transmission Cable

The 9-mi (14.5-km) portion of the BITS located on the OCS will consist of a single industry-standard 3-core 34.5-kV submarine cable that will carry 3-phase AC power (Figure 4). The cable will consist of three bundled aluminum or copper conductor cores surrounded by layers of insulating material within conducting and non-conducting metallic sheathing. Specific insulating, sheathing, filler, and protective coating material are dependent on the manufacturer. One or more fiber optic cables will be included in the interstitial space between the three conductors and will be used to transmit data from associated facilities on Block Island and the Rhode Island mainland as part of the SCADA System. The bundled cable will be approximately 6 in to 10 in (15.2 cm to 25.4 cm) in diameter, depending on the manufacturer. The cable will be buried to a target depth of approximately 6 ft (1.8 m) beneath the seafloor. The actual burial depth will depend on substrate encountered along the route and could vary from 4 ft to 8 ft (1.2 m to 2.4 m).

2.3.2 Associated Facilities

The BITS submarine cable will traverse submerged lands through state territorial waters to make landfall on Block Island and the Town of Narragansett, Rhode Island (Figure 1). Associated onshore facilities on Block Island include a terrestrial cable that begins at a manhole at the parking lot of the Block Island Town Beach and traverses existing public road ROWs to the Block Island Power Company (BIPCO) property adjacent to Corn Neck Road. The BITS will terminate at a new switchyard on the BIPCO property (BITS Island Switchyard) that will serve as the point of interconnection for the BITS on Block Island.

Deepwater Wind is considering two alternatives for the landfall on the Rhode Island mainland. Under Alternative 1, the preferred alternative, the BITS will make landfall at the parking lot of the Narragansett Town Beach in southern Narragansett and terminate at an existing riser pole within the parking lot. Under Alternative 2, the BITS route traverses state submerged lands to a landfall further north of Narragansett at the University of Rhode Island (URI) Bay Campus. BITS Alternative 2 includes a buried terrestrial cable to the end of the URI property where the BITS will transition into the existing National Grid system. Final interconnection of the BITS to the existing electrical grid system on the Rhode Island mainland, including any system expansions or upgrades, will be performed by National Grid.

In connection with the BITS, Deepwater Wind Block Island, LLC, also a wholly owned indirect subsidiary of Deepwater Wind Holdings, LLC, proposes to develop the Block Island Wind Farm (BIWF), a 30-megawatt (MW) offshore wind farm located in state waters approximately 3 mi (4.8 km) southeast of Block Island. The BIWF will consist of five, 6-MW wind turbine generators (WTGs) arranged in a radial configuration spaced approximately 0.5 mi (0.8 km) apart, a 34.5-kV submarine cable interconnecting the WTGs (Inter-Array Cable), and a 34.5-kV transmission cable from the northernmost WTG to an interconnection point on Block Island (Export Cable). Deepwater Wind will select the WTG model that is best suited for the sub-bottom and wind resource conditions southeast of Block Island that will be commercially available by construction. Deepwater Wind currently plans to install the Siemens 6.0 MW direct drive WTG or comparable model. Each WTG will be attached to the seafloor using a four-leg jacket foundation. The Inter-Array Cable and Export Cable will consist of the same three-core submarine cable as the BITS.

The WTGs, Inter-Array Cable, and a portion of the Export Cable are located within the Rhode Island Renewable Energy Zone established by the Rhode Island Coastal Resources Management Council (CRMC) through the RI Ocean Special Area Management Plan (RI Ocean SAMP). The terrestrial portion of the Export Cable will be collocated in the same duct bank as the BITS terrestrial cable on Block Island and will terminate at a new BIWF Switchyard adjacent to the new BITS Island Switchyard on the BIPCO Property. The BIWF will connect to the BITS at the BITS Island Switchyard.

The BITS will also include upgrades to the existing BIPCO substation to support interconnection. The BITS will be capable of transmitting:

1) power from the BIWF to the BIPCO system;

2) excess power from the BIWF to the National Grid distribution system on the Rhode Island mainland; and

3) power from the mainland to Block Island.

2.4 Construction

2.4.1 Contracting, Mobilization, and Verification

Deepwater Wind will complete final engineering and design of the BITS and submit a Facility Design Report and Fabrication and Installation Report to BOEM in accordance with the BOEM Final Rule (§§ 285.700-702). Deepwater Wind will coordinate with BOEM to engage a Certified Verification Agent (CVA) to review and certify the reports as specified in the BOEM Final Rule (§§ 285.705-713).

Upon receipt of all requisite permits and approvals, Deepwater Wind will: (i) finalize contracts with vendors, fabrication contractors, and installation contractors; (ii) mobilize the necessary service vessels; and (iii) finalize arrangements at Quonset Point to support offshore installation activities.

Prior to construction, Deepwater Wind will prepare an environmental compliance plan that will describe all of the environmental and permitting commitments to be carried out during construction. In addition, Deepwater Wind will also employ an environmental inspector to monitor construction activities.

2.4.2 Cable Installation

Deepwater Wind will utilize several marine construction vessels to install the BITS. Vessels that will not be transporting material from Quonset Point will travel directly to the work sites from locations that will be determined prior to construction. Table 4 lists the types of vessels that will potentially be utilized to install the BITS depending on contracting agreements and vessel availability.

Table 4 Vessel Types

Vessel Type	Approximate Dimensions (ft) Length x width x depth (draft)	Remarks
Cable-laying Barge	400 x 120 x 40 (18)	Floating barge with a dynamic positioning system, a turntable, a cable ramp and a 100 ton crawler crane and a 4 anchor mooring system.
Work Vessel	300 x 80 x 25 (10)	Floating barge with a 4 anchor mooring system and a crawler crane.
Work Vessel Support Tug	160 x 40 x 35 (18)	60 ton bollard pull ocean going tug to support and anchor out the work vessel.
Crew Transport Vessel	70 x 30 x 15 (5)	Provides crew transfer to/from the work sites.
Helicopter	54 x 15 x 17	Emergency air transport from work sites.
Support Vessel	50 x 15 x 20 (6)	Single hull vessel to host the environmental and marine mammal observers.
Material Barge	120 x 50 x 20 (10)	Floating barge with pumps and other equipment for the jet plow.

Prior to installation, Deepwater Wind will complete route clearance and pre-lay grapnel activities to identify any obstructions along the cable route. Obstructions identified during the route clearance and pre-lay grapnel run will be removed or moved, as is appropriate under the circumstances.

Submarine transmission cable installation will utilize a jet plow to minimize seafloor disturbance (Figure 5). Jet plowing is a process that can simultaneously lay and bury the cable with one device and can be used in areas of soft sediment. The jet plow will be operated from a cable-laying barge with the assistance of an additional material barge. The cable-laying barge will be equipped with a dynamic positioning (DP) system. DP vessels maintain their position with the use of thrusters instead of anchors, which will minimize impacts to the seabed from anchors and cable sweep along the majority of the cable route during routine cable installation. The cable-laying barge will also house a linear cable engine, which will control the speed at which the cable is paid-out over the back of the barge.

The jet plow may be a rubber-tired or skid-mounted plow that will be pulled along the seafloor behind the cable-laying barge with the assistance of a material barge. Umbilical cords will connect the submerged jet plow to the vessel to control equipment and allow the operators to monitor and control the installation process and make adjustments to the speed and alignment as the installation proceeds across the water. High-pressure water from vessel-mounted pumps will be injected into the sediments through nozzles situated along the plow, causing the sediments to temporarily fluidize and creating a liquefied trench. As the plow is pulled along the route behind the barge, the cable will be laid into the temporary, liquefied trench through the back of the plow. The trench will be backfilled by the water current and the natural settlement of the suspended material.

Depth of burial is controlled by adjusting the angle of the plow relative to the bottom. The submarine transmission cable will be buried to a target depth of 6 ft (1.8 m), but may be between 4 ft and 8 ft (1.2 m and 2.4 m) depending on substrate conditions as described in Section 2.3.1. The trench width will be up to 5 ft (1.5 m). The actual burial depth will depend on substrate encountered along the route and can vary from 4 ft to 8 ft (1.2 m to 2.4 m). If less than 4 ft (1.2 m) burial is achieved, Deepwater Wind may elect to install additional protection, such as concrete matting or rock piles. Figure 6 contains a typical drawing of the additional protection. Deepwater Wind expects that no more than 1 percent of the BITS cable will require additional protection. Alternatively, Deepwater Wind may elect for divers to attempt to bury the cable to target depth, or as deep as possible given the seafloor conditions, using jet lances post lay.

The BITS crosses four existing telecommunications cables in federal waters (Figure 3). Two of these cables are in service and two have been decommissioned. In addition, the BITS may cross a fifth abandoned cable that is identified on a NOAA Chart 13218; however, Deepwater Wind has been unable to verify the existence of this cable despite the screening level environmental and engineering surveys conducted in 2009 and the detailed geophysical, geotechnical, benthic habitat, and archeological surveys completed in 2011. Where the BITS crosses each of the in-service cables, the BITS cable will be installed directly on the seafloor and will be protected from external aggression using a combination of sand bags and concrete mattresses (Figure 7). Anchored vessels will be used to install the submarine transmission cable armoring at these locations. The anchor spread will have a radius of approximately 500 ft (152 m) around the crossing and a burial depth of up to 6 ft (1.8 m). Decommissioned cables will be cleared from the BITS route in accordance with industry standard procedures. As recommended by the International Cable Protection Committee (ICPC), Deepwater Wind will coordinate with the cable owners prior to crossing the operating cables and clearing the route of the inactive cables.

Deepwater Wind is considering different options for cable landfall on Block Island and the Rhode Island mainland. On Block Island, Deepwater Wind is proposing two alternative landfall methodologies for the BITS: either (i) a long-distance HDD from the Town Beach parking lot to a temporary cofferdam located up to 1900 ft (579.1 m) from shore or (ii) a short-distance HDD to bring the cable to an excavated trench located at mean high water (MHW) from which a jet plow would be launched directly from the beach.

For the BITS Alternative 1 landing at the Narragansett Town Beach landing, Deepwater Wind is similarly proposing either (i) a long-distance HDD with a temporary cofferdam located up to 1600 ft (487.7 m) from shore or (ii) a short-distance HDD with a jet plow launched directly from the beach.

For the BITS Alternative 2 landing at the URI Bay Campus, the use of short-distance HDD and a jet plow is not feasible, therefore Deepwater Wind is proposing a long-distance HDD from an existing cleared storage area to a temporary cofferdam located up to 1800 ft (548.6 m) from shore.

Depending on bottom conditions, weather, and other factors, cable installation is expected to take 2 to 4 weeks on the OCS. This schedule assumes cable laying is able to proceed 24 hours per day, 7 days per week without delays due to weather conditions or other factors. Section 2.9.1 describes the health, safety, and environmental measures that will be implemented during construction.

2.4.3 Commissioning and Post-Construction

Once all of the Project and associated facilities have been installed, Deepwater Wind will commence commissioning of the Project. After the BITS submarine cable has been installed, but before connection to the terrestrial cables are completed, Deepwater Wind will perform a conductor continuity test and a voltage test. Once connections to the terrestrial cables are complete, Deepwater Wind will perform additional commissioning tests, including a second continuity test and an AC voltage test. In addition, an optical time domain reflectometer (OTDR) will be used to verify the continuity fiber optic cable and that its terminations are in good working order. These testing and commissioning activities may be performed while the cable is energized.

Deepwater Wind will also conduct a post-installation inspection of the route using a multi-beam survey and shallow sub-bottom profiler (chirp) to ensure burial depth was achieved to verify reconstitution of the trench.

2.5 Operations and Maintenance

The submarine portion of the BITS cable has no maintenance needs unless a fault or failure occurs. Cable failures are only anticipated as a result of damage from outside influences, such as boat anchors. The armoring of the cable and its burial will ensure that this will be an unlikely occurrence. Deepwater Wind anticipates the BITS will remain operational in perpetuity. However, the BITS submarine transmission cable has an anticipated life expectancy of approximately 50 years. Therefore, the cable will be scheduled for replacement/upgrade based on expected life expectancy and/or an alternative National Grid or other industry standard schedule.

The cable burial depth along the route will be inspected using a sub-bottom profiler at least once every 5 years. The cable burial depth might be inspected more frequently based on the as laid data specific sections of the cable.

Operations-phase reporting for the BITS submarine transmission cable will be implemented, as necessary, in accordance with the requirements specified in the ROW Grant issued by BOEM.

2.6 Decommissioning

Deepwater Wind proposes to allow the BITS submarine cable to remain in place following the termination of the ROW Grant and requests a departure from the decommissioning requirements in the BOEM final rule to remove all facilities (§§285.904). Abandoning decommissioned submarine cables in place is standard industry practice and will avoid sediment disturbance and other impacts comparable to the impacts resulting from construction activities.

Deepwater Wind will submit a decommissioning application to BOEM with the final decommissioning plan. Once the decommissioning application is approved, Deepwater Wind will submit a decommissioning notice under §285.400 at least 60 days before commencing decommissioning activities.

2.7 Schedule

Construction of the BITS is scheduled to begin in 2014. Table 5 provides a general schedule of proposed activities.

Table 5 Schedule of Project Activities

Activity	Dates
Deepwater Wind files ROW Grant Request & Qualifications Package	October 2011
Deepwater Wind files revised ROW Grant Request with 200-ft BITS Route Corridor	November 2011
Deepwater Wind submits General Activities Plan (GAP)	April 2012
Deepwater Wind obtains all federal, state, and local permits and approvals	Spring 2013
Contracting, mobilization, and verification	Spring 2013 to Spring 2014
Deepwater Wind submits Facility Design Report & Fabrication and Installation Report for the BITS	Summer 2013
Cable landfall construction	January 2014 to May 2014
Construction of associated onshore facilities	October 2013 to May 2014
Offshore cable installation	April to August 2014
Demobilization and remediation for cable landfall	May to July 2014
Commissioning of the BITS cable	October to November 2014

2.8 Permits and Approvals

Several federal, state, and local agencies have regulatory authority over the Project based on the location of the different Project components. This GAP focuses on the segment of the BITS route located on the OCS in federal territorial waters. A ROW Grant from the BOEM will be necessary for the portion of the BITS that traverses through federal waters. BOEM's issuance of the ROW Grant also requires review of the environmental effects and benefits of the Project in accordance with the National Environmental Policy Act (NEPA [42 USC 4321 *et seq*.]). Federal permitting agencies are also required to comply with Section 7 of the Endangered Species Act, the Magnuson-Stevens Fishery Conservation and Management Act, Section 106 of the National Historic Preservation Act, and Section 307 of the Coastal Zone Management Act (CZMA).

Construction and operation of the BITS will require an Individual Permit from the U.S. Army Corps of Engineers (USACE) under Section 10 of the Rivers and Harbors Act (33 USC 403) and Section 404 of the Clean Water Act (33 USC 1344). Prior to issuance of an Individual Permit, USACE must review the environmental effects and benefits of the Project in accordance with NEPA. As previously discussed with BOEM, USACE will act as the federal Lead Agency for the Project and BOEM is anticipated to act as a Cooperating Agency.

At the state level, an Assent from the CRMC under the Rhode Island Coastal Resources Management Program (CRMP) is required for the Project. The CRMC Assent also constitutes federal consistency concurrence under the CZMA (16 USC 1452). A submerged lands lease from CRMC is required for the portion of the BITS that traverses through state territorial waters. The Rhode Island Department of Environmental Management (RIDEM) will review the effect of the Project on the state's water quality standards and protected species.

Table 6 provides a list of the required approvals and consultations for the BITS, the anticipated timeline, and the status as of the writing of this GAP.

Deepwater Wind has been engaged in consultation with several federal, state, and local agencies regarding the Project since 2008. Table 7 provides a summary of relevant and recent consultations.

2.9 Health, Safety, and Environmental Protection Measures

Deepwater Wind will implement project-specific health, safety, and environmental protection measures to adhere to the conditions of the ROW Grant (§§ 285.800-811). Sections 2.9.1 through 2.9.3 describe the measures that Deepwater Wind anticipates may apply to the activities associated with construction, operation, and decommissioning of the BITS under the ROW Grant. These measures will be revised as necessary upon receipt of the ROW Grant from BOEM.

2.9.1 Construction

Navigation Safety

Deepwater Wind will implement a communication plan during construction to inform commercial and recreational fishermen, mariners, and recreational boaters of construction activities and vessel movements. Communication will be facilitated through maintaining a Project website and submitting local notice to mariners (LNMs) and vessel float plans, as appropriate, to the United States Coast Guard (USCG).

Table 6 Summary of Environmental Permits, Approvals, and Consultations for the BITS

Permit, Approval, or Consultation	Regulatory Authority(ies)	Filing Date	Anticipated Approval	Status
Federal				
Individual Permit pursuant to Section 10 Rivers and Harbors Act (33 USC §403) & Section 404 Clean Water Act (33 USC §1344)	USACE, New England District	Q1 2012	Q4 2012	Pre-application meetings with USACE. Application submittal anticipated May 2012.
Right-of-Way (ROW) Grant for BITS on the OCS pursuant to the Outer Continental Shelf Lands Act (43 USC §§1331 *et seq*.) and implementing regulations (30 CFR 250, 285, 290)	BOEM	Q4 2011	Q4 2012	ROW Grant request submitted to BOEM in November 2011.
Consultation and Incidental Take Authorization (IHA) pursuant to the Marine Mammal Protection Act (MMPA) (16 USC §§1361 *et seq*.)	National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA Fisheries)	Q2 2012	Q4 2012	Pre-application consultation. Studies to support consultation have been completed and will be provided in the Environmental Report to be submitted as a separate filing.
Review pursuant to the National Environmental Policy Act (NEPA) (42 USC §§4321 *et seq*.)	USACE, BOEM	Q1 2012	Q4 2012	Scoping with primary Federal permitting agencies. Surveys completed; information to support review will be provided in the Environmental Report to be submitted as a separate filing.
Consultation pursuant to Section 7 of the Endangered Species Act (ESA) (16 USC §§1531 *et seq*.)	NOAA Fisheries, USFWS	Ongoing	Q3 2012	Surveys completed in accordance with agency-reviewed protocols. Information to support consultation between federal permitting agencies and federal wildlife resource agencies will be provided in the Environmental Report to be submitted as a separate filing.
Consultation pursuant to the Migratory Bird Treaty Act (MBTA) (16 USC §§703 *et seq*.)	USFWS	Ongoing	Q3 2012	Surveys completed in accordance with agency-reviewed protocols. Information to support consultation with USFWS will be provided in the Environmental Report to be submitted as a separate filing.
Essential Fish Habitat (EFH) Consultation pursuant to the Magnuson-Stevens Act (16 USC §§1801 *et seq*.)	NOAA Fisheries	Ongoing	Q3 2012	Pre-application consultation. Information to support consultation between federal permitting agencies and federal wildlife resource agencies will be provided in the Environmental Report to be submitted as a separate filing.
Consultation pursuant to Section 106 of the National Historic Preservation Act (NHPA) (16 USC §§470 *et seq*.)	Rhode Island Historical Preservation and Heritage Commission (RIHPHC) State Historic Preservation Office (SHPO), Narragansett Tribe, Wampanoag Tribe	Ongoing	Q3 2012	Consultation ongoing since 2009. Cultural resource surveys completed in accordance with agency-reviewed protocols and through coordination with agencies and tribes. Information to support consultation provided in this GAP (Section 3.3; Appendix C).

Permit, Approval, or Consultation	Regulatory Authority(ies)	Filing Date	Anticipated Approval	Status
Water Quality Certification under Section 401 of the Clean Water Act (33 USC §1341)	Rhode Island Department of Environmental Protection (RIDEM)	Q1 2012	Q4 2012	Information to support review will be provided in the Environmental Report to be submitted as a separate filing.
U.S. Environmental Protection Agency (USEPA) Air Conformity Determination pursuant to the Clean Air Act (42 USC §§7401 *et seq*.)	USEPA	Q1 2012	Q3 2012	Air emissions analysis completed. Information to support review provided in the Environmental Report to be submitted as a separate filing.
State				
State Assent under the Rhode Island Coastal Resources Management Program (RIGL 46-23-1 *et seq.*)	CRMC	Q1 2012	Q4 2012	Pre-application meetings with CRMC, Habitat Advisory Board (HAB), Fisheries Advisory Board (FAB). ER to be submitted with application to CRMC shortly after USACE application submittal.
Concurrence with Federal Consistency Certification pursuant to Section 307 of the CZMA (16 USC §1456)	CRMC	Q1 2012	Q4 2012	The CRMC Assent will serve as the State's concurrence with the federal consistency certification.
Submerged Lands Lease	CRMC	Q4 2012	Q1 2013	Pre-application meetings.
Coastal and Freshwater Wetlands Permit (RIGL 46-23-6)	CRMC/RIDEM	Q1 2012	Q3 2012	Wetland surveys completed.
Consultation under the Rhode Island Endangered Species Act (RIGL 20-37-1 *et seq.*)	RIDEM	Ongoing	Q3 2012	Surveys completed in accordance with agency-reviewed protocols. Information will be provided in the Environmental Report submitted as a separate filing to support consultation (Section 4.6.7).
Consultation under the Rhode Island Historic Preservation Act (RIGL 42-45-1 *et seq.*)	RIHPHC	Ongoing	Q3 2012	Surveys completed in accordance with agency-reviewed protocols and through coordination with agencies and tribes. Information to support consultation will be provided in the Environmental Report to be submitted as a separate filing.
Rhode Island Pollution Discharge Elimination System (RIPDES) General Permit for Storm Water Discharge Associated with Construction Activity pursuant to Section 402 of the CWA (33 USC §1342)	RIDEM	Q2 2012	Q3 2013	Draft storm water pollution prevention plan will be prepared and included in the Environmental Report to be submitted as a separate filing.
Local				
Special Use Permit for work on BIPCO property	Town of New Shoreham – Zoning Board	Q4 2011	4/3/12	Approved on 4/3/12, 5-0 (Favorable)
Development Plan Review for wok on BIPCO property	Town of New Shoreham – Planning Board	Q4 2011	4/11/12	Approved on 4/11/12, 5-0 (Favorable)
Special Use Permit for work in wetland buffer	Town of Narragansett	Q1 2012	Q3 2012	Application pending

Table 7 Summary of Relevant and Recent Agency Consultation

Agency	Date	Consultation Summary
USFWS, CRMC, University of Rhode Island	6/25/2009	Project introduction meeting.
NOAA Fisheries	9/13/2009	Meeting to discuss study approach.
RIDEM	3/9/2010	Letter with determination that air quality permits are not required for the Project.
Department of Defense, Naval Seafloor Cable Protection Office	3/12/2010	E-mail correspondence regarding the Narragansett Bay Shallow Water Test Facility in the Narragansett TSS.
USACE, RIHPHC, Narragansett THPO	4/28/2010	Meeting to discuss terrestrial survey approach.
RIDEM	5/11/2010	Letter approval of sediment analysis plan.
USACE, BOEM (via phone), Narragansett THPO, NOAA, CRMC, RIDEM, RI SHPO	7/26/2011	Inter-agency pre-survey meeting for marine geophysical, geotechnical, archaeological, and benthic surveys.
BOEM	8/4/2011	Pre-survey meeting for marine geophysical, geotechnical, archaeological, and benthic surveys.
CRMC	9/13/2011	General Project meeting.
RIDEM	10/5/2011	General Project update meeting with RIDEM director.
RIDEM	10/20/2011	General Project meeting to discuss RIDEM permitting.
NOAA Fisheries	10/26/2011	Conference call to discuss approach to marine species risk assessment.
USACE, BOEM, NOAA Fisheries, CRMC, RIDEM	11/1/2011	Conference call to discuss approach to benthic habitat and fisheries assessment.
BOEM	11/3/2011	Conference call to discuss approach to marine species risk assessment.
USACE, CRMC	11/4/2011	Pre-application meeting.
EPA	11/7/2011	General Project meeting to discuss applicability of air quality regulations to the Project.
NOAA Fisheries, USACE, BOEM (via phone), CRMC, RIDEM	11/7/2011	Benthic habitat and fisheries assessment meeting to discuss study approach and avoidance and mitigation measures.
USFWS	11/16/2011	Meeting to present and discuss draft study results.
CRMC, Habitat Advisory Board.	12/19/2011	Pre-application Project meeting to discuss habitats in accordance with the RI Ocean SAMP.
CRMC, Fisheries Advisory Board	1/4/2012	Pre-application Project meeting to discuss fisheries in accordance with the RI Ocean SAMP.
USACE	1/5/12	General Project update meeting.
Department of Defense, Naval Seafloor Cable Protection Office	3/29/12	E-mail and phone correspondence prior to marine route survey and regarding avoidance of the Narragansett Bay Shallow Water Test Facility in the Narragansett TSS in siting of the BITS cable.

Health, Safety and Environment

Deepwater Wind will have a Health, Safety and Environmental (HSE) plan in place fulfilling the Occupational Safety & Health Administration (OSHA) and International Maritime Organization (IMO) requirements, and will ensure that all contractors and vessels will those requirements. Offshore personnel on the BITS Project will have received training in accordance with IMO Standards of Training, Certification, and Watchkeeping (STCW), OSHA and general offshore construction practices.

Marine Debris Elimination and Awareness

Deepwater Wind will implement a Marine Debris Elimination and Awareness Plan during installation of the BITS. Deepwater Wind will ensure that each vessel has a garbage management plan that conforms to applicable laws and regulations governing marine waste management.

Oil Spill Response

Deepwater Wind will develop procedures for oil spill prevention, coordination and response activities to be performed by the owners/operators of the marine vessels associated with deployment, operation and decommissioning activities. Each marine vessel will have its own Oil Spill Response Plan written in accordance with USCG regulations.

Protected Species Avoidance

Deepwater Wind will conduct an assessment of acoustic harassment to marine mammals and sea turtles associated with the DP vessels during cable laying activities and will implement appropriate measures to avoid harassment as part of the permitting process with NOAA Fisheries. Deepwater Wind will also incorporate vessel strike avoidance and reporting procedures into the environmental compliance requirements for installation of the BITS.

Sensitive Cultural Resources

Remote sensing surveys have not identified any submerged cultural resources in federal waters. However, construction activities have the potential to encounter unidentified submerged cultural resources. As a result, an unanticipated discoveries plan will be developed for this Project in accordance with § 285.802 and in consultation with the RIHPHC.

2.9.2 Operations and Maintenance

Deepwater Wind does not anticipate any operations and maintenance activities beyond typical vessel operations necessary to conduct periodic inspections or repair. In the event that a vessel must remain onsite to conduct maintenance or repair, the vessel contractors or other authorized representative will submit an LNM to the USCG.

2.9.3 Decommissioning

Deepwater Wind proposes to allow the submarine cable to remain in place; as such, there are no health, safety, or environmental compliance measures associated with decommissioning of the BITS following termination of the ROW Grant.

3.0 SITE CHARACTERISTICS

3.1 Geology, Sediments, and Shallow Hazards

Deepwater Wind has conducted site-specific surveys to evaluate the BITS route corridor. The site-specific studies were conducted in two phases. The first phase was conducted between July and October of 2009 and consisted of a comprehensive Sediment Profile Imagery (SPI) Survey to characterize the bottom sediment type along the proposed BITS route. This first phase of site-specific work helped define the preferred BITS route. The second phase of studies was comprised of a multi-disciplinary marine investigation specifically designed to further characterize and evaluate seafloor conditions and underlying shallow stratigraphy to support detailed Project siting, engineering design, address shallow hazard concerns, and to provide information on areas that could potentially be affected by construction and operational activities including marine and terrestrial archaeological resources and important marine and terrestrial habitats. This second phase of site-specific studies was conducted from September 2011 to January 2012 and included the following:

- **Hydrographic Survey**: to determine water depths and reveal the existing seafloor topography using multi-beam depth sounding techniques;
- **Sub-bottom Survey**: to identify subsurface stratigraphy and possible large buried obstructions using seismic reflection methods (Chip, Boomer) and included vibratory coring to verify material;
- **Side Scan Sonar Survey**: to identify morphologic variations and natural and human-caused obstructions present on the seafloor using surficial acoustic imaging techniques;
- **Magnetometer**: to identify ferrous objects on or buried below the seafloor (including existing cables);
- **Remotely Operated Vehicle (ROV) Inspections**: to inspect the seafloor using a remotely operated video camera to identify benthic conditions, as well as aid in seafloor characterization; and
- **Existing utility mapping (cable toner)**: to map the precise location of known active submarine cables that cross the proposed route with "tones" provided by the cable operator.

These surveys were conducted in accordance with BOEM guidelines, established by BOEM in a document entitled "Guidelines for Providing Geological and Geophysical, Hazards, and Archeological Information Pursuant to 30 CFR Part 285" dated April 21, 2011. Deepwater Wind submitted the survey protocols to BOEM for review and approval and held a pre-survey meeting with BOEM on August 4, 2011 to discuss the survey approach. Detailed descriptions and results of each of the site characterization studies can be found in the Marine Site Characterization Study included as Appendix A and the Benthic Survey Report included as Appendix B.

The route proposed for the BITS consists of mobile sand closest to the Block Island coastline with pockets of undisturbed cobble present. Moving into the deeper waters along the BITS route between Block Island and Point Judith, the bottom sediments turn to mostly silty sand and soft silt. The shallow region just south of Point Judith is composed of a mix of mobile sand, washed gravel, undisturbed cobble and some silty sand. At the mouth of Narragansett Bay, the sediment type is consistently composed of soft silt. At the coastal connection points in Narragansett, the bottom sediments are composed of mobile sand and silty sand. Sand content increases in the areas closest to the Alternative 2 location, but still contain significant silt.

According to the 2008 USGS National Seismic Hazard Maps (USGS 2008), there is a low seismic hazard potential in the area surrounding the BITS route. The peak horizontal ground accelerations with a 10 percent and a 2 percent probability of exceedance in 50 years are 1 to 2 percent and 4 to 6 percent of acceleration due to gravity, respectively (USGS 2008). In addition, there are no known active faults within Rhode Island Sound.

Based on regional geologic mapping, there is no karst topography in the area and therefore no ground subsidence from these conditions is anticipated for onshore facilities. The most recent regional volcanic activity was approximately 65 million years ago in Cape Nedrick, Maine.

Slope failures and collapse are also unlikely due to the topography and composition of the sediments, the bathymetry, and the current tectonic environment.

Shallow hazards in the vicinity of the BITS route consist of one identified unexploded ordinance located approximately 1 mi (1.6 km) southeast from the BITS cable route (Figure 3) that is characterized as an unexploded depth charge (1995) (NOAA Chart 13218).

3.2 Biological Resources

Deepwater Wind developed the benthic survey plan mentioned in Section 3.1 to characterize benthic resources that were not previously surveyed in the area that could be affected by the construction of the BITS. The survey considers a distance of 3280.8 ft (1000 m) from the cable centerline in accordance with the BOEM "Draft Guidelines for Benthic Habitat Surveys in the Atlantic for Offshore Wind Energy Development" dated July 21, 2011. Soft substrate benthic resources were previously evaluated in the Sediment Profile and Plan View Imaging Report for the BITS which informed the cable siting (CoastalVision and Germano and Associates 2010). The Benthic Survey Report (Appendix B) includes an evaluation of all benthic substrate resources along the BITS cable route.

The Marine Site Characterization Study initially used a side scan sonar survey to document the distribution of hard substrate within a 3280.8 ft (1,000 m) corridor of the BITS centerline. Substrate conditions were characterized as one of five types (Table 8). Of these, Types III, IV, and V may include hard substrate habitats in quantities that triggered a need for further characterization of benthic resources (e.g., video surveys).

Table 8 Substrate types

Type	Description
I	Low reflectivity, low relief, drag marks common, interpreted as fine grained sediments (mostly silt and fine sand) with possible boulders.
II	Medium to high reflectivity, moderate relief, sand ribbons distinctive, interpreted as medium to coarse grained sand and gravel, possible isolated boulders.
III	Low to high reflectivity, low to moderate relief, interpreted as complex mixture of alternating bottom types including fine to coarse grained sediments and boulders.
IV	Low to high reflectivity, moderate to high relief, abundant boulders, interpreted as glacial moraine deposits including silt, sand, gravel, and boulders.
V	High reflectivity, high relief, interpreted as bedrock outcrops on seafloor.

Areas identified by side scan sonar as potentially containing hard substrate (Types III, IV, and V) were further examined using underwater video, the results of which are also included as a supplement to the Benthic Survey Report. No areas surveyed by side scan sonar were classified as Type IV or V. Examination of areas classified as Type II or Type I/II under high resolution showed that these types include heterogeneous substrates that include small areas of mixed substrates (e.g., coarser than sand, with and without boulders) that may be useful to include in the video survey. Deepwater Wind selected stations that reflect all of the hard substrate conditions that occur in either the anticipated direct or indirect impact areas. The underwater video survey was stratified by proportionally distributing stations (i.e., transects) across the different hard substrate habitats found by the side scan sonar. Areas that are distant from construction activities were included in the video survey to serve as a type of control site.

The benthic survey determined the presence of epibenthic invertebrates and habitat, submerged aquatic vegetation, shellfish, lobster burrows, fish, and organisms to the lowest practicable taxonomic level. Benthic infauna in soft substrate in Block Island and Rhode Island Sound consisted of surface-swelling, tube mat-forming ampeliscid amphipods (*Ampelisca agassizi*) dominate in the finest sediments with the nut clam (*Nucula*) co-dominating in some cases. Other amphipod species (e.g., *Byblis serrata* and haustorids) and polychaetes (such as *Aricidea*, maldanids, nephtyids, and spionids) dominate in coarser sands. Bivalves such as *Mytilus edulis* (blue mussel) and *Arctica islandica* (ocean quahog) are also present. Hard substrate supported northern coral, sponges, sea stars, and some kelp. BITS Alternative 1, reaching landfall at the Narragansett Town Beach, was refined to avoid crossing directly through these patches; a side scan sonar survey showed that while hard substrate exists at the southern edge of the 984-ft (300-m) survey corridor, the 200-ft (61-m) wide centerline corridor avoids rock. No hard substrate was found near shore at the BITS Alternative 2 route to the URI Bay Campus.

Eelgrass (*Zostera marina*) is the only species of seagrass documented in the Project Area. CoastalVision and CR Environmental (2010) documented the existence of an eelgrass bed in the southern margin of Old Harbor, Block Island, approximately 2,000 ft (610 m) southeast of the original Block Island landfalls, consistent with RIGIS records. Deepwater Wind relocated the BIWF and BITS Block Island landfalls to increase the distance from this eelgrass bed. No eelgrass has been reported in the vicinity of the proposed BITS Alternative 1 Narragansett Beach landfall, but there is a suspected bed in the vicinity of the BITS Alternative 2 landfall at the URI Bay Campus. An appropriate survey of this suspected bed will be undertaken in the summer 2012 when biomass is at its peak.

Other biological resources along the BITS route are fish, essential fish habitat, marine mammals, and threatened and endangered species. Deepwater has conducted detailed evaluations of these resources that will be part of the Environmental Report that will be submitted to BOEM as a separate filing pursuant to 30 CFR §285.646.

3.3 Archaeological Resources

Two archaeological surveys prepared by Deepwater Wind and an archeological survey prepared by the RI Ocean SAMP identified the archaeological resources along the BITS corridor. The 2009 Post-Contact Period Marine Archaeological Sensitivity Assessment conducted by Deepwater Wind produced an extensive inventory of reported vessel casualties concentrated in coastal waters around Block Island and Narragansett, particularly south of Point Judith. The RI Ocean SAMP also provided additional indication that portions of the BITS Project area was subaerially exposed land on a coastal plain at the time corresponding with the archaeologically projected date for the earliest human habitation in the Northeast (i.e., circa 11,500 years before present) and, likely, for several thousand years thereafter. As a result of the 2009 assessment and the 2010 RI Ocean SAMP, a majority of the underwater portion of the BITS Project within state waters may be considered to have a high to moderate sensitivity for containing submerged post-contact period shipwrecks. Based on the results of the RI Ocean SAMP and the oral history of the Narragansett Tribe summarized and documented within it, portions of the BITS may also be considered to have moderate sensitivity for containing submerged pre-contact period habitation sites.

The second archaeological survey produced by Deepwater Wind, the Phase I Marine Archeology Remote Sensing Identification Survey, consisted of coordination/consultation, research, marine geophysical survey, marine geotechnical sampling, data analyses and interpretation, and reporting. The survey protocol was developed in accordance with:

- the Secretary of the Interior's *Standards and Guidelines for Archaeology and Historic Preservation* (48 FR 44716, 1983);
- BOEM's Guidelines for Providing Geological and Geophysical, Hazards, and Archaeological (GGARCH) Information;
- RI Historical Preservation & Heritage Commission's (RIHPHC) *Performance Standards and Guidelines for Archaeological Projects* (2007);
- Narragansett Indian Tribe Archeological/Anthropological Committee's *Standards and Guidelines for Archaeological Survey* (1994); and
- the National Association of Tribal Historic Preservation Officers' (NATHPO's) *Tribal Consultation: Best Practices in Historic Preservation* (2005).

Prior to initiation of the surveys, the protocol was reviewed and approved by relevant federal and state agencies and by the Narragansett Indian Tribe. Both the Narragansett Indian Tribe and the Wampanoag Tribe of Gay Head (Aquinnah) participated in the marine surveys and the review of the data. The marine surveys were conducted from September 2011 to January 2012. The BITS Submarine Cable Phase I Marine Archeology Remote Sensing Identification Survey Report, included as a confidential appendix to this GAP (Appendix C), describes the results of the survey.

3.4 Air Quality

There are no operational emissions associated with the BITS; however, there are emissions associated with the BITS construction. Emissions from the BITS construction activities are divided into four categories:

(1) Onshore activities at Quonset Point;

(2) Construction of the BITS portions of the Block Island Substation (including the BITS Island Switchyard);

(3) BITS land cable activities (i.e., HDD for the cable landfall on Block Island and Narragansett, installation of the BITS cable on Block Island, installation of the cable between the HDD site and the mainland terminus); and

(4) BITS offshore construction activities, including installation and burial of the cabling between Block Island and Narragansett.

Emissions from the Quonset Point and BITS construction activities are shown in Tables 9 and 10. Emissions from Quonset Point activities include construction activities associated with both BIWF and BITS and make up the majority of the emissions shown in Tables 9 and 10. Emissions associated with the eventual decommissioning of the BITS would involve comparable types of equipment and would be less than or equivalent to those shown in Tables 9 and 10. General Conformity requirements are not expected to apply, but if necessary, emissions from both the BIWF and the BITS construction will need to be considered in the General Conformity determination. OCS air permitting requirements pursuant to 40 CFR 55 also do not apply (Cruickshank 2011).

Construction of the BITS will result in emissions of NO_x and other air pollutants, but are temporary, "one-time" emissions. Once the BITS is operational, it will displace emissions from fuel-fired electricity generators every year.

Table 9 Emissions from BITS Construction in 2013 (tons)

Pollutant	VOC	NOx	CO	PM_{10}	SO_2	GHG
Quonset*	0.80	7.16	4.26	0.43	0.011	1,145
Substation BI	0.35	2.88	1.65	0.27	0.004	425
BITS land cable	0.14	1.24	0.74	0.10	0.002	202
BITS	0	0	0	0	0	0
TOTAL	1.29	11.29	6.64	0.80	0.016	1,773

**Includes construction activities associated with both BIWF and BITS.*

Table 10 Emissions from BITS Construction in 2014 (tons)

Pollutant	VOC	NOx	CO	PM_{10}	SO_2	GHG
Quonset*	5.0	49.4	24.8	3.1	0.06	6,665
Substation BI	0.2	1.7	1.0	0.2	0.002	254
BITS land cable	0.6	5.0	2.9	0.4	0.01	808
BITS	5.8	161.8	17.8	9.8	0.10	10,010
TOTAL	11.6	217.9	46.54	13.4	0.17	17,738

**Includes construction activities associated with both BIWF and BITS.*

4.0 FINANCIAL ASSURANCE

Deepwater Wind will comply with the requirements of the BOEM Final Rule (§§ 285.520, et seq.) regarding financial assurances.

5.0 REFERENCES

CoastalVision and Germano & Associates. 2010. Sediment Profile and Plan View Imaging Report. Evaluation of Sediment and Benthos Characteristics Along Potential Cable Routes and Turbine Locations for the Proposed Block Island Wind Farm. Prepared for Ecology and Environment.

Cruickshank, 2011. Telephone conversation between Walter Cruickshank (BOEM Deputy Director) and Aileen Kenney (Deepwater Wind), December.

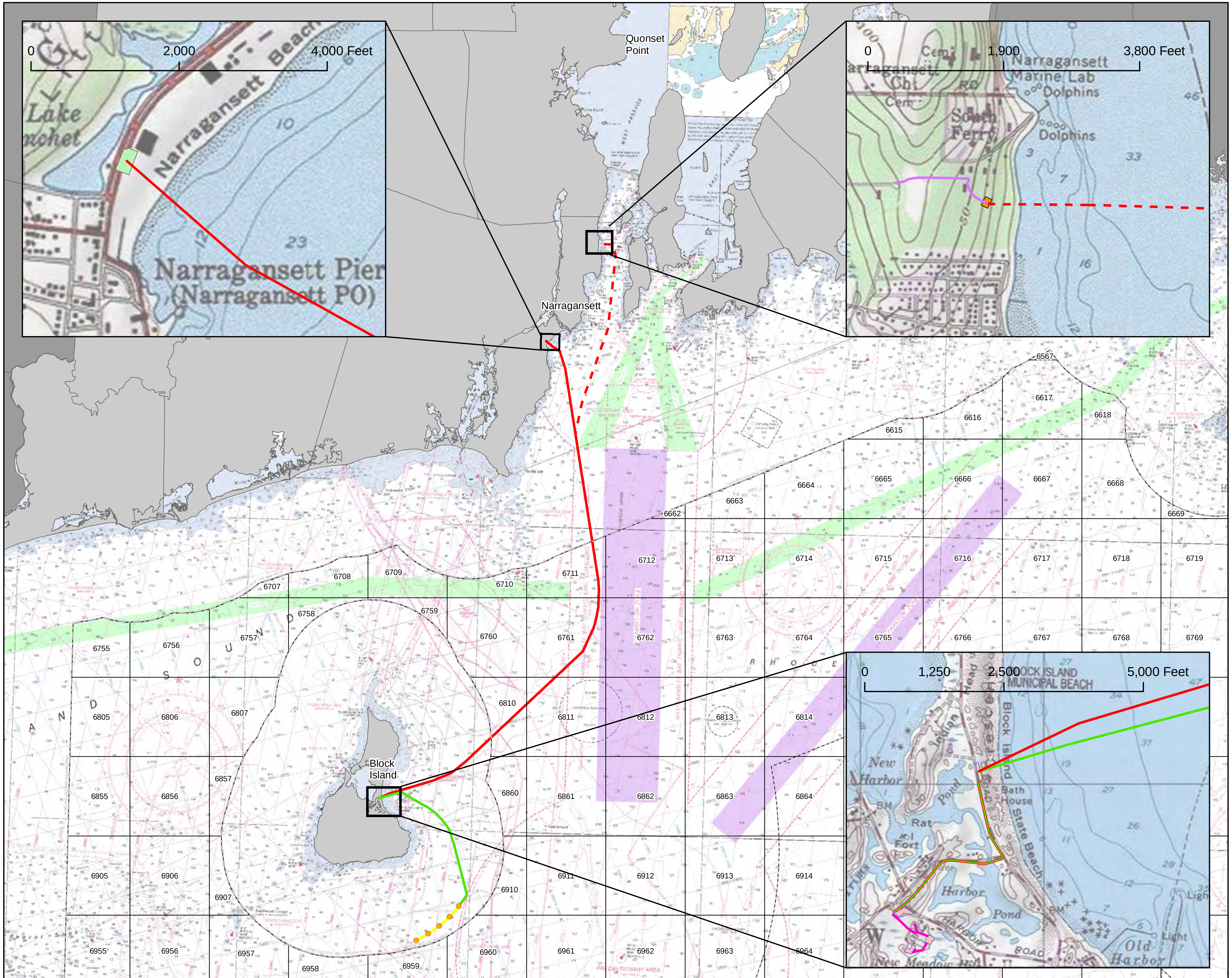
RI Ocean SAMP (Rhode Island Ocean Special Area Management Plan). 2011. Rhode Island Coastal Resources Management Council, updated May 4, 2011.

USGS (U.S. Geological Survey). 2008. "National Seismic Hazard Maps." Available online at: http://gldims.cr.usgs.gov/website/nshmp2008/viewer.htm.

FIGURES

Deepwater Wind Block Island Transmission System General Activities Plan Figure 1 Location Plat

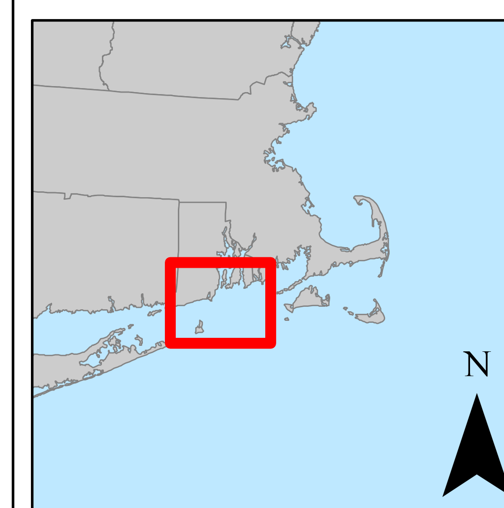
April 2012



- Turbine Array
- BITS Alternative 1
- BITS Alternative 2
- BIWF Export Cable
- BIWF Inter-Array Cable
- Block Island Proposed Overhead Line
- Block Island HDD Area
- Block Island Substation: Proposed Alternatives
- BITS Alternative 1 HDD Area
- BITS Alternative 2 Onshore Route
- BITS Alternative 2 HDD Area
- Lease Block
- 3 Nautical Mile Line (State Waters)
- 12 Nautical Mile Line (Federal Waters)

0 2 4 6 Miles

0 1 2 3 4 Nautical Miles



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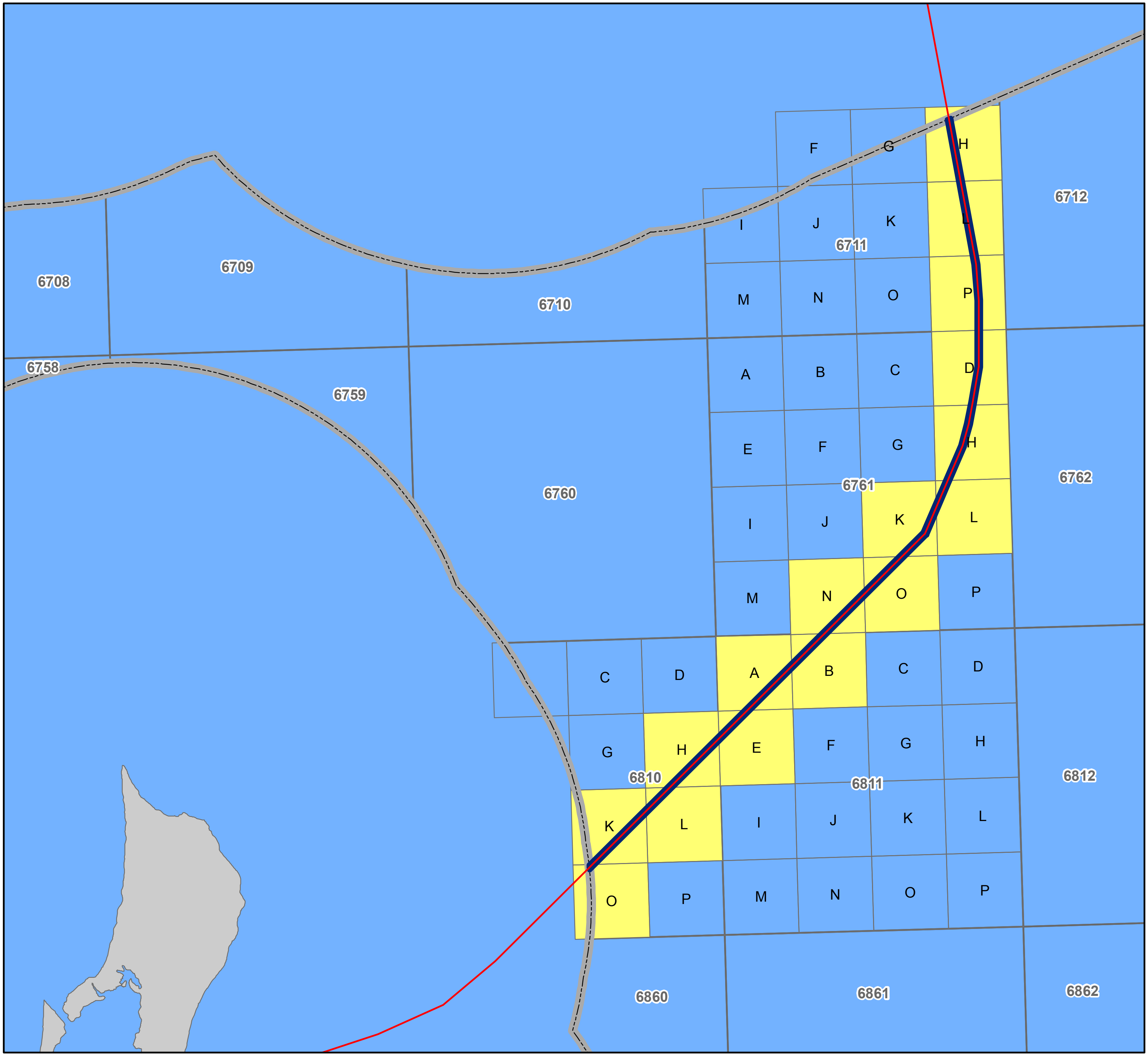
Prepared By: william.scales
Coordinate System: NAD 1983 UTM Zone 19N

Deepwater Wind
Block Island Transmission System
General Activities Plan
Figure 2:
ROW Grant Request Area

April 2012

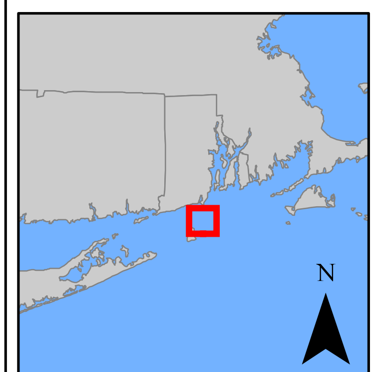


BITS
BITS Cable Corridor (200 ft)
Lease Block
State Territorial Waters Boundary
Federal Waters Boundary

Source: BOEMRE Lease Blocks (2010), NOAA State Water Limits (2011)

0 0.5 1 1.5 2 Miles

0 0.25 0.5 0.75 1 Nautical Miles



DEEPWATERWIND

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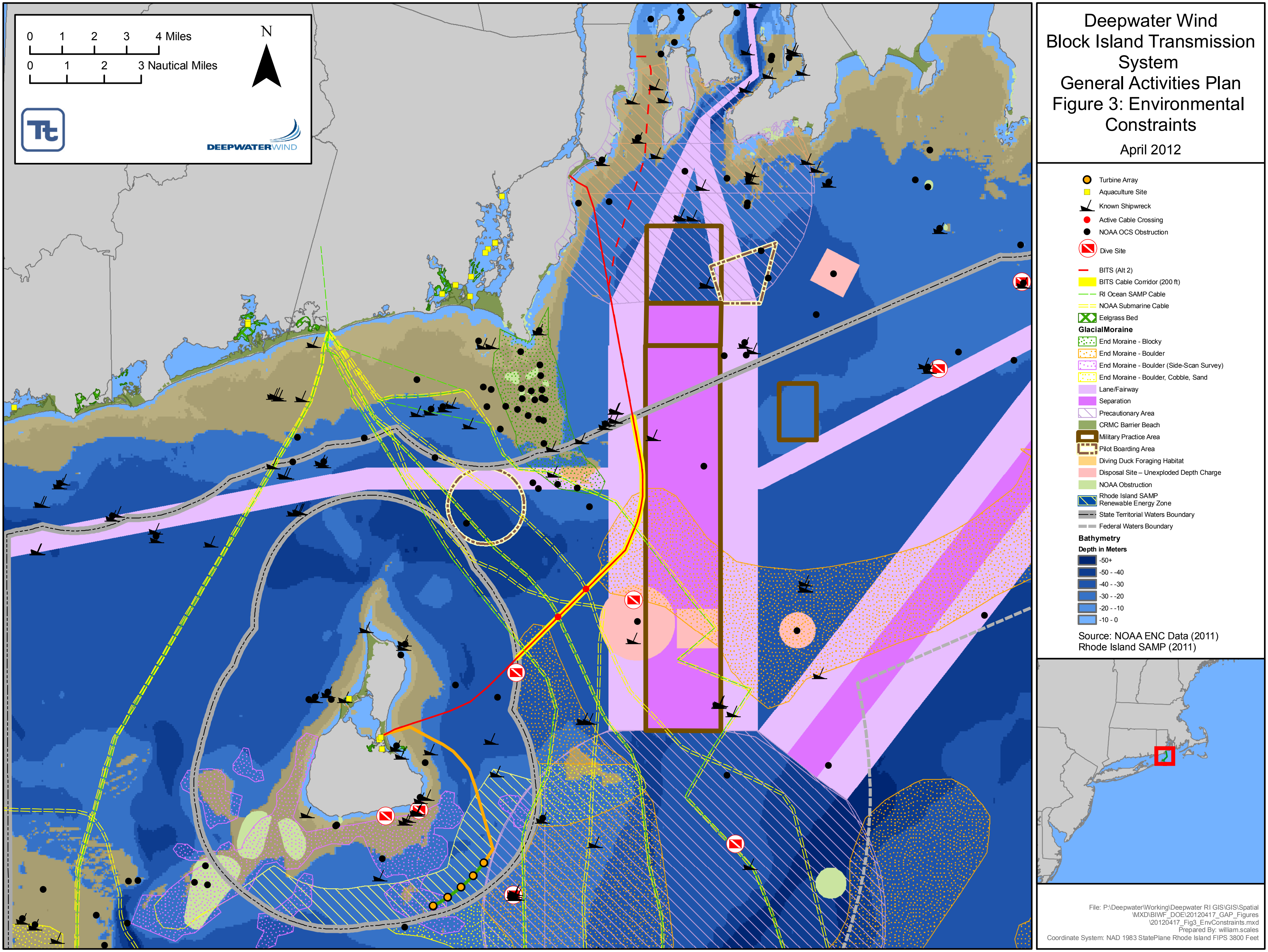
Coordinate System: NAD 1983 StatePlane Rhode Island FIPS 3800 Feet


0 1 2 3 4 Miles
0 1 2 3 Nautical Miles
N
DEEPWATERWIND
Deepwater Wind
Block Island Transmission System
General Activities Plan
Figure 3: Environmental Constraints
April 2012
Turbine Array
Aquaculture Site
Known Shipwreck
Active Cable Crossing
NOAA OCS Obstruction
Dive Site
BITS (Alt 2)
BITS Cable Corridor (200 ft)
RI Ocean SAMP Cable
NOAA Submarine Cable
Eelgrass Bed
GlacialMoraine
End Moraine - Blocky
End Moraine - Boulder
End Moraine - Boulder (Side-Scan Survey)
End Moraine - Boulder, Cobble, Sand
Lane/Fairway
Separation
Precautionary Area
CRMC Barrier Beach
Military Practice Area
Pilot Boarding Area
Diving Duck Foraging Habitat
Disposal Site – Unexploded Depth Charge
NOAA Obstruction
Rhode Island SAMP Renewable Energy Zone
State Territorial Waters Boundary
Federal Waters Boundary
Bathymetry
Depth in Meters
-50+
-50 - -40
-40 - -30
-30 - -20
-20 - -10
-10 - 0
Source: NOAA ENC Data (2011)
Rhode Island SAMP (2011)
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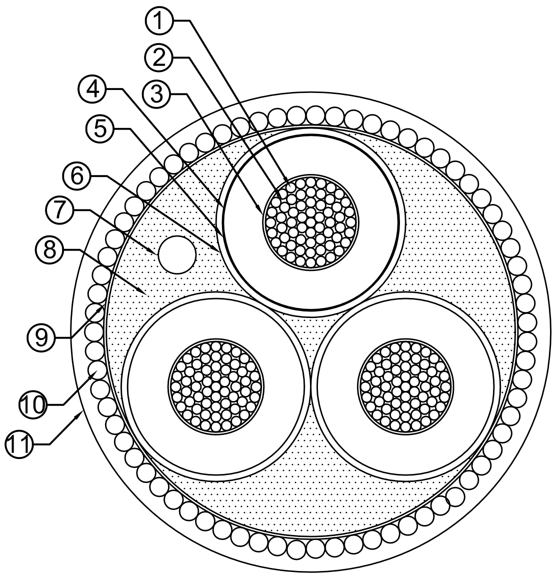
Prepared By: william.scales
Coordinate System: NAD 1983 StatePlane Rhode Island FIPS 3800 Feet

REV	REVISIONS	DATE	DRN	DSGN	CKD	APPD
A	ISSUED FOR REVIEW	2/09/12	MT	CMD	CMD	

LEGEND

1. - CONDUCTOR
2. - FILLING COMPOUND
3. - CONDUCTOR SCREEN
4. - INSULATION
5. - INSULATION SCREEN
6. - SHEATH
7. - INTERSTITIAL FIBER OPTIC
8. - YARN FILLERS
9. - BINDER TAPES
10. - ARMOUR WIRES
11. - YARN AND BITUMEN



35KV 3-CORE
SUBMARINE CABLE

DEEPWATERWIND

	DSGN	CMD	02/09/2012	
	DRN	MT	02/09/2012	
	CKD	CMD	02/09/2012	
	SCALE:	N.T.S		
REFERENCE DRAWINGS	FOR 8.5x11 DWG ONLY			

Mott MacDonald

DEEPWATER WIND

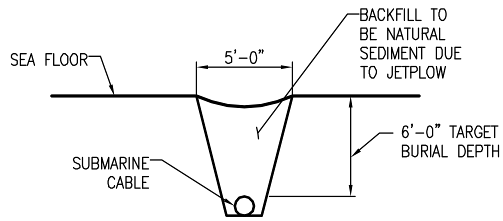
BLOCK ISLAND TRANSMISSION PROJECT

Figure 4
Typical 3-Core Submarine Cable

JOB NUMBER: 276847
REV: A
DRAWING NUMBER: 1 OF 1

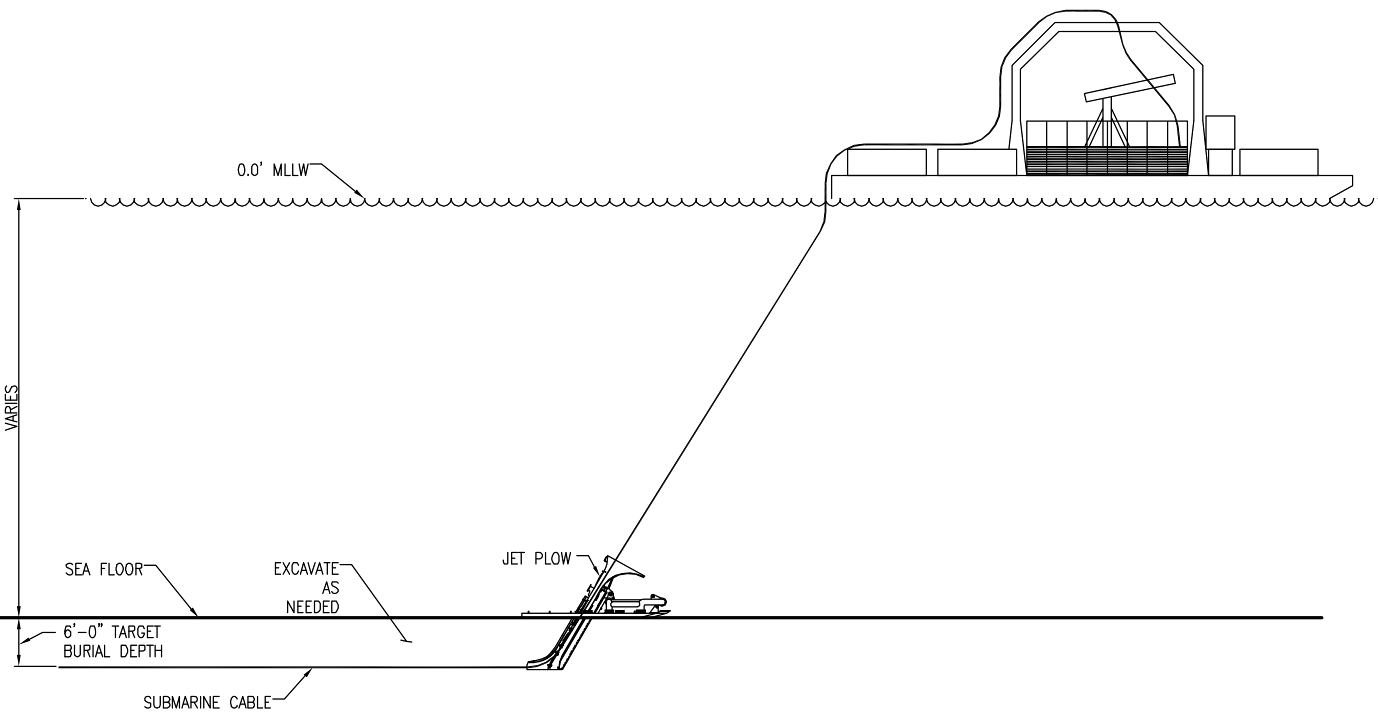
SUBMARINE CABLE DETAIL.dwg

REV	REVISIONS	DATE	DRN	DSGN	CKD	APPD
D	ISSUED FOR REVIEW	02/14/2012	JJS	JJS	DEJ	
C	ISSUED FOR REVIEW	02/03/2012	JJS	JJS	DEJ	
B	ISSUED FOR REVIEW	01/30/2012	JJS	JJS	DEJ	
A	ISSUED FOR REVIEW	01/17/2012	JJS	JJS	DEJ	



SECTION

SCALE N.T.S.



ELEVATION VIEW

SCALE N.T.S.

DEEPWATERWIND

DSGN	JJS	1/17/2012	DEEPWATER WIND	JOB NUMBER 119630
DRN	JJS	1/17/2012	BLOCK ISLAND TRANSMISSION PROJECT	REV D
CKD	DEJ	1/17/2012	Figure 5	DRAWING NUMBER
SCALE:	N.T.S.		Submarine Installation Detail	1 OF 1
REFERENCE DRAWINGS	FOR 8.5x11 DWG ONLY			

POWER ENGINEERS

Submarine Detail.dwg

THIS DRAWING WAS PREPARED BY POWER ENGINEERS, INC. FOR A SPECIFIC PROJECT, TAKING INTO CONSIDERATION THE SPECIFIC AND UNIQUE REQUIREMENTS OF THE PROJECT. REUSE OF THIS DRAWING OR ANY INFORMATION CONTAINED IN THIS DRAWING FOR ANY PURPOSE IS PROHIBITED UNLESS WRITTEN PERMISSION FROM BOTH POWER AND POWER'S CLIENT IS GRANTED.

REV	REVISIONS	DATE	DRN	DSGN	CKD	APPD
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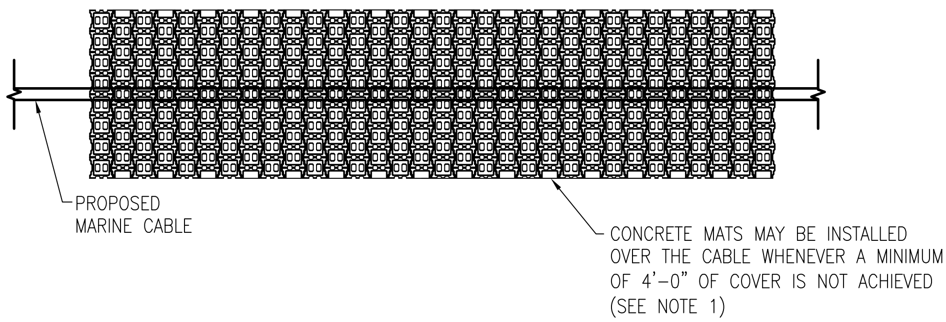
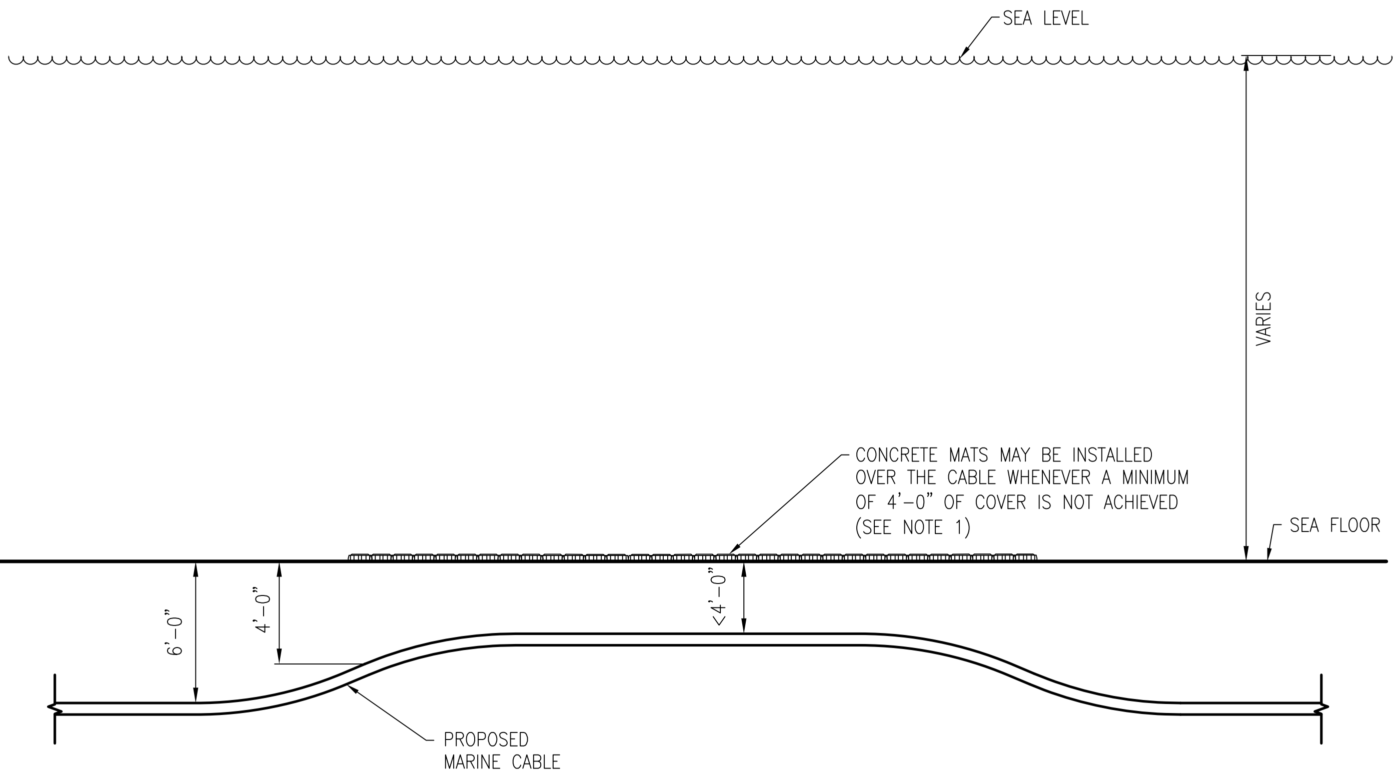
A	ISSUED FOR REVIEW	04/13/2012	JJS	JJS	DEJ	



PLAN VIEW



PROFILE VIEW

NOTES:

1. ROCK DROPPING WITH SIMILAR PROFILE MAY BE USED IN LIEU OF CONCRETE MATS WHERE TARGER DEPTH WAS NOT ACHIEVED.

SHALLOW PENETRATION DETAIL

SCALE N.T.S.

AECOM

DEEPWATERWIND®

SHALLOW PENETRATION.dwg

		DSGN	JJS	04/13/2012
		DRN	JJS	04/13/2012
		CKD	DEJ	04/13/2012
		SCALE:	N.T.S.	
REFERENCE DRAWINGS		FOR 8.5x11 DWG ONLY		

POWER ENGINEERS

DEEPWATER WIND

BLOCK ISLAND TRANSMISSION PROJECT

Figure 6

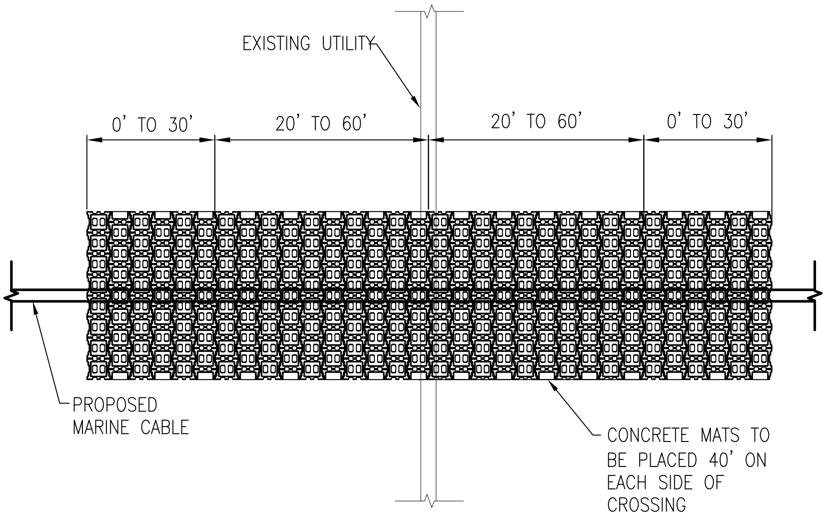
Shallow Penetration Detail

JOB NUMBER	REV
119630	B

DRAWING NUMBER

1 OF 1

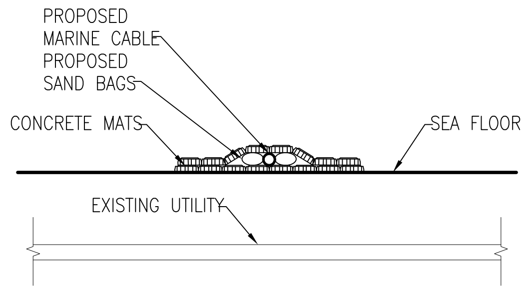
REV	REVISIONS	DATE	DRN	DSGN	CKD	APPD
D	ISSUED FOR REVIEW	02/14/2012	JJS	JJS	DEJ	
C	ISSUED FOR REVIEW	02/03/2012	JJS	JJS	DEJ	
B	ISSUED FOR REVIEW	01/30/2012	JJS	JJS	DEJ	
A	ISSUED FOR REVIEW	12/30/2011	JJS	JJS	DEJ	



PLAN VIEW

EXISTING UTILITY CROSSING

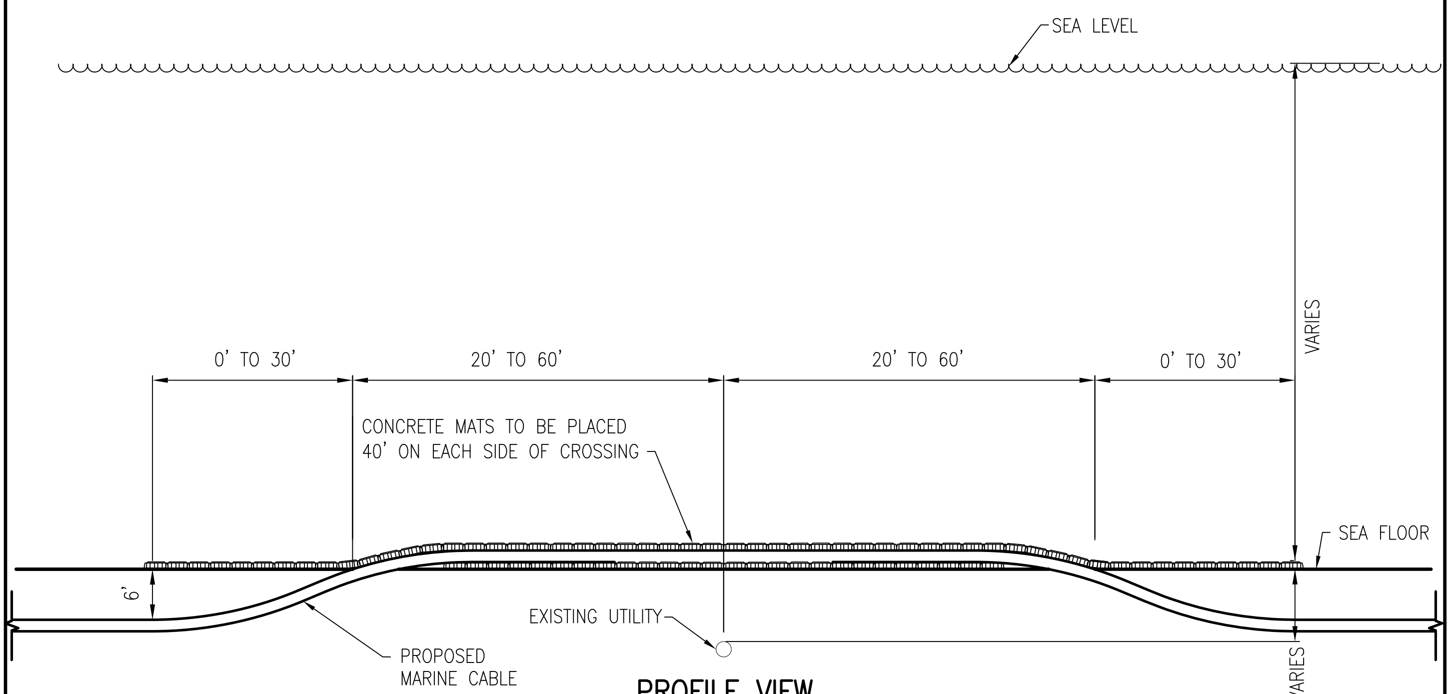
SCALE N.T.S.



CROSS SECTION

EXISTING UTILITY CROSSING

SCALE N.T.S.



PROFILE VIEW

EXISTING UTILITY CROSSING

SCALE N.T.S.

DEEPWATERWIND®

UTILITY CROSSING.dwg

REFERENCE DRAWINGS	DSGN JJS 12/30/2011	POWER ENGINEERS	DEEPWATER WIND	JOB NUMBER 119630
	DRN JJS 12/30/2011		BLOCK ISLAND TRANSMISSION PROJECT	REV D
	CKD DEJ 12/30/2011		Figure 7	DRAWING NUMBER 1 OF 1
	SCALE: N.T.S.		Typical Utility Crossing Detail	
	FOR 8.5x11 DWG ONLY			

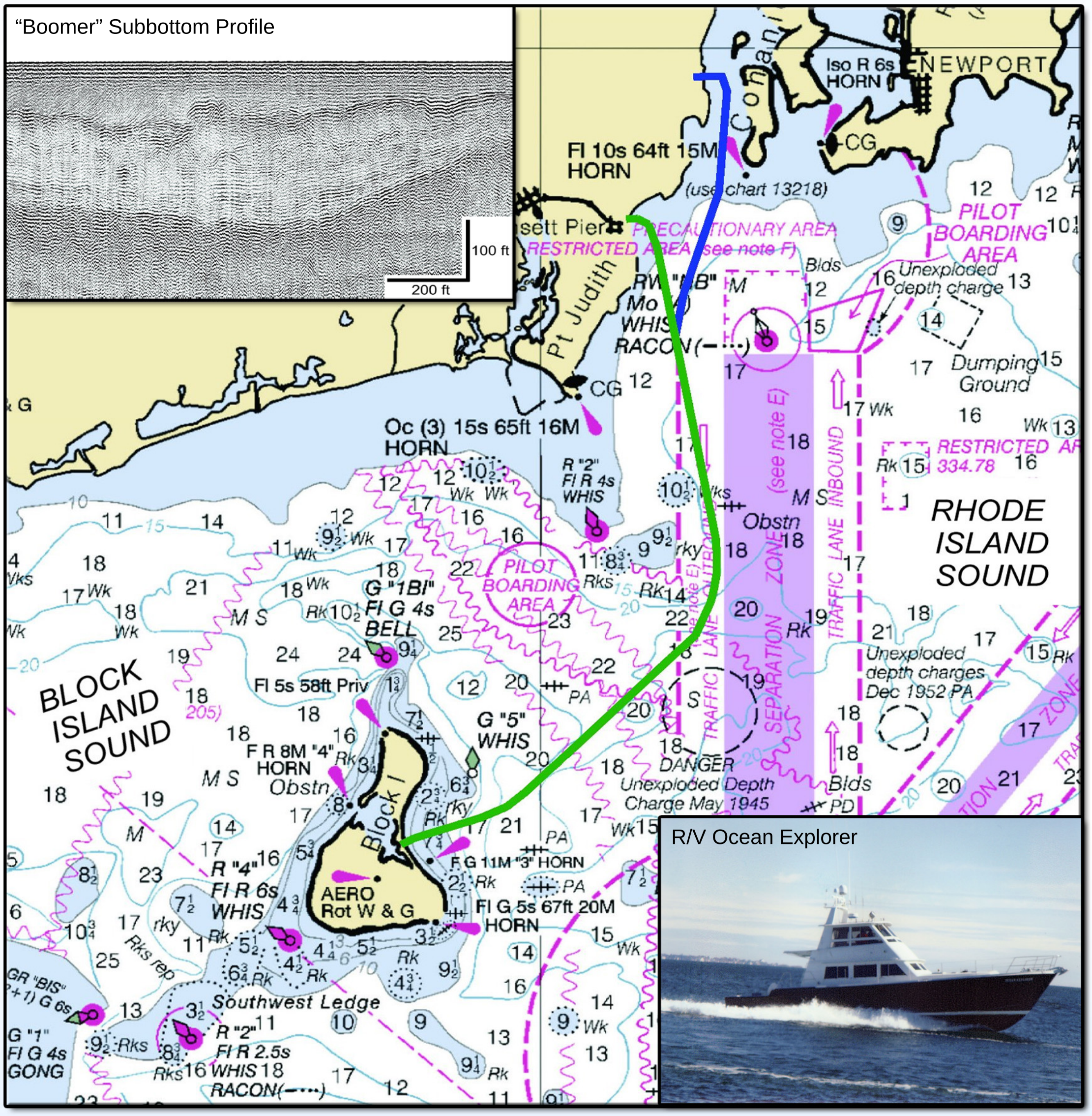
APPENDIX A

Marine Site Characterization Study

Final Report

Marine Site Characterization Study
Geophysical and Geotechnical Investigations

Block Island Transmission System
Submarine Cable Route
Rhode Island Sound
Block Island to Narragansett, Rhode Island



OSI Report #11ES074
10 March 2012

Prepared For:
AECOM
10 Orms Street, Suite 405
Providence, RI 02904

And:
Deepwater Wind Block Island Transmission, LLC
56 Exchange Terrace, Suite 101
Providence, RI 02903

Prepared By:
Ocean Surveys, Inc.
129 Mill Rock Road East
Old Saybrook, CT 06475

FINAL REPORT

MARINE SITE CHARACTERIZATION STUDY

GEOPHYSICAL AND GEOTECHNICAL INVESTIGATIONS

BLOCK ISLAND TRANSMISSION SYSTEM
SUBMARINE CABLE ROUTE
RHODE ISLAND SOUND
BLOCK ISLAND TO NARRAGANSETT, RHODE ISLAND

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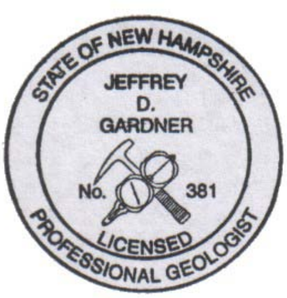
Geophysical Section Manager



10 March 2012

EXECUTIVE SUMMARY

Geophysical, geotechnical, and remote sensing investigations have been performed as part of a marine site characterization study for the BITS project proposed by Deepwater Wind. The project involves the installation of a submarine cable linking Block Island to mainland Rhode Island. The planned cable alignment follows a 21.7 mile long route through western Rhode Island Sound connecting the east shore of Block Island to Narragansett. An alternate mainland landing site north near the URI Bay campus would increase the route length to 26 miles.

While a majority of the BITS route is located in state waters, a portion of the cable alignment traverses waters beyond three nautical miles from shore on the OCS (federal jurisdiction). As a result, the entire project was planned and executed according to BOEM guidelines to maintain consistency in data acquisition, product development, and submittals, except where state requirements were more stringent. Specific federal and state guidelines for collecting and providing geological, geophysical, shallow hazards, archaeological, and benthic habitat information were followed.

The multi-disciplinary marine investigations conducted for this study were designed to provide scientific information on a 300-meter wide corridor centered on the route where potential impacts from future construction activities might occur. Objectives of the study were to: (1) characterize/evaluate seafloor conditions and underlying shallow stratigraphy, (2) address state and federal marine archaeological, benthic, and shallow hazard concerns, and (3) provide information in support of state and federal permit requirements and application submittals.

To accomplish the above objectives, tasks completed as part of the marine field program included: multibeam bathymetry, side scan sonar imaging, magnetic intensity measurements, shallow and intermediate subbottom profilers, vibratory core sampling, and existing submarine cable detection. Studies were completed from September 2011 to January 2012 using offshore survey vessels designed for specific tasks and experienced scientific crews to efficiently conduct the operations and manage the field program. Multiple vessels worked simultaneously to expedite the data acquisition while meeting BOEM requirements, and ultimately produce results within the project timeline proposed.

Geologic conditions present on and below the seafloor today are primarily the result of glacial processes that took place 10,000-25,000 years ago. The carving of underlying bedrock and coastal plain strata by an ice sheet over a mile thick, vast accumulations of material deposited by the glaciers, modification by meltwater streams during retreat, transformation by fluvial systems during subaerial exposure, and the reworking of deposits

by shoreline transgression, all played an important role in shaping the submarine landscape on the inner continental shelf off Rhode Island. The underlying basement units transition from Paleozoic bedrock on the mainland and under the northern two-thirds of the route to Cretaceous-Tertiary age coastal plain strata offshore and under Block Island.

Specifically along the BITS alignments, predominantly sand and gravel with possible coarser materials (cobbles and boulders) exist on nearshore slopes and offshore shoals, while finer grained sediments (silt-clay-fine sand) infill swales in the seafloor topography. Sand is the primary constituent of surface and subsurface materials. Isolated boulders may be present in some areas and sand waves exhibiting relief of 1-2 feet are common. Isolated subcrops (peak of basement material in the upper 10 feet) of bedrock and/or coarse glacial till (boulders, cobbles) exist immediately offshore from both mainland landfalls.

In addition to general characterization of surface and subsurface conditions for engineering and design purposes, the geophysical data were also reviewed to determine the presence of natural and man-made shallow hazards that could impact the project, also of interest to BOEM. The following hazards were considered for their possible existence in the site and included as features of interest that were searched for during data review and interpretation.

- <u>Natural seafloor hazards</u>: steep/unstable slopes, mass movement structures, water scour, bedforms, hard grounds, diapiric structures, gas/fluid expulsion features, faulting expression
- <u>Natural subsurface hazards</u>: collapse features, shallow water flow, gas hydrates, faults and faulting attenuation, mass movement structures, diapiric structures, shallow gas, buried channels
- <u>Man-made hazards</u>: debris, shipwrecks, cables, pipelines, ordnance, cultural resources (relict coastal geomorphic features)

None of the identified features (summarized below) are believed to pose any significant impediment to the planned installation of the BITS power cable. Objects on or adjacent to the route can be mitigated. Of the hazards included in the review, bedforms (sand waves) and associated minimal water scour are evident on the seafloor, buried channels, shallow gas, and small scale slumps are present in the subsurface, and man-made hazards include debris and submarine cables (five potential crossings). Some areas contain a higher concentration of apparent man-made objects and a number of individual targets and anomalies are positioned on or very close to the route alignment. In most cases, geophysical data indicate these hazards are of limited size and areal extent, or laterally positioned off the centerline, or vertically below the anticipated cable burial depth.

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7 Quality Assurance/Quality Control

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10 Side Scan Sonar Target Listings (with BOEM formats)
11 Magnetic Anomaly Listings (with BOEM formats)
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13 Drawing #2 PDFs; BITS Alternate Route Alignment Sheets
14 Drawing #3 PDFs; Multibeam Data for Benthic Mapping
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16 Drawing #5 PDFs; Magnetic Intensity Contours of Primary Route Corridor
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ACRONYMS

Abbreviation	Definition
OSI	Ocean Surveys, Inc.
WTG	wind turbine generator
BITS	Block Island Transmission System
PPA	Power Purchase Agreement
PUC	Public Utilities Commission
CRMC	Coastal Resource Management Council (State of Rhode Island)
SAMP	Special Area Management Plan (Rhode Island Ocean)
SPI	Sediment Profile Imaging
OCS	Outer Continental Shelf
BOEM	Bureau of Ocean Energy Management
RIHPHC	Rhode Island Historical Preservation and Heritage Commission
GPS	global positioning system
GIS	geographic information system
URI	University of Rhode Island
NGS	National Geodetic Survey
NOAA	National Oceanic and Atmospheric Administration
NAD	North American Datum (of 1983)
NAVD	North American Vertical Datum (of 1988)
MLLW	mean lower low water
GNSS	global navigation satellite system
USGS	United States Geological Survey
R/V	research vessel
TAT	Trans-Atlantic Telecommunications
HP	horse power
VHF	very high frequency
USBL	ultra-short base line
MP	milepost
CTD	conductivity, temperature, density
NMEA	National Marine Electronics Association
USCS	Unified Soil Classification System
TVG	time variable gain
IMU	inertial measurement unit

Units	Definition
miles	statute miles
nm	nautical miles
ft	ft / foot
m	meter(s)
ft/s	ft per second
m/s	m per second
Hz	hertz
kHz	kilohertz
ms	milliseconds
kV	kilovolt
kW	kilowatt
MW	megawatt

MARINE SITE CHARACTERIZATION STUDY

GEOPHYSICAL AND GEOTECHNICAL INVESTIGATIONS
BLOCK ISLAND TRANSMISSION SYSTEM
SUBMARINE CABLE ROUTE
RHODE ISLAND SOUND
BLOCK ISLAND TO NARRAGANSETT, RHODE ISLAND

1.0 INTRODUCTION

During the period 19 September 2011 to 11 January 2012, a multi-phase marine site characterization study was conducted by Ocean Surveys, Inc. (OSI) in support of a proposed submarine cable route linking Block Island to the Rhode Island mainland. The new submarine cable, referred to as the Block Island Transmission System (BITS), has been proposed by Deepwater Wind Block Island Transmission, LLC (Deepwater Wind), a wholly owned subsidiary of Deepwater Wind Holdings, LLC. The planned cable alignment covers approximately 21.7 statute miles (miles) between the east shore of Block Island and Narragansett, Rhode Island, with an alternate landfall option that extends approximately 8 miles (from the primary route intersection near MP 18) to the north near the University of Rhode Island (URI) Bay campus (Figure 1).

The investigations documented herein were completed under contract with AECOM (Project #60217918.500) on behalf of Deepwater Wind. The BITS marine site characterization study was completed under OSI Project No. 11ES074.

In connection with the BITS, Deepwater Wind has also proposed to develop the Block Island Wind Farm (BIWF or Wind Farm), a planned 30 megawatt (MW) offshore wind farm located approximately 3 nm southeast of Block Island. The Wind Farm is expected to consist of five 6 MW wind turbine generators (WTGs), a submarine cable interconnecting the WTGs (Inter-Array Cable), and a 34.5-kilovolt (kV) transmission cable to connect the northernmost WTG to an interconnection point on Block Island (Export Cable).

The BITS field program was purposely integrated with the BIWF project field investigations for survey efficiency and cost effectiveness, as well as to maintain both projects on the accelerated schedule proposed for permit submission. The results of the BIWF surveys are included separately in the OSI Report No. 11ES075 entitled, "Marine Site Characterization Study, Geophysical and Geotechnical Investigations, Block Island Wind Farm, Rhode Island Sound-Atlantic Ocean, Offshore Block Island, Rhode Island."

1.1 Project Background

In 2008, the State of Rhode Island conducted a competitive solicitation to select a preferred developer for offshore wind projects. Through this solicitation, which attracted bids from seven potential developers, Deepwater Wind was selected as the State's preferred developer. In January 2009, Deepwater Wind executed a joint development agreement with the State in which the parties agreed to develop two projects. The first of these projects, BIWF, is designed to supply renewable energy to Block Island while also supporting the construction of the first-ever connection between Block Island and the mainland electricity grid (BITS). The State of Rhode Island adopted legislation authorizing the purchase by the State's electric distribution company of the output from the BIWF. State law also calls for construction of the BITS.

On June 20, 2010, Deepwater Wind and National Grid executed a Power Purchase Agreement (PPA) for the sale of power from the BIWF to National Grid. The Rhode Island Public Utilities Commission (PUC) issued a written order on August 16, 2010 approving the PPA. On July 1, 2011, the Rhode Island Supreme Court upheld the approval of the PUC.

The BITS has been significantly informed by the State of Rhode Island's marine spatial planning efforts. The State of Rhode Island, as part of its effort to support the development of offshore wind, through the Rhode Island Coastal Resource Management Council (CRMC), has completed a comprehensive baseline environmental data collection effort, the Rhode Island Ocean Special Area Management Plan (SAMP).

Deepwater Wind has conducted additional project specific surveys to inform the BITS. During the summer of 2009, several reconnaissance level survey tasks were undertaken to provide initial data for characterizing the seafloor conditions in the area and refining development plans. Reconnaissance survey tasks completed during the summer of 2009 program include (tracklines and areas covered shown in Figure 2):

1. Turbine array site investigation southeast of Block Island (blue lines)
2. Survey lines extending west-northwest from the turbine array site (parallel to 3 mile limit) transiting over Southwest Ledge (red lines)
3. Preliminary BITS route lines connecting Block Island to mainland, concentrating on the shoal in the middle of the alignment (green line)

Results from the reconnaissance surveys were presented in the following submittals:

- OSI Final Report # 09ES041 “Reconnaissance Geophysical Investigation, Wind Farm Development Site, Off Block Island, Atlantic Oceans, Offshore Rhode Island” (23 October 2009)
- OSI Letter Report “Summary of Operations and Data Products, Reconnaissance surveys, Summer 2009, Proposed Wind Farm Development Block Island” (8 October 2009)
- OSI Project No. 09ES041 Final Drawings #1 (Multibeam), #2 (side scan sonar) and #3 (subbottom profiles) (6 October 2009)
- OSI Preliminary Cable Route Side Scan Mosaic Drawing, 4 sheets (12 August 2009)

In addition, during the summer of 2009, Deepwater Wind conducted a Sediment Profile Imaging (SPI) analysis of the proposed BITS route. The SPI identified a region of hard cobble near the Point Judith shoal that the proposed BITS route now circumvents. Results from the SPI analysis were presented in the following submission:

- Sediment Profile and Plan View Imaging Report: Evaluation of Sediment and Benthos Characteristics Along Potential Cable Routes and Turbine Locations for the Proposed Block Island Wind Farm. Prepared by: Ecology and Environment, Coastal Vision and Germano & Associates. (April 2010)

Further seabed assessment was conducted during the summer of 2010 in the vicinity of landfalls proposed on the east shore of Block Island and approaching the mainland in Narragansett. These reconnaissance surveys were performed to map the distribution of eelgrass beds and any hard substrate in the areas. Results from these and previous studies were used to modify the cable landfall approaches to avoid hard bottom areas and were presented in the following reports:

- Eelgrass and Seafloor Condition Survey for Landfall Sites in Narragansett and Block Island, Rhode Island. Prepared by: CoastalVision, LLC, Newport, RI. CV Report 2010-011. (2010)
- Proposed Survey Corridor Route for Block Island Transmission System (BITS), Rhode Island. Prepared by: CoastalVision, LLC, Newport, RI. CV Report 2011-08. (February 2012)

A portion of the BITS is on the Outer Continental Shelf (OCS) beyond the three nautical mile limit and is, therefore, subject to Bureau of Ocean Energy Management (BOEM) jurisdiction. As such, the field program was developed in accordance with BOEM guidelines, established by BOEM in a document entitled "Guidelines for Providing Geological and Geophysical, Hazards, and Archaeological Information Pursuant to 30 CFR Part 285" (21 April 2011), for the entire BITS to the extent practical to maintain consistency in data collection and scientific information available for project design. The field program followed applicable state guidelines where they were more stringent including the Rhode Island Historical Preservation and Heritage Commission's (RIHPHC) *Performance Standards and Guidelines for Archaeological Projects* (rev. 2007). Finally, additional side scan sonar surveys were conducted to support development of a benthic survey plan. In the absence of standard benthic survey guidelines from BOEM, the additional survey areas were identified based on the protocols recommended in BOEM's Interim Policy Leases for meteorological towers in the Mid-Atlantic entitled, "Guidelines for Biologically Sensitive Habitat Field Surveys and Reports."

The final project design was thus based on the results of State of Rhode Island's SAMP, Deepwater Wind's reconnaissance surveys, and state and federal recommended survey requirements for offshore linear transmission routing and renewable energy related projects.

1.2 Project Objectives

The multi-phase study was designed to provide pertinent data and results in support of the BITS project to:

(1) characterize/evaluate seafloor conditions and underlying shallow stratigraphy in the zone of impact where construction activities will occur during cable installation

(2) address state and federal marine archaeological, benthic, and shallow hazard concerns

(3) provide marine scientific information in support of state and federal permit requirements and application submittals

1.3 Project Tasks

In support of the project objectives stated above, the following marine survey tasks were completed as part of the site characterization study. Survey methods were tailored specifically to the required resolution and depth of interest for each project area and are detailed in the next section.

- **Hydrography (depth sounder)**: to determine water depths and reveal the existing bottom topography by means of multibeam and single beam depth sounding techniques
- **Seafloor imaging (side scan sonar)**: to identify geomorphologic variations and natural and man-made targets present on the bottom using surficial acoustic imaging techniques
- **Magnetic intensity measurements (magnetometer)**: to measure variations in the earth's total magnetic field to identify ferrous objects on and below the seafloor
- **Shallow subbottom profiling (chirp)**: to map shallow subsurface sediments and geologic features
- **Intermediate subbottom profiling (boomer)**: to map stratigraphy and geologic features deeper below the seafloor
- **Geotechnical sampling (vibratory corer)**: to directly sample the upper 10 feet (ft) of seabed materials to document composition and ground truth shallow seismic profile interpretations

Additional survey tasks were performed as a result of site conditions identified during the primary site characterization study and in response to specific data requests. These included:

- **Existing utility mapping (cable toner)**: to map the precise location of existing submarine cables that cross the proposed route

OSI provided all the results from the BITS seafloor and subsurface characterization study to the project team's benthic specialist and maritime archaeologist for their professional assessment and identification of biologically sensitive habitats and cultural resources that may be present in the route corridor. Please refer to those separate reports for documentation of the benthic and archaeological results.

2.0 DATA ACQUISITION DESIGN

A survey plan and procedural approach was developed for the project, which outlined the survey coverage and general methodology to be implemented for this investigation. The survey plan was documented and approved prior to commencement of the field program in the OSI report entitled, "Final Survey Plan, Marine Geophysical Investigation, Block Island Transmission System, Submarine Cable Route, Block Island to Narragansett, Rhode Island" (2 September 2011).

Based on the 2009 geophysical reconnaissance data and SPI work along the BITS pathway, a final proposed alignment was chosen connecting the east shore of Block Island to the mainland. Determination of coverage and line spacings was based on previous offshore utility project experience and the requirements of state and federal agencies which were outlined in the final survey plan. In addition to the guideline documents, BOEM recommendations and requirements were transmitted to Deepwater and OSI during a pre-survey meeting prior to the field program.

2.1 Geophysical Investigations

Marine geophysical surveys were performed within a 300-meter (m) wide corridor centered on the proposed BITS primary and alternate route alignments in accordance with the approved survey plan. Multibeam depth, magnetometer, and chirp subbottom data were recorded along 11 tracklines oriented parallel to the proposed cable route and spaced 30 m apart. Figure 3 illustrates the geophysical data acquisition plan and trackline coverage in the APE-Direct corridor. Additional multibeam fill-in lines were surveyed in shallow water to attain full bottom coverage there. Side scan sonar imagery was acquired at a 75 m sweep range along the proposed route centerline as well as along 60 m and 120 m offsets to either side. Data acquisition was conducted as close to shore as possible, to a point where it was unsafe to navigate the vessel due to shallow water and/or potential obstructions. Figures 4, 5, and 6 illustrate the survey tracklines completed and the inaccessible area adjacent to shore (through the surf zone) at each landfall. This distance along the route centerline was less than 500 ft at all three landfalls.

The chirp shallow subbottom profiling system was configured to record subsurface information to a total depth of 65 m, equivalent to at least 25 m below the seafloor in the deepest section. Deeper penetrating boomer data (intermediate subbottom profiler) were collected along the route centerline and in areas requested by the project archaeologist based on preliminary review of the chirp profiles. Offsets were also surveyed over shoals where coarser materials limited chirp penetration. The seismic acquisition system for the boomer was set to record a 330 millisecond (ms) total time section equivalent to a 250 m depth profile (825 ft) using a 1,524 m/s (5,000 ft/s) average sediment velocity. As a means of providing quality control and confirmation of depth, magnetometer and chirp subbottom data acquired along the primary tracklines, additional data were acquired along a series of cross or “tie” lines set perpendicular to the cable route and spaced 150 m apart.

Areas of potential post-contact period archaeological sensitivity were defined by the project archaeologist (Figure 7). Within these areas, additional magnetometer and chirp data were acquired along tracklines spaced 15 m apart and side scan sonar imagery was collected along 30 m spaced tracklines using a 75 m sweep range. Additional geophysical data were also acquired (3 lines at a 30 m spacing) in the vicinity of some existing submarine cables to widen the survey corridor for anchor placement during construction, if necessary. Thus a 300 ft (90 m) swath was added to the existing corridor in these locations.

In areas designated as potentially significant benthic habitats within 1 kilometer (km) of the proposed centerline (i.e. those areas where Rhode Island geographic information system (GIS) substrate layers show the presence of glacial moraine or other potential hard bottom conditions), additional side scan sonar imagery (75 m sweep range along 150-m spaced tracks) was acquired to confirm surficial sediment boundaries (Figure 8). Where these conditions paralleled the BITS route, the survey was extended approximately 100 m beyond the GIS boundary (where it is within 1 km of the centerline) to ensure that the edges of hard bottom areas were accurately delineated.

2.2 Geotechnical Sampling

Vibratory core stations were generally laid out along the BITS primary and alternate route centerlines at 0.5-0.7-mile (2,640-3,695 ft) increments with additional stations near landfalls and in areas of special interest (Figure 9). A total of 62 stations were occupied (45 stations on the primary route, 17 stations on the alternate route), with most stations (46) sampled to obtain engineering (physical) properties, some sample stations (3) were designated for environmental (chemical) analyses, and others (13) were requested for archaeological purposes (see Appendix 2). Cores were planned for a maximum penetration of 10 ft below the seafloor with multiple attempts made at many stations to achieve better penetration. Core samples were delivered to AECOM onsite who was responsible for all handling, transport, lab analyses, data workup, and reporting. Engineering cores were transported offsite while environmental cores were split and subsampled onboard the vessel. Logs and photographs of the engineering cores were subsequently provided to OSI by AECOM following completion of those tasks.

2.3 Existing Utilities Mapping

After preliminary review of the geophysical data, it was apparent that in at least two places in-service submarine cables (TAT-12 and CB-1) cross the BITS primary route alignment. To provide enhanced positioning of these existing utilities, a cable detection system was employed to verify their horizontal location. An acoustic tone is generated and impressed on part of the cable onshore that is transmitted along the cable components in the offshore direction. A series of tracklines run perpendicular to the toned cable are then surveyed with a sensor towed just above the seafloor. The sensor, tuned to the exact tone signature, is then able to measure a strong deviation of the tone above background levels as the sensor passes over the cable. In this manner, points marking the maximum signal deflection in the data are connected to represent the active cable position.

3.0 FIELD OPERATIONS SUMMARY

The BITS field program was completed using a variety of survey and sampling equipment operated by numerous field crews working on multiple survey vessels, often simultaneously to expedite the data acquisition. Components integral to the investigations are summarized in the following sections.

3.1 Survey Instrumentation

The following list and Table 1 summarize the scientific equipment used for all the various phases of this project. A complete discussion of this equipment, along with the operational procedures employed to collect the data, can be found in Appendix 5.

Navigation and Positioning:

- Applanix POS MV Differential Global Positioning System, includes gyro compass and motion sensor (heave, pitch, roll)
- Applanix POSPAC Mobile Mapping Suite
- HYPACK Navigation Software
- LinkQuest TrackLink 1500 Acoustic Tracking System

Seafloor Mapping and Inspection:

- Klein 3000 Dual-Frequency Digital Side Scan Sonar System
- Geometrics G882 Cesium Marine Magnetometer
- Reson SeaBat 7101 Focused Multibeam Echosounder
- Innerspace Model 448 Single Beam Depth Sounder
- Sea-Bird Electronics SBE19*plus* SEACAT Profiler

Subbottom Profiling:

- EdgeTech 3200XS “Chirp” Subbottom Profiling System
- Applied Acoustics 200J “Boomer” Seismic Reflection System

Geotechnical Sampling:

- OSI Model 1500 Vibratory Corer

Submarine Utility Mapping:

- GS2500 Cable Toner and Detection System

Table 1
Survey Equipment Summary

Equipment System	Function
Applanix POS MV GPS with Trimble ProBeacon differential receiver	Satellite positioning system which uses differential correctors from a US Coast Guard reference station to provide reliable horizontal positioning (+/-1 meter). The system outputs position fixes at a rate of 5-10 per second to an onboard navigation and data logging computer that allows the vessel helmsman to accurately navigate the vessel along pre-selected survey tracklines. System includes inertial motion sensor (pitch, roll, heave) and compass for reliable heading measurements.
Applanix POS Pac Mobile Mapping Suite	The POSPac MMS is the next generation software for direct georeferencing of survey sensors using GNSS and inertial technology, specifically integrated with the POS MV for marine mapping applications. Raw POS MV horizontal and vertical position measurements are adjusted for the differential corrections from the CORS network reference stations and simultaneously processed along with the inertial measurement unit (IMU) data using Applanix IN-Fusion™ technology. This robust process solves for GNSS ambiguities (i.e. outages, atmospheric delays) to produce accurate final vessel position and orientation.
HYPACK navigation software	Sophisticated navigation software operating on a data logging computer that provides real time trackline control (helmsman steerage for survey lines), digital data recording, and position interfaces for all equipment systems. The HYSWEEP module also logs all the data from the multibeam sounding system and heading and motion sensors. This package allows the simultaneous acquisition of data from multiple systems correlating all by vessel position and time.
Link Quest TrackLink 1500 USBL underwater positioning system	Ultra short baseline (USBL), underwater positioning system designed for tracking deployed sensors from a vessel. System interfaces with the Trimble GPS as well as motion and gyro sensors to provide real-time coordinates for sensors separated from the vessel navigation. Beacons operate in the 31 to 43 kHz range and were used to track the side scan sonar and magnetometer sensors.
Klein 3000 dual-frequency side scan sonar	Side-looking sonar which transmits and receives frequency bandwidth signals in the 100 and 500 kHz ranges from transducers mounted on an underwater towfish that is towed by the survey vessel. The output from the side scan sonar is essentially analogous to a high angle, oblique acoustic "photograph" providing detailed representations of bottom features and characteristics. The side scan sonar will be operated at 50-75 m sweep range and is capable of providing image resolution of small discrete targets of 0.5-1.0 m in diameter.
Geometrics G882 cesium marine magnetometer	Marine magnetic sensor designed to detect ferrous objects on or beneath the bottom. The magnetometer, which acquires measurements of the earth's total magnetic field intensity to 0.1 gamma accuracy, uses an underwater sensor. During acquisition the magnetometer will be towed approximately 6 m above the bottom. The magnetometer sensor measures magnetic intensity values 10 times per second and features an altimeter that provides height of the sensor above the bottom.

Equipment System	Function
Reson SeaBat 7101 multibeam echosounder	The SeaBat 7101 measures up to 40 swaths per second with up to 511 individual soundings equidistant in each swath using a 240 kHz signal. This swath configuration provides complete bottom coverage over a 150° wide by 1.5° long geometrically correct cross section. Real-time roll stabilization combined with the equidistant sounding density maximizes usable swath width.
Innerspace Model 448 digital depth sounder	Microprocessor controlled, high resolution, survey-grade depth sounder that operates at a frequency of 200 kilohertz, providing precise water depth measurements below the transducer. Sound speed correction allows fine tuning of real-time depth soundings. Depths recorded in digital and graphic formats to a tenth of a foot.
Sea-Bird 19*plus* CTD profiler	Vertical water column profiler which measures conductivity, temperature, and density 4 times per second in up to 600 m of water. For this project, the CTD profiler is critical for obtaining sound velocity measurements through the water column for adjusting the depth values obtained by the multibeam depth sounding system, as well as applying sound velocity to the USBL tracking system.
EdgeTech 3200XS "chirp" subbottom profiler	Shallow subsurface profiler that generates an intense, short duration acoustic pulse in the water column in the range of 2-16 kHz. The high acoustic frequencies used by this system are intended for increased resolution of layers in the shallow subsurface. Vertical bed resolution of at least 0.3 m in the uppermost 15 m below the mudline is common.
Applied Acoustics 200J "Boomer" subbottom profiler	Intermediate subsurface, seismic reflection profiler that generates a high energy acoustic pulse in the water column in the range of 0.5-8 kHz. System includes a 200 joule sound source and 8 element hydrophone array with seismic control unit for real-time processing, filtering, TVG, and display. The system is designed for increased penetration and imaging of stratigraphy deeper below the bottom.
OSI Model 1500 vibratory corer	Pneumatically powered coring device designed to collect marine sediments inside a 3.5-4 inch diameter barrel from the upper 10 ft below the seafloor. The Model 1500 vibratory corer features a stand to prevent the unit from falling over in deep water or high currents and a penetrometer to measure how far the core barrel has advanced into the bottom. The geotechnical information obtained from the cores is important for ground truthing the subbottom profiles and developing a geologic cross section.
GS2500 Cable Toner and Detection System	The GS2500 system was used to locate existing submarine cables. An electrode tone generator onshore functions by energizing the cable with a low frequency sine wave signal with variable settings up to 500 milliamps at 500 volts and at frequencies ranging from 5-50 Hz. The applied current has specific signal characteristics to increase the sensitivity of detection over longer distances.

Primary geophysical systems used for the site characterization study were run simultaneously aboard the survey vessels wherever necessary, in a manner to reduce acoustic interference. Multiple sonar systems operating simultaneously (multibeam, side scan sonar, subbottom profiler), especially using overlapping frequencies, have a tendency to exhibit cross talk, the over-writing of one system's signals on another. This effect was minimized during the investigation by the lateral separation of acoustic systems as well as the application of minimal signal transmit and/or receiver gain while still acquiring high-quality data.

On the geophysical vessels, a side scan sonar sweep range of 75 m was used with towfish heights maintained at 10-15% of the sweep range (nominally 7-10 m). The magnetometer sensor was towed directly behind and slightly below the side scan sonar towfish at a planned height of 6 m or less, except where shallow water forced reduced sensor heights. Statistical analysis of the magnetometer altimeter values revealed sensor heights of 6 m or less were recorded over 98.3% of the survey. Brief fluctuations above 6 m were due to a variety of onsite conditions, including along track changes in speed-over-ground (the affect of tidal currents, wind, seas on vessel maneuvering), minor height adjustment of the side scan towfish for optimum image quality, turning points in the route and lines, obstruction avoidance, and vessel speed adjustments to compensate for the aforementioned conditions. Overall, the sensor height never exceeded 7 m during the entire survey (total trackline mileage ~650 nm). In addition, sensitivity of the marine magnetometer used for this survey (0.004 gammas) is much higher than the lower limit (1 gamma) stated in the BOEM guidelines.

The TrackLink USBL system provided positioning for the sonar and magnetic sensors towed astern of the vessel in deep water, while straight offsets and laybacks were input to HYPACK for the shallow water setup. The “chirp” subbottom profiler transducer sled was towed approximately 1-2 m below the hull off one side of the vessel. The “boomer” system was deployed off the stern using a spreader bar to maintain the sound source (board) and receiver (eel) outside of the vessel wake and propeller wash. Survey speeds of 3-5 knots were realized, depending on weather conditions. Typically, as sea conditions worsen survey speed decreases to maintain the high-quality data.

The Reson 7101 multibeam system was used primarily to collect swath bathymetry over the survey corridor and other areas of interest. Single beam hydrography was performed on some lines outside the primary 300 m wide corridor and close to shore where the larger offshore vessel could not access. All digital sounding data were interfaced to

HYPACK/HYSWEEP along with heave, pitch, and roll data from the POS MV inertial measurement unit (IMU). This is critical for open water work where swell and chop can cause a deterioration of data quality (the effects of the sea conditions are removed during post-survey processing of the data set). NOAA predicted and observed tides, along with the NGS reference stations, provided reference to the project's vertical datum while multiple CTD profiles were collected over the course of each day for sound speed adjustments.

Subsequent vibratory coring and utility mapping were conducted independently on separate vessels due to differences in scope of work and required support equipment. Vibratory core samples were collected from the upper 10 ft of the seabed along the entire route. Cores were typically positioned within 5 ft of the planned location. Once the rig was back on deck, the core liner was removed from the barrel and the sample was cut into appropriate lengths and stored upright in a core stand/rack until arriving at the dock, where the cores were offloaded and handled by AECOM for transport to the laboratory for analysis. Mapping of existing submarine cables crossing the BITS route was performed using a cable toner and detection system that uses a sensor towed 2-5 ft above the seafloor for optimum resolution of the applied cable tone signature. The sensor was positioned using the TrackLink USBL system. Multiple short transects were surveyed perpendicular to the cable at a 50-100 ft spacing.

3.2 <u>Vessels</u>

Three separate vessels were used to support the various survey and sampling tasks required for this project. Vessels utilized for this offshore field program were sturdy, highly maneuverable work platforms capable of handling the often difficult sea conditions encountered during the winter season in southern New England. Vessels were equipped with a full assortment of safety gear, including standard PFD's, work vests, cold weather immersion suits, an automatic inflatable life raft, and an Emergency Position-Indicating Radio Beacon (EPIRB) to signal maritime distress, if necessary. A full suite of standard vessel navigation equipment (radars, VHF radios, GPS plotters, cellular and satellite phones, etc.) were onboard the vessels to provide safe transport, security, and continuous communications while offshore. Float plans were submitted to the local U.S. Coast Guard

Station prior to commencement of field activities to alert the station to anticipated survey logistics and specific contact information for each work platform.

Vessels used to conduct offshore operations for the BITS project have been described below. Over 95% of the geophysical surveys were performed by the *R/V Ocean Explorer*, while some special tasks and nearshore fill-in were completed by the *R/V West Cove*.

Ocean Explorer

The *R/V Ocean Explorer* is a 60-foot aluminum hulled, C. Ray Hunt designed vessel with a 17-foot beam and 6-foot draft featuring twin Iveco (2007) 1020 HP diesel engines (Figure 10). The *Ocean Explorer* is equipped for offshore survey work and is fitted with a stern mounted A-frame and hydraulic winch to provide efficient subsurface tow capability for geophysical sensors. Davits and electric winches located amidship provide the handling capability for other deployed sensors, such as the chirp towsled and multibeam transducer. A 20 kilowatt (kW) main generator (Northern Lights) and a 16 kW backup generator provide power for this sturdy platform. The vessel is outfitted for year round service for either day excursions or short endurance missions, holding 400 gallons of fresh water and 1,800 gallons of fuel.

A spacious interior salon provides ample room for scientific electronics and accommodates up to 5 scientists or observers. The *Ocean Explorer* features a lower navigation station (helm) in addition to the large, fully enclosed hard-top pilothouse where the primary steering station and navigation instruments reside. Vessel cruising speed is nominally 20 knots with a maximum speed of 28 knots.

West Cove

The *R/V West Cove* is a 42-foot Duffy with 14.5-foot beam and 4.5-foot draft featuring twin Caterpillar 350 HP diesel engines, hydraulic winches and an A-frame for handling towed sensors off the stern, and a large cabin for housing the survey electronics (Figure 11). A hydraulic pot hauler with davit on the starboard side provides the handling capabilities and tow point for additional sensors. A 7 kW generator provides plenty of electrical output for the vessel and scientific equipment. The *West Cove* is especially suited for nearshore day excursions with ample range (two 250 gallon fuel tanks) and cruising speed of 20 knots.

Connecticut

The *R/V Connecticut* is a 76-foot long steel-hulled vessel with a 26-foot beam and 8.5-foot draft, owned and operated by the University of Connecticut Marine Science Department (Figure 12). The vessel contains ample interior lab space, open deck area, and handling equipment for a wide variety of scientific operations. The vessel has a single screw diesel Caterpillar engine capable of a 10 knot cruising speed, as well as bow and stern thrusters for tight maneuvering and onsite positioning of deployed sensors. A Kongsburg/Simrad dynamic positioning system interfaces all the propulsion units allowing the vessel to accurately maintain station without anchoring. The *Connecticut* has a multitude of handling gear including a stern A-frame, oceanographic winches, deck crane, trawl winches, a capstan, and a 14-foot inflatable support work boat. The vessel is outfitted for year round coastal service for either day excursions or 7 to 10 day endurance missions, holding 2,400 gallons of fresh water and 5,500 gallons of fuel.

Vibratory core operations were optimized onboard the *Connecticut* which is a highly efficient platform for deep water coring due to its dynamic positioning system (bow and stern thrusters interfaced to navigation). This vessel capability allowed the vibratory core operations to be performed without anchoring, saving significant time on the water.

3.3 Survey Crews

Scientific teams were assembled to provide experienced field crews specifically tailored to each project task. Field teams were supported by a group of data processing and analysis personnel in the Connecticut office dedicated to the project. The following OSI personnel participated in the multi-phase field investigations completed for the BITS project:

Primary Geophysical Survey *(Ocean Explorer)*

Justin M. Bailey	Senior Geophysical Project Manager
John R. Ayer	Geophysical Electronics Technician
Bonnie L. Johnston	Senior Hydrographic Scientist
Kyle R. Orde	Electronics Technician/First Mate
George Main II	Captain, Chief Mechanic

Supplemental Geophysical & Utility Mapping Surveys *(West Cove)*

Jeffrey D. Gardner	Senior Geophysical Project Manager
John R. Bean	Senior Environmental Scientist
John D. Sullivan	Geophysical Section Manager
Alexander G. Unrein	Hydrographic/Environmental Scientist
Carl E. Cantrell	Electronics Technician
Myke Coyle	Captain, Chief Mechanic

Geotechnical Survey *(Connecticut)*

Robert M. Wallace	Senior Project Manager
Kevin O. Murphy	Senior Geotechnical Specialist
Michael D. Lincoln	Geotechnical Assistant
Daniel Nelson	Captain
Marc Liebig	First Mate
Frank Boccia	Engineer
Aaron Kaufman	Deck Hand
Bob Dillard	Cook

Additionally, John Sullivan (OSI Geophysical Section Manager) assisted with the commencement of the geophysical field program as coordinator and project team liaison. Cultural resource representatives from Fathom Research (David Robinson, Marine Archaeologist), the Narragansett Indian Tribal Historic Preservation Office (Doug Harris and John Brown), and the Wampanoag Tribe of Gay Head (Aquinnah) Tribal Historic Preservation Office (Jonathon Perry and Elizabeth James-Perry) were onboard the *Ocean Explorer* for the majority of the field work. Other individuals who participated as observers include: Paul Murphy and Bryan Wilson (Deepwater Wind), Allen MacPhail (Power Engineering), and Rich Michalewich, Donald Schall, Suzy Baird, Kaitlin Hartman, and Keith Robinson (AECOM). Certified AECOM personnel served as marine mammal observers (MMO) during the field program. Ted Timreck from Stafford Films also rode the vessel on 6 October 2011 to record video for documentation of survey activities.

During the geotechnical operations aboard the *Connecticut*, in addition to the vessel and OSI crew members, the following observers were onboard on 4 January 2012: Paul Murphy (Deepwater Wind) along with Tom Bellow, Lou Ferreria, and Rich Michalewich (AECOM). In support of onsite processing and sampling of the environmental cores collected for chemical analyses, Stacy Doner, Paula Winchell, and Steve Aubrey (AECOM) were onboard 6 and 10 January 2012. AECOM representatives received the core samples onsite and were responsible for all logistics once off the vessel.

3.4 Horizontal and Vertical Control

Navigation and positioning of the survey vessel were accomplished using an Applanix POS MV differential global positioning system (DGPS) interfaced to a navigation computer running HYPACK software. Differential correctors were received from the U.S. Coast Guard reference station in Acushnet, Massachusetts (306 kHz at 200 bps) by the Trimble ProBeacon receiver interfaced to the POS MV system. Geodetic position data output by the DGPS were converted by HYPACK navigation and data acquisition software in real time to the Rhode Island State Plane Coordinate system (Zone 3800) and referenced to the North American Datum of 1983 (NAD 83) in ft. Navigation checks were performed at the beginning and end of each day at the marinas where the vessels were docked to ensure the DGPS was providing accurate horizontal positions. In this configuration, the manufacturer's state an accuracy of +/-1 meter is typical; however, positioning repeatability of less than a meter is commonly observed in the field. Points used for these daily checks have been listed in Table 2 below.

Vertical reference for the field investigations was Mean Lower Low Water (MLLW) based on predicted and observed tides for NOAA (National Oceanic and Atmospheric Administration) stations bordering the survey areas in Rhode Island Sound. In addition, to account for tidal staging during each survey day and over the full duration of the field program, the Applanix POSPac Mobile Mapping Suite (MMS) application was used to record vessel position and elevation for additional comparison with the NOAA tide gauge measurements.

Table 2
Project Control

Control Point	Position *	Description
Payne's T-Dock	N 36311.65 E 307361.12	Great Salt Pond on Block Island, RI; point is marked by a stainless steel screw located at the seaward end of the main T-dock at Payne's Marina
Payne's Short T-Dock	N 36229.43 E 307433.21	Great Salt Pond on Block Island, RI; point is marked by a stainless steel screw located at the seaward end of the shorter T-dock at Payne's Marina
DEM Pier	N 109517.05 E 325905.07	Point Judith Harbor of Refuge in Galilee, RI; point is marked in the center of a yellow metal pipe located on the bulkhead at the State of Rhode Island Department of Environmental Management pier

*Note: Position coordinates referenced to the Rhode Island State Plane Coordinate System, Zone 3800, in ft (NAD83).

Following completion of the survey, POSPac MMS integrates recorded POS MV global navigation satellite system (GNSS) and inertial aided position files with reference receiver data imported via the internet. The system uses the CORS (Continuously Operating Reference Stations) network established and maintained by the National Geodetic Survey (NGS). The POSPac application automatically selects and downloads the best-fit solution of network receivers to cover the survey area, and performs a quality check on the reference data to provide some of the highest level positioning possible. POSPac is ideal for studies conducted over wide areas to take advantage of established reference stations and eliminate the time and cost associated with standard kinematic positioning that may require one or more local GPS base stations. The combination of the POS MV and POSPac software allowed accurate georeferenced and motion compensated water depth information to be obtained for the project, referenced to the MLLW datum.

3.5 Summary of Field Program and Procedures

Table 3 below provides a general chronology of the tasks completed during the BITS field program. Depending on the location of the survey work (offshore versus near the mainland), operations were based out of either Block Island or Point Judith to minimize transit time and maximize data acquisition time on the water during each field day.

Table 3
General Chronology of Field Program

Task	Dates	Description
Offshore, primary geophysical operations *(Ocean Explorer)*		
Mobilization	12-18 September 2011	Load, test, secure geophysical equipment and handling gear
Survey Operations	19 Sept. to 17 Nov. 2011	Transit to and from the site, onsite calibrations, perform offshore marine geophysical surveys
Demobilization	19 November 2011	Return to home port
Supplemental geophysical & utility mapping operations *(West Cove)*		
Mobilization	10-15 November 2011	Load, test, secure remote sensing equipment and handling gear
Survey Operations	16-22 November 2011	Onsite calibrations, nearshore geophysics and boomer profiling
	1-4 December 2011	Cable location surveys
	9-11 January 2012	Cable location surveys and added geophysics
Demobilization	12 January 2012	Return to home port
Geotechnical operations *(Connecticut)*		
Mobilization	2-3 January 2012	Load, test, secure vibratory corer and support equipment
Survey Operations	4-11 January 2012	Collect vibratory cores
Demobilization	12 January 2012	Return to home port

In addition to maintaining a safe work environment during all field tasks, an equally high priority was the quality of the survey, which includes up-to-date geophysical techniques, equipment, methodologies and procedures, much of which was outlined in the BITS Survey Plan document. Quality assurance and quality control practices are in place for every step of the program. This includes careful maintenance, system checks, and calibration of all equipment in the lab prior to mobilization, as well as onsite calibration of equipment after full systems integration onboard the vessel. Refer to Appendix 7 for details concerning calibration methods and results.

Record quality was maintained at a high standard in the field since survey operations were always halted when poor weather conditions reduced data quality to an unacceptable level. Under suitable weather conditions, survey operations were typically conducted at a 3-4 knot speed and provided excellent data resolution with little to no ambient noise affects. As sea conditions deteriorated or tidal current speed increased, survey speed was reduced to maintain acceptable data quality. Weather limitations for ensuring high-quality data cannot be strictly defined, as the factors affecting the vessel, geophysical sensors, and resulting data are variable and include wind speed and direction, distance offshore, sea state (height and period), and trackline orientation relative to the seas. For example, the survey may be able to continue under 4-6 ft seas with a 10-15 second period; however, operations will certainly stop given the same wave height but a shorter period (3-6 seconds). Weather conditions during the field program were documented in the survey logsheet and are included in digital Appendix 8 (on the accompanying DVD).

To increase data quality and resolution under degrading conditions, vessel heave, pitch, and roll were compensated for by the Applanix IMU, which includes a motion sensor and gyrocompass, to accurately position sounding points on the seafloor. Furthermore, internal swell filters on the chirp and boomer subbottom acquisition units allow sea swell effects to be removed in real time, enhancing record interpretability in the field and for post-survey review.

Minor equipment malfunctions that did occur were dealt with immediately by stopping data acquisition, turning the vessel offline and transiting back to where the problem occurred, and restarting data collection again prior to the point of equipment mishap. Any equipment issues are detailed in the field survey logsheets included in digital Appendix 8. When occasional vessel traffic and fishing gear caused the off-track margin of error (nominally +/-5% of track spacing) to be exceeded, that portion of the survey line was rerun. Operations were also discontinued by the MMO due to potential marine mammal sightings. After the required shut-down period (no sonar pinging in the water column) with continual mammal monitoring and no additional sightings, survey operations were restarted and data acquisition overlapped where the stoppage occurred.

Since all sensor laybacks and offsets are incorporated into HYPACK and individual system topside computers, providing true sensor geographical positioning in real time, a review of all geophysical data at intersection points of survey tracklines (cross lines) reveals excellent correlation. Figures 13 and 14 illustrate the equipment layout and configuration aboard the two geophysical vessels used for these investigations.

In addition to the real-time quality control performed as the survey progresses, daily review of raw data is conducted on the way back to port to check record quality. Any areas where marginal information was collected as conditions deteriorated were identified as reruns/holidays and subsequently covered by another survey line. Based on field review and post-survey processing of data, there were no apparent problems with the geophysical data that have hampered the ability of OSI scientists to interpret surface and subsurface geologic features and hazards.

4.0 OVERVIEW OF DATA ANALYSIS AND PRESENTATION

4.1 Personnel

The following scientific staff at OSI headquarters in Old Saybrook, Connecticut participated in the various stages of data processing, analysis, interpretation, correlation, and compilation of results.

Hydrographic Data Processing

Joseph J. DiPalma	Hydrographic Scientist
Rachel K. Griffin	Hydrographic Data Processor
Alex G. Unrein	Hydrographic/Environmental Scientist
Joseph V. Tyler	Hydrographic Scientist

Geophysical Data Processing and Interpretation

Jeffrey H. Hall	Senior Geophysical Scientist
Margaret H. Sano	Senior Geophysical Scientist
Jesse H. Baldwin	Geological Scientist
Kerry H. Cutler	Environmental Scientist
Jeffrey D. Gardner	Senior Geophysical Project Manager

Drafting

Angela M. Rizzo	Senior Graphics Designer
David T. Somers	Hydrographic Data Manager

Reporting

Jeffrey D. Gardner	Senior Geophysical Project Manager
Jeffrey H. Hall	Senior Geophysical Scientist

Quality Control

David T. Somers	Hydrographic Data Manager
Margaret H. Sano	Senior Geophysical Scientist
Jeffrey D. Gardner	Senior Geophysical Project Manager
John D. Sullivan	Geophysical Section Manager
Ted A. Nowak	General Manager

The following paragraphs summarize the analysis, interpretation, and characterization that were completed on the geophysical datasets. For a more detailed description of processing steps performed on the data acquired from each individual system (multibeam, side scan sonar, magnetometer, chirp, and boomer) please refer to Appendix 6.

4.2 Seafloor Characterization

Surficial features were mapped and reviewed using data from the multibeam and single beam depth sounders as well as the side scan sonar system. Individual acoustic targets as well as areas of stronger amplitude acoustic reflectivity on the sonar images suggestive of coarser material (gravel, cobbles, boulders), man-made obstructions, or benthic communities were mapped. Sonar targets were differentiated by lateral size and height above the bottom as well as acoustic characteristics that might suggest their origin as natural or man-made.

Surficial Sediment Mapping

Side scan sonar imagery represent acoustic returns that are indicative of different reflectivity and texture of surficial materials on the seafloor. General categories of reflectivity are listed and described briefly below. These categories are based on the interpretation of the sonar records that have been correlated with surface materials observed in the core samples. Correlation with the geotechnical information allows the reflectivity categories to be generally defined as different sediments present on the seafloor. In general, weaker reflectivity is associated with finer grained sediments (silt, clay) while stronger reflectivity is produced by coarser sediments (gravel, cobbles, boulders, bedrock). Sandy surficial sediments tend to exhibit a range of the moderate reflectivity, gradational from fine to coarse sand. Stronger reflectivity may also be due partly to the presence of epifaunal (surficial) benthic communities. These communities may include organisms and their habitation structures such as polychaete (worm) and/or amphipod tubes, shellfish (mussels, clams), and possibly macroalgae. Figure 15 presents representative sections of side scan sonar imagery that illustrate the four reflection categories identified.

Reflective Categories/Sediment Classification

TYPE 1 Low reflectivity, low relief, drag marks common, interpreted as fine grained sediments (mostly silt and fine sand) with possible isolated boulders.

TYPE 2 Medium to high reflectivity, moderate relief, sand waves distinctive, interpreted as medium to coarse-grained sand and gravel, possible isolated boulders.

TYPE 3 Low to high reflectivity, low to moderate relief, interpreted as complex mixture of alternating bottom types including fine to coarse grained sediments and boulders.

TYPE 4 Low to high reflectivity, moderate to high relief, interpreted as hard, compact seabed including primarily gravel, cobbles, and boulders in a sand matrix.

The distribution of sediments on the seafloor is not commonly organized into well-sorted grain sizes with distinct geographical boundaries. Natural physical processes in the coastal environment tend to form deposits inclusive of a range of grain sizes with gradational boundaries separating more broadly defined sediment types, as described above. To further define the qualitative terms used in the sediment classification scheme, Table 4 below quantifies the grain sizes associated with these sediments imaged on the seafloor and interpreted in the subsurface. The term “coarse material” as used in the geologic descriptions for this project, can be defined as varying percentages of gravel, cobbles, and boulders (usually in a sand matrix).

Table 4
Unified Soil Classification System (USCS) for Granular Sediments

Particle Size		Millimeters	Inches
Boulders		>300	>11.8
Cobbles		75-300	2.9-11.8
Gravel	Coarse	19-75	0.75-2.9
	Fine	4.8-19	0.19-0.75
Sand	Coarse	2.0-4.8	0.08-0.19
	Medium	0.43-2.0	0.02-0.08
	Fine	0.08-0.43	0.003-0.02
Fines	Silt	<0.08	<0.003
	Clay	<0.08	<0.003

Sonar Target Interpretation

Individual acoustic targets on the seafloor were mapped from the side scan images and multibeam hydrographic data. Acoustic targets include features such as individual boulders, concrete blocks, lobster pots, drag marks, wire, line, and other man-made debris. Priority was given to targets interpreted as representing possible man-made objects, since most boulders are included within Type 3 and 4 surficial sediment categories. In many cases it is difficult to ascertain from the side scan sonar alone if an isolated target is a natural (i.e. boulder) or man-made (i.e. concrete block) feature as targets may be covered with a thin veneer of sediment or partially buried in soft substrate. In addition, the acoustic reflection from a target may not be representative of the object's actual shape. Because of the potential importance of any target to the cable installation, even small targets were identified during this review process. Note that there are some apparent targets not labeled on the sonar mosaic, as these represent schools of fish or drifting debris that were abundant in the water during the survey. Line-to-line correlation of the imagery during the processing stage allows ephemeral features such as this to be discerned and removed from the final sonar target listing.

Magnetic Intensity Data Analysis

Magnetic intensity measurements were reviewed and short-period anomalies interpreted from all lines surveyed in the 300-foot corridor. A magnetic anomaly can be defined as a local disturbance in the earth's total field intensity due to the presence of ferrous material, either natural (i.e. metamorphic bedrock) or man-made (i.e. 55 gallon steel drum). Many factors contribute to an anomaly's size and shape such as sensor height, object burial depth, amount of ferrous mass, magnetic susceptibility of the object's metal, object orientation relative to the sensor, and more. Through the interpretation process, an attempt is made to discern potential man-made ferrous objects from anomalies caused by natural, geologic features.

Since anomaly amplitude (strength in gammas) is not necessarily related to the ferrous object's origin or significance, all isolated magnetic anomalies were mapped, regardless of amplitude. Magnetic anomalies associated with an acoustic target at the same location indicate the sonar contact has a ferrous component and is potentially man-made versus a natural feature (boulder). Anomalies with no associated sonar target may represent a buried ferrous object at that position. The acoustic targets and magnetic anomalies are plotted with the mosaic in the second plan view panel on the route alignment sheets.

To differentiate the magnetic anomalies for review, a class system was assigned to subdivide the data by anomaly strength (gammas). This provides a visual reference of each anomaly's relative size (amplitude) when reviewing the BITS route alignment sheets. Anomaly classes and associated symbols presented on the drawings are as follows:

- Class 1: ≤ 10 gammas (solid cyan triangle)
- Class 2: > 10 to 50 gammas (solid navy blue triangle)
- Class 3: > 50 gammas (solid dark blue triangle)

Seafloor Hazards Review

The surficial mapping datasets were also reviewed for shallow hazards in the route corridor, as some acoustic targets and seabed features as well as magnetic anomalies identified may fall into this category. Data were interpreted to identify the presence or absence of the following features:

- Man-made debris including shipwrecks
- Unstable seafloor areas (high slopes)
- Mass movement structures (surface slumps, slides)
- Bedforms (sand waves)
- Water scour
- Diapiric structures, gas/fluid expulsions
- Faulting expressions
- Hard grounds

4.3 Subsurface Characterization

Seismic reflection data were processed using an average acoustic velocity of 5,000 ft/s to determine reflector depths below the seafloor, an average reported value for the predominantly sandy, saturated marine sediments. Prominent, relatively continuous reflectors were mapped in the upper 10-20 ft and deeper in places (it is often advantageous for interpretation to trace seismic horizons beyond the depth of interest to develop an understanding of the local geology). Both the shallow (chirp) and intermediate (boomer) subbottom profiles were reviewed to map the shallow subsurface. The boomer system obtained better penetration in areas of compact sand and coarser material (gravel, cobbles, boulders) along the route, with the chirp system providing ample resolution in the nearsurface. The digital chirp subbottom profile image was integrated with the water depth profile to generate a geologic cross section for the centerline shown in the lower profile panel of the route alignment sheets.

Shallow Subsurface Mapping

Seismic reflectors were then interpreted and correlated with sediment interfaces logged from the vibratory cores in an attempt to map the shallow stratigraphy and extrapolate horizons laterally. The core logs, photographs, and any lab results (grain size) assisted the correlation with the subbottom profiles to determine the nature of seismic facies or sequences present in the upper 10 ft. Core locations and descriptions were included on the profile panel of the drawing to provide more detail (where available) on nearsurface sediments and shallow stratigraphy along the route.

Paleofeatures Interpretation

In support of cultural resource assessment by the project archaeologist, chirp profiles recorded along the primary 30 m spaced tracklines were reviewed and interpreted for the presence of paleofeatures. In general, geologic features and structures apparent on the profiles that might be indicative of relict fluvial systems and other coastal environments were identified. These include geomorphic features such as buried channels, alluvial terraces, levee ridges, and point bar deposits. Seismic characteristics that might suggest these paleofeatures are present include sloping reflectors representative of foreset/angular bedding and concave upward contacts representing the erosional base of a channel and internal depositional sequence.

Interpretations were documented in detail for each paleofeature identified in an Excel spreadsheet for subsequent mapping on the project drawings, and for delivery to the project archaeologist for additional review in the context of cultural resources. A digital image of each feature was also captured as part of the documentation process. Most of the features are buried channels or paleochannels, the most prominent preserved relict fluvial feature. Relict channel preservation is higher than other features (levees, terraces, channel margins) due to the depth of erosion which often preserved the lower portion of the fluvial channel during the Holocene transgressions. Information documented in the data spreadsheet include: depth below the seafloor to each bank and thalweg, apparent width of feature, internal seismic characteristics, channel generations (if more than one), and associated survey information (date, line #, run #, events, etc.). Once individual channels were mapped in plan view along tracklines, correlation of all the features was performed to map channel geomorphology and trends through the survey area.

Subsurface Hazards Review

Chirp and boomer subbottom profiles were also interpreted to map other subsurface geologic structures suggestive of shallow hazards along the route. While the focus of this study was the shallow subsurface appropriate for a submarine cable installation, the boomer subbottom profiles were collected to enhance the image of subsurface geology and stratigraphy along the route in case coarser surficial materials limited the higher frequency signals of the chirp system. The centerline boomer seismic files were digitally processed and reviewed to a depth of 325 ft (below the water surface) to develop an overview of the route geology and assist with determining the existence and location of shallow hazards.

Data were interpreted to identify the presence of the following features:

- Buried man-made debris including cables and pipelines
- Faulting
- Slump blocks or slide sediments
- Shallow gas
- Buried channels and other relict geologic structures
- Diapiric structures

Magnetometer data were also used to help delineate existing submarine utilities in the subsurface that might be crossing the proposed BITS route, first suspected from review of the nautical chart. Further positioning of active submarine cables, primarily telecommunications lines, was performed with the cable toner and detection system to pinpoint the horizontal location of the cables.

4.4 <u>Data Products</u>

Numerous preliminary data products were developed to support ongoing tasks by project team members (archaeologists, biologists, engineers) both during and after completion of the field program. Most of these products displayed data that had been fully processed, but not presented in a final format (drawing with border, notes, legends, etc.) to expedite delivery of scientific information. Following completion of all phases of the field program, final processing, interpretation, and presentation of results were accomplished with the goal of providing all necessary data products specific to the BITS project areas as well as those items required for state and federal environmental permit applications.

Table 5 below summarizes the final products generated for the BITS project to transmit the results of the marine site characterization study. The DVD accompanying this report contains other digital products (listed below) in support of the project, some specifically to meet BOEM requirements and data formats.

Table 5
Final Products Submitted for BITS

Product	Format / Scale	Description	Location
Appendices (end of this report)			
Report Figures	Figures (8.5 x 11")	Photos, diagrams, digital images	Appendix 1
Geotechnical Information; BITS Primary and Alternate	Table (8.5x11")	Summary and condensed version of vibratory core logs	Appendix 2
Side Scan Sonar Target Reports and Listings	Tables and Images (8.5x11")	Individual target images with dimensions, listing of all targets with positions and dimensions	Appendix 3
Magnetic Anomaly Listings	Tables (8.5x11")	Listings of all magnetic anomalies with survey information and details of signature characteristics	Appendix 4
Quality Assurance / Quality Control	Text and Images (8.5x11")	Summary of field calibration results and data processing quality control	Appendix 7
Digital Appendices (on accompanying DVD)			
Original Field Survey Logsheets	Excel Table	Spreadsheet containing all original survey logsheets for all geophysical vessels	Appendix 8
Geotechnical Information; Vibratory Core Listing	Excel Table	Spreadsheet containing the vibratory core data with BOEM formats	Appendix 9
Side Scan Sonar Target Listings	Excel Table	Sonar target details with BOEM formats	Appendix 10
Magnetic Anomaly Listings	Excel Table	Magnetic anomaly data with BOEM formats	Appendix 11
Drawing #1 Primary Route Alignment Sheets	Drawing PDFs (24 x 36") Sheets 1-11 1"=400' Horiz. 1"=20' Vert.	11 plan and profile sheets including water depth contours and color shaded relief, side scan sonar mosaic with targets and magnetic anomalies, subsurface geologic structures and paleofeatures, geologic cross section with digital chirp image	Appendix 12

Product	Format / Scale	Description	Location
Drawing #2 Alternate Route Alignment Sheets	Drawing PDFs (24 x 36”) Sheets 1-4 1”=400’ Horiz. 1”=20’ Vert.	4 plan and profile sheets including water depth contours and color shaded relief, side scan sonar mosaic with targets and magnetic anomalies, subsurface geologic structures and paleofeatures, geologic cross section with digital chirp image	Appendix 13
Drawing #3 Multibeam for Benthic Mapping	Drawing PDFs (24 x 36”) Sheets 1-3 1”=400’ Horiz.	3 plan view sheets presenting the water depth contours and color shaded relief of areas designated for benthic study	Appendix 14
Drawing #4 Side Scan Sonar for Benthic Mapping	Drawing PDFs (24 x 36”) Sheets 1-3 1”=400’ Horiz.	3 plan view sheets presenting the side scan sonar imagery/mosaic with surficial sediment type boundaries of areas designated for benthic study	Appendix 15
Drawing #5 Magnetic Intensity Contours of Primary Route Corridor	Drawing PDFs (24 x 36”) Sheets 1-3 1”=400’ Horiz.	3 sheets with multiple plan view panels displaying contours of the earth’s total magnetic field intensity	Appendix 16
Drawing #6 Magnetic Intensity Contours of Alternate Route Corridor	Drawing PDFs (24 x 36”) Sheet 1 1”=400’ Horiz.	1 sheet with multiple plan view panels displaying contours of the earth’s total magnetic field intensity	Appendix 17
Drawings #1-6	AutoCAD 2007	Complete set of digital AutoCAD drawings with all support files	Appendix 18

5.0 REGIONAL GEOLOGY

The BITS route alignment passes through western Rhode Island Sound, an embayment due south of Narragansett Bay whose basement bedrock and coastal plain surfaces were first carved and shaped in the Late Tertiary by rivers forming major drainage pathways southward (McMaster and Ashraf, 1973). The landscape was then modified further by Pleistocene glaciations that scoured as well as deposited vast amounts of material, and the seabed was finally reworked most recently by Holocene transgressions. A significant volume of research has been conducted by the United States Geological Survey (USGS) on this region (Needell et al., 1983a, 1983b, 1983c; Needell and Lewis, 1984; McMullen et al., 2008, 2009; Poppe et al., 2002 and more; please refer to the many open file reports on the USGS website http://woodshole.er.usgs.gov/pubsearch/pub_list.php). A brief summary of the regional geology of Rhode Island Sound follows.

Early seismic reflection studies conducted in the Sound (McMaster et al., 1968; Needell et al., 1983c; McMullen et al., 2009) helped delineate the stratigraphic framework and Quaternary history of the inner continental shelf south of Narragansett Bay. While metamorphic (gneiss, schist) and plutonic (granite) Paleozoic bedrock underlies the northern two-thirds of the route, the bedrock is unconformably overlain by coastal plain and continental shelf strata (late Cretaceous-early Tertiary) that form the basement below the southern third of the route (Needell et al., 1983a). The coastal plain strata are shallow in places offshore and have been mapped in outcrops on Block Island. These strata were extensively eroded by a complex fluvial drainage system during the late Tertiary-early Pleistocene that formed a lowland and cuesta with an incised north-facing escarpment (Needell et al., 1983a; Needell and Lewis, 1984). This buried escarpment and boundary between foundation materials is positioned approximately 7-9 miles northeast of Block Island, according to maps generated by previous research.

During the Pleistocene, the inner shelf south of New England was glaciated at least twice, with the preglacial landscape, including the lowland and landward flank of the coastal plain cuesta, modified each time by erosion during advance and retreat of the ice sheet. The last glacial advance (late Wisconsinan) deposited the vast volumes of glacial material (moraines, drift) in Rhode Island Sound, with end moraines marking the southernmost extent of the glaciers. As the ice receded northward, meltwaters supplied freshwater lakes that formed behind the end moraines connecting Long Island, Block Island, and Martha's Vineyard (Sirkin, 1982; Boothroyd and Sirkin, 2002). Thick deposits of laminated silt and clay accumulated in the lakes and associated valleys. Late-Pleistocene post-glacial streams incised channels into the drift once the region was subaerially exposed. During the ensuing Holocene transgression, valleys began to fill with fluvial sediments while estuarine and beach deposits formed along the coast. As sea level rose, these deposits along with the glacial drift were reworked and eroded by waves and currents.

Today surficial sediments in the Sound are a combination of reworked glacial drift and some marine sediments deposited over the years. Waves and currents have eroded and redistributed finer material off shoals into deeper areas, leaving coarse materials (gravel, cobbles, boulders) and compact sands behind on many topographic highs. Glaciolacustrine deposits (clay, silt, fine sand) are present just below recent marine sediments in the deeper portions of the Sound, infilling former drainage pathways and glacial lakes that occupied the inner shelf.

6.0 ROUTE DISCUSSION

The following discussion summarizes site conditions in the vicinity of the BITS primary and alternate route centerlines from south to north (Block Island to the mainland), referenced to the distance along the alignment (MP; mileposts in statute miles rounded to the tenth of a mile and stationing in ft) from the Block Island landfall at Crescent Beach. The BITS primary route extends approximately 21.7 miles from the east shore of Block Island to the Narragansett landfall. The BITS alternate route intersects the primary route near MP 18 and transects 8 miles north to the URI landfall (at MP 26).

The discussion is organized into sections of the route exhibiting similar seabed geomorphology or inclusive of unique geologic conditions (Figure 16). The following topics are addressed: water depths and bottom topography, surficial sediments, side scan sonar targets, magnetic anomalies, nearsurface subbottom stratigraphy, geotechnical data, and correlation of all of the above. Water depths are referenced to MLLW and depths to subbottom strata are reported relative to the seafloor (depth below the bottom). Refer to the BITS route alignment sheets showing the geophysical data and results (Drawing #1, Sheets 1-11 and Drawing #2, Sheets 1-5, plan and profile format, 1 inch=400-foot scale). Figures referenced in the text below are included in Appendix 1 and a summary of vibratory core results are listed in Appendix 2.

A brief summary of survey results is presented at the onset of each route section below. The section summary highlights data results focused on the route centerline and immediate vicinity. Topics summarized in the bullet list include water depths and bottom topography, seafloor geology, target concentration (sonar and magnetic), subsurface geology focused on the upper 10-15 ft, and man-made features of interest to the project.

6.1 BITS Primary Route

6.1.1 MP 0.0 to 2.2 (Station 0+00 to 118+00)

Section Summary:
- Water depths: 0-118 ft, low local relief on a gentle offshore slope
- Seafloor: primarily sand with some coarser (gravel-cobbles) and finer material
- Targets: high concentration close to shore, low to moderate overall
- Subsurface: primarily sand with silt and gravel, coarser material possible
- Features: fish trap area nearshore, Block Island ferry route

The BITS route alignment heads offshore from the southern end of Crescent Beach on the east shore of Block Island near MP 0.1 (Station 3+60) and descends gradually down (less than 2° slope) a predominantly sandy offshore slope to water depths of 118 ft at the seaward end of this section. This is near the toe of the slope and the offshore limit of patchy sand wave fields (Type 2 sediments) evident on the side scan sonar imagery. The variations in surficial reflectivity suggest there may also be some coarser material (gravel, cobbles) present locally, particularly between MP 1.1-1.3 (Stations 58+00 to 70+00), as well as a gradational fining toward the base of the slope. In general, the route appears to be positioned along a favorable path as there are rocky areas noted on the chart to the north off Clay Head and south along the shore in Old Harbor (Figure 17).

A high concentration of magnetic anomalies exists from shore out to MP 0.5 (Station 26+00) with only a few scattered sonar targets, indicating the majority of ferrous objects are buried. An increase in density of man-made objects is common along harbor approaches and in proximity to commercial activity. The concentration of anomalies becomes generally low offshore from MP 0.5 (Station 26+00) with isolated groupings of anomalies (moderate concentration locally) adjacent to and on the centerline. Two such groupings are located in the vicinity of MP 1.2 and MP 2. No linear magnetic trends suggestive of submarine utility lines are apparent in the spatial distribution of anomalies. However, the density of anomalies nearshore may mask magnetic trends from any single ferrous object.

In the subsurface, numerous seismic reflectors in the upper 5 ft suggest some sediment variability along portions of this route segment. Limited chirp signal penetration also indicates possibly more compact materials as well as coarser sediments in the subsurface. This is supported by core V-2 where only 2.7 ft of recovery was attained in compact fine sand near MP 1.2 (Station 65+70). Overall, sand is still interpreted as the primary constituent in the upper 10 ft; however, given the shallow water and higher energy environment, it is likely that some coarser material is present as well.

As far as regulated areas are concerned, the south end of a charted fish trap area covers the route from the shoreline out near MP 0.2 (Station 7+70) in less than 10 ft of water. Farther offshore in the vicinity of MP 0.8 (Station 45+00) is the official Block Island ferry route, although the charted routes may not be indicative of the actual ferry transit paths.

6.1.2 **<u>MP 2.2 to 7.6</u>** (Station 118+00 to 404+00)

Section Summary:

- Water depths: 118-129 ft, generally smooth bottom topography
- Seafloor: primarily silt and sand with coarser material possible
- Targets: low concentration
- Subsurface: mainly silt and sand with coarser material possible
- Features: TAT-10, TAT-12, and one unidentified charted cable crossing, state-federal jurisdictional boundary, OCS lease blocks 6810, 6811

Maximum water depths along the entire route exist in the vicinity of MP 3.1 (129 ft from Station 160+00 to 174+00) and gradually decrease northward toward MP 5 (Station 264+00). Depths then level off to the north between 120-124 ft to the north end of this route segment. A smooth seafloor topography void of bedforms or any local relief is apparent that suggests fine grained unconsolidated materials are prominent (Type 1 sediments, silt-fine sand). More surface variability is apparent north of MP 6.8 (Station 358+00) where a mixture of grain sizes may be present (Type 3 sediments).

A sparse distribution of magnetic anomalies and sonar targets exists, except for two linear magnetic trends crossing the BITS alignment near MP 5.2 (Station 274+00) and MP 6.7 (Station 351+75). These magnetic trends are associated with the TAT-10 and TAT-12 submarine cables (Figure 18).

Subbottom profiles reveal an acoustically transparent seismic unit in the upper 10-15 ft from MP 2.2 to MP 6.3 that is often suggestive of generally homogenous sediments. Vibratory core samples collected from this portion of the route (V-4 to V-8, V-10) recovered primarily silt with an absence of layering. Only core V-9 at MP 5.6 (Station 295+25) was the exception, recovering 9.6 ft of fine sand. From MP 6.3 to MP 7.6 more sand was recovered in cores where the subbottom data showed more nearsurface reflectors. Cores V-11 and V-12 retrieved 5 ft and 10 ft of surficial sand, respectively, in the northern end of this section. Overall, all cores retained over 90% of the penetration depth.

Man-made features include two Trans-Atlantic Telecommunications (TAT) cables, TAT-10 and TAT-12 that cross the BITS route near MP 5.2 and MP 6.7, respectively. Both cables were detected with the marine magnetometer and the TAT-12 cable was further located using the cable toner and detection system. There is one other charted submarine cable crossing in the vicinity of MP 7.3 where no linear magnetic trend was apparent in the data (see Figure 18). None of the cables were recorded on the side scan sonar indicating they are all buried at some depth below the seafloor. The alignment also passes from state into federal waters at approximately MP 4.9 (Station 257+50; three nautical mile limit). This section of the BITS route transects OCS lease blocks 6810 and 6811 in federally regulated waters.

6.1.3 <u>MP 7.6 to 12.6</u> (Station 404+00 to 664+00)

Section Summary:

- Water depths: 85-128 ft, more variable surface texture and relief, bottom slopes on either side of southern extension of Point Judith Shoal
- Seafloor: mainly sand with gravel and coarser material on shoal, sand and silt on flanks
- Targets: low to locally moderate concentration
- Subsurface: primarily sand with gravel on shoal, sand and silt on flanks
- Features: CB-1 and TAT-6 cable crossings, Narragansett Bay outbound traffic lane and OCS lease blocks 6811, 6761, 6711

This section of the BITS route is part of the eastward bend that avoids the southern extension of the Point Judith Shoal (Figure 19). The shoal is clearly evident on the multibeam contours and shaded relief that show water depths as shallow as 78 ft to the north-northwest of the alignment. The shallowest depth attained along the centerline is 85 ft near MP 11.6 (Station 614+00). The route parallels the water depth contours with seafloor slopes of less than 5° across the BITS alignment (steepest section from Station 620+00 to 626+00). Bottom topography is more variable with a rough surface texture present on the shoal. Side scan sonar reveals abundant sand waves (less than 2 ft height) with the potential for scattered coarse material (gravel, cobbles, and isolated boulders).

A buried channel bisects the shoal between MP 9.7 and MP 10.7, evident as a slight depression along the route filled with finer sediments (mainly silt). Water depths reach 128 ft in this area and the seafloor exhibits a smooth and featureless topography.

Low to moderate concentration of sonar targets and magnetic anomalies are apparent except where two linear magnetic trends cross the route near MP 7.9 (Station 418+10) and MP 10.3 (Station 545+00). These magnetic signatures represent the CB-1 and TAT-6 submarine cables, respectively. On the shoals, particularly between MP 11-12.6, sonar targets are more abundant with fewer magnetic anomalies present.

In the subsurface, interpretation of the subbottom profiles indicates coarser, more compact materials on the shoals with finer unconsolidated sediments in the depression. Cores provide ground truthing of the upper 10 ft and verify softer, silt in the deep section (MP 9.7-10.7) with primarily sand on the shoals. Core V-19 at MP 11.8 (Station 623+30) also recovered gravel at depth (5.9-9.4 ft) underlying the surficial sand (5.9 ft thick). Data suggest this portion of the shoal between MP 11-12.3 is comprised of very compact sand with a significant coarse material fraction locally. As a result, the chirp profiler did not achieve much penetration due to the conditions; however, even the boomer system did not penetrate far below the seafloor (2-10 m).

Two more submarine cables exist in this stretch of the route at MP 7.9 and MP 10.3, as noted previously. Both cables were detected with the marine magnetometer and the CB-1 cable was also positioned using the cable toner and detection system. The BITS route passes through (traffic lane, lease blocks) and nearby (separation zone/torpedo range) a number of regulated areas along this route segment including:

- ❖ Narragansett Bay outbound traffic lane; from MP 8.9 to MP 12.6
- ❖ Separation zone/torpedo range; adjacent to east edge of survey corridor, route never enters this zone
- ❖ OCS lease blocks 6811, 6761, 6711; route passes through
  Figure 20 shows the BITS route in relation to the OCS lease blocks.

6.1.4 <u>MP 12.6 to 20.7</u> (Station 664+00 to 1092+00)

Section Summary:
- Water depths: 59-103 ft, generally smooth seafloor topography, patches of increased bottom texture, some local relief
- Seafloor: mainly silt with sand, more sand and possible coarser material in shallower sections (MP 16.7-17.6)
- Targets: low to moderate concentration; target at Station 930+00
- Subsurface: mainly silt with sand, more sand with possible gravel in shallower sections; internal slump blocks along east edge of corridor from MP 13.8-14.7
- Features: Narragansett Bay outbound traffic lane, state-federal jurisdictional boundary, OCS lease block 6711, Precautionary Area, fish trap area

Continuing north along the BITS route, water depths of 101-103 ft persist from MP 12.6 to MP 16.3 exhibiting a flat-lying, featureless seafloor. A slight shoal exists between MP 16.7-17.6 where increased surface relief and rougher bottom texture are apparent (Type 2 sediments). The seafloor then slopes up gradually to the north end of this section at MP 20.7, featuring a smooth bottom surface void of sharp relief. Surficial sediments interpreted from the sonar reflectivity again correlate with the multibeam results, with finer grained silt-clay marking the smooth areas and sand with possible coarser material in variable topographic (usually shallower) sections.

A generally low concentration of targets and anomalies exists, with some areas showing a slight increase in concentration locally. While some smaller groupings of objects are apparent, no larger or longer trends of acoustic or magnetic data are present in the corridor. A small grouping of magnetic anomalies is centered on the alignment near MP 14.1 possibly associated with one or more sonar targets (SS3074 and SS3075). Another sonar target stands out (SS3023) because it is located only 8-15 ft east of the centerline at MP 17.6 (Station 930+00). The object was imaged by both the side scan sonar and multibeam systems which recorded acoustic dimensions of 5x25 ft with an apparent relief of over 4 ft. Magnetic anomaly M907 (10 gammas) was measured in the vicinity, but not necessarily close enough to suggest any association with target SS3023.

Subbottom profiles and vibratory core samples indicate the shallow subsurface is mainly comprised of silt with some sand in deeper areas, with sand and coarser sediments (gravel, cobbles) on the shoal. This shoal from MP 16.7-17.6 separates two expansive relict glaciofluvial channels (or lacustrine deposits in a depression), one north and one south, each containing thick deposits of laminated silt-clay and possible some interbedded fine sand at depth. Interpretation of seismic data on the flanks of and under the shoal reveal that a thick, broad deposit of coarse glacial till is the foundation for this shoal. All cores penetrated 9-10 ft and recovered silt, clay, and fine sand except for core V-28 on the shoal which penetrated 6.5 ft meeting refusal (core barrel bound up) in a sand and gravel layer 5-6.5 ft below the bottom.

Along the east edge of the survey corridor, over 300 ft east of the route centerline between MP 13.8-14.7, chirp profiles reveal some minor displacement of seismic reflectors suggestive of limited vertical movement of sediments (see location in Figure 19). The subbottom profiles show numerous slip planes concentrated in a north-south oriented zone east of the route. Vertical displacements of the seismic reflectors range from 0.5 to 3 ft (Figure 21). The features appear to be restricted to the glaciofluvial deposit (laminated silt-clay in-filling the buried channel) underlying the 10-15 ft thick surficial sediments (reworked drift and marine sediments). There is no evidence of vertical displacement of horizons in the overlying surficial layer or in stratigraphic units underlying the relict channel feature. This suggests the deformation structures are contemporaneous (formed during deposition or immediately following) with the glaciofluvial unit. The development of these small scale slumps may be associated with *in situ* processes inherent to depositional regimes, such as uneven sediment accumulation and loading on a slope, local variations in porosity and grain size, biological activity, sediment diagenesis, or differential compaction. Whatever the origin, local subsurface conditions were favorable for the development of these features within the confines of the relict channel deposits.

The route passes through a number of regulated areas described in the prior section, including the Narragansett Bay outbound traffic lane and OCS lease block 6711. The three nautical mile limit (state-federal boundary) is located near MP 13.9 (Station 732+00). Other man-made features include the Precautionary Area that begins at approximately MP 17.4 (Station 920+00) and covers nearshore areas to the north, and a fish trap area that covers the route from MP 19.7 (Station 1040+00) to MP 20.1 (Station 1063+60).

6.1.5 **MP 20.7 to 21.7** (Station 1092+00 to 1147+89)

Section Summary:

- Water depths: 0-59 ft, gradual offshore slope
- Seafloor: primarily silt and sand offshore, sand and possible gravel closer to shore
- Targets: low to moderate concentration locally; magnetic trend at Station 1116+50
- Subsurface: mainly silt and sand offshore with sand and gravel nearshore
- Features: none charted

The bottom exhibits a generally smooth topography and fairly constant slope up (less than 2°) toward the Narragansett landfall. Similar to previous areas, smooth seafloor is correlative with finer sediment (silt-fine sand) while some patches of rough texture on the sonar imagery indicate coarser materials (sand with gravel of Type 3 sediments). The slightly rougher surface is primarily evident landward of MP 21.1 (Station 1114+00). The BITS route avoids most of the coarser Type 3 sediments which are positioned north and south of the centerline. The coarsest material is located south of the route centerline adjacent to shore, where an abundance of boulders (possible rip rap) exists likely with gravel and cobbles in a sand matrix (Type 4).

An overall low concentration of sonar targets and magnetic anomalies exists, with locally moderate concentrations of anomalies. In particular, a linear magnetic trend crosses the route near MP 21.2 (Station 1116+50) although there is no charted cable area in this part of the Sound. Anomaly characteristics (amplitude, duration) might indicate the magnetic trend represents a shallow bedrock feature, except the subbottom profiles do not show any obvious acoustic basement reflector in that location. There is also no associated side scan sonar target or seafloor feature that coincides with this magnetic signature.

Subbottom profiles recorded numerous parallel reflectors, representing generally horizontally bedded sediments, intersecting the sloping seafloor at an acute angle. Penetration was frequently limited below nearsurface reflectors in the upper 3-5 ft. Data suggest more compact sand with coarser materials (gravel, cobbles) exists with lateral variability as the route progresses up-section toward shore. Isolated boulder-sized material may be present below the seafloor. At MP 20.7 (Station 1093+00) in particular, the chirp and boomer profiles reveal a steep-sided subcrop that could represent coarse glacial till (gravel, cobbles, boulders) or bedrock, since the boomer did not penetrate below this acoustic basement reflector. The top of this subcrop reaches 7-8 ft below the seafloor (Figure 22).

Besides the debris identified by the sonar and magnetometer, no other apparent man-made features are present (charted) along this section of the route. The route intersects the shoreline near MP 21.7 (Station 1145+00).

6.2 BITS Alternate Route

6.2.1 MP 18.0 to 24.3 (Station 948+93 to 1282+00)

Section Summary:

- Water depths: 45-99 ft, smooth bottom topography, minimal local relief
- Seafloor: mainly silt with some sand, coarser material possible
- Targets: low concentration
- Subsurface: primarily silt with some sand, coarser material possible
- Features: Precautionary Area

The BITS Alternate route intersects the primary alignment near MP 18.0 (Station 948+93) and takes a heading slightly east of north toward the West Passage of Narragansett Bay. A smooth seafloor topography void of sharp relief exists with a gentle slope upward to the north. The shallowest depth of 45 ft is attained in the vicinity of MP 23.7 (Station 1254+00). Weak surface reflectivity on the sonar imagery is indicative of the finer sediments (mainly silt, Type 1) composing the seabed. More variability on the surface is evident east of MP 23.2 (Type 3 sediments), but overall fine-grained materials persist (mixture of silt and fine sand).

A low to moderate concentration of magnetic anomalies exists through this section with a sparse distribution of sonar targets. Since most of the anomalies do not have associated sonar targets, the magnetic signatures likely represent buried ferrous objects. In some places, a locally high concentration of anomalies is present. Most of these are located off the route centerline, but a few are positioned near the alignment, including a linear trend crossing the route near MP 21.2 (Station 1120+50), a group concentrated near MP 22.3 (Station 1180+00), and an abbreviated linear trend at MP 23.8 (Station 1256+00).

Interpretation of the subbottom profiles reveals acoustically transparent sediments over a majority of this route segment, indicative of finer grained sediment such as silt and clay. Vibratory cores in this area recovered predominantly silt with some fine sand and clay, and typically penetrated the full 10 ft into the seabed.

The route continues through the Precautionary Area heading north, the only apparent regulated zone in this portion of the Sound.

6.2.2 MP 24.3 to 26.0 (Station 1282+00 to 1374+13)

Section Summary:

- Water depths: 0-48 ft, broad topographic features, steeper slopes locally
- Seafloor: primarily sand with silt and coarser material possible
- Targets: low-moderate to high concentration
- Subsurface: mainly sand with silt; coarse material subcrop in upper 3-10 ft between Stations 1347+50 and 1350+50
- Features: charted cable area nearshore

Seafloor topography becomes highly variable on the approach to the URI landfall, but surface texture remains mostly smooth with little to no local relief. Sand waves are present in some areas. There is a shoal west of the route at MP 24.8-24.9 that projects east, sloping down over the centerline from MP 24.6 (Station 1299+00) to MP 25.0 (Station 1324+00). The shallowest depth on this shoal is 31 ft near MP 24.9 (Station 1316+50). Continuing toward shore, a slight swale is evident in the topography which reaches a depth of 47 ft near MP 25.3 (Station 1335+00) before the seafloor slopes up toward the beach. A relatively steep nearshore slope punctuates the landfall approach from Station 1353+00 to 1353+50. This slope approaches 14-15° and gets steeper to the north in the survey corridor, suggesting some scour of the seafloor may be occurring here.

Surficial sediments are predominantly sand and silt, as interpreted from the side scan sonar imagery with minimal ground truthing from the vibratory cores. Consistent with the remainder of the route, coarser surficial sediments (sand with some gravel) exist on the topographic highs with finer materials (silt and fine sand) infilling the swales.

A generally low to moderate concentration of magnetic anomalies and sonar targets is evident over the offshore half of this section from MP 24.3 to MP 25.2, followed by an abundance of magnetic anomalies closer to shore, particularly north of the route between MP 25.2 (Station 1334+00) and MP 25.4 (Station 1344+00). Another group of magnetic anomalies close to the centerline exists at MP 25.7 (Station 1360+00) in less than 10 ft of water. Very few sonar targets are present, once again indicating the ferrous objects are buried.

The high concentration of magnetic anomalies north of the route happens to coincide with a charted cable area in the nearshore zone. The cable area extends from an offshore limit of MP 24.7 (Station 1302+30) to MP 25.5 (Station 1344+80) along the BITS route, and angles in toward the shoreline well north of the URI landfall. One or more linear magnetic trends could be interpreted from this group of anomalies that may run semi-parallel to the route, but the trend appears to stay north of the BITS alignment and not cross the centerline.

Review of the subbottom records reveals similar subsurface conditions observed over the remainder of the route (predominantly sand, silt, some gravel; coarser on shoals, finer in depressions), except nearshore in the vicinity of MP 25.5. A strong seismic reflector was mapped near the seafloor, peaking at 3-5 ft below the bottom between Stations 1348 to 1350. This reflector may represent the top of a dense, coarse glacial till deposit (gravel, cobbles, boulders in a sand matrix) or the bedrock surface, since no deeper penetration was achieved. This subcrop is mapped in the upper 10 ft over a 300-foot distance from Station 1347+50 to 1350+50 (Figure 23).

7.0 SHALLOW HAZARDS

Geophysical and geotechnical information acquired for the marine site characterization study was also reviewed and interpreted for the presence of shallow hazards. Some of the hazards have been described already as surficial or subsurface features in the previous route discussion, but all will be summarized briefly in this section. While some hazards are relevant to the BITS geologic setting, the following are not common to the project area, and therefore, not included in the subsequent discussion:

- Collapse features indicative of karst environments (carbonates)
- Shallow water flow (deep water, higher pressure)
- Gas hydrates (deep water)

The shallow hazards discussed below are based on the geophysical data acquired for the BITS project which were designed to focus on the seafloor and shallow subsurface appropriate for submarine cable design, engineering, and installation. As summarized in the Project Background (Section 1.1), reconnaissance surveys of the BITS pathway identified hazards in the region which were subsequently avoided during final route selection. While a number of hazards of interest to BOEM are evident in the route corridor, none exhibit the size or areal extent to be considered detrimental to the installation of a submarine cable.

7.1 Natural Seafloor Hazards

Surface features were primarily delineated using the high-frequency multibeam depth data and side scan sonar imagery. It is important to note that many surface hazards are in a state of constant change (i.e. sand waves, scour), so maps produced from this study document conditions present at the time of the survey. Table 6 below summarizes the findings. Figure 24 shows examples of the seafloor hazards identified in the BITS survey corridor.

Table 6
Natural Seafloor Hazards Summary

Hazard	Definition	Identified / Description
Steep/unstable slopes	A stretch of ground forming a natural or artificial incline, with a slope that approaches the angle of repose (maximum angle at which the material remains stable).	Not present
Mass movement structures (slump, slide)	Large scale structures that result from the downslope movement of sediments due to instability and gravity. In the submarine environment these structures are often found in slope environments along coastal margins.	Not present
Water scour	Erosion of material due to water flow. Often associated with erosion adjacent to larger natural and man-made structures.	Present; tidal currents flowing over unconsolidated sediments will always produce scour
Bedforms (sand waves)	Bedforms (sand waves) are the result of the movement of sediment by the interaction of flowing water; critical angle and forces required for movement are dependent upon many factors.	Present; small scale sand waves (less than 2 ft height) abundant in Type 2 sandy sediment areas
Hard grounds	Any semi-lithified to solid rock strata exposed on the seafloor; in this area, may include bedrock or a nearly continuous pavement of fragmented rock or boulders.	Not present (avoided during route selection)
Diapiric structures	The extrusion of more mobile and ductily-deformable material forced onto the seafloor from pressure below.	Not present
Gas/fluid expulsion features	Upward movement of gas/fluid via low resistance pathways through sediments onto the seafloor; may be related to other hazards listed (diapirs, faults, shallow water flows).	Not present
Faulting expression	Physiographic feature (surface expression) related to a fracture, fault, or fracture zone along which there has been displacement of the sides relative to one another.	Not present

7.2 Natural Subsurface Hazards

The identification of subsurface hazards is primarily based on the interpretation of high-resolution chirp subbottom profiles collected on all lines in the 300 m wide corridor. The chirp system showed variable penetration along the route alignment, with less than 1 m apparent in areas of compact and/or coarser material (coarse glacial till) to over 20 m where finer unconsolidated sediments are prominent (glaciolacustrine deposits). The lower frequency boomer system typically obtained deeper penetration through the coarse glacial till, with estimated penetration ranging from 2-15 m. The system recorded geologic structures to over 60 m where conditions were ideal for signal penetration (finer sediments over a majority of the stratigraphic column. Boomer profile data were collected mainly on the route centerline, with several offset lines surveyed to document the areal extent of suspected hard grounds. Table 7 below summarizes the findings. Figure 25 illustrates examples of the subsurface hazards identified in the BITS survey corridor.

Table 7
Natural Subsurface Hazards Summary

Hazard	Definition	Identified / Description
Shallow faults, faulting attenuation	A fracture or fracture zone along which there has been displacement of the sides relative to one another, parallel to the fracture; attenuation is the translation of movement along a fault into surrounding mediums.	Not present
Mass movement structures (slump, slide)	Often distinguished by a single coherent mass of material displaced from its original location, in which the sediment/rock mass remains virtually intact and moves outward and downward.	Present (small scale slumps); small in size and areal extent, off route centerline
Diapiric structures	A type of intrusion in which a more mobile and ductily-deformable material is forced into brittle overlying strata; typically associated with massive mud or salt deposits at depth.	Not present
Shallow gas	Subsurface concentration of material in gaseous form that has accumulated by the process of decomposition of carbon-based materials (former living organisms, typically plants).	Present; limited extent and well below cable burial depths; not in sufficient quantities to cause any disturbance of overburden
Buried channels	Formerly the deepest portion of a waterway filled in with sediment over time and preserved to some extent by sea level rise and depositional processes.	Present; upper surface of most below cable burial depths

7.3 Man-Made Hazards

Man-made hazards may be present on the surface or buried below the bottom. Man-made objects include some discarded accidently (shipwrecks, trash) and those placed on/below the seafloor with a purpose in mind (cables, pipelines). While some man-made features may impede installation of submarine utilities, most are avoided by minor rerouting during construction or bridging, in the case of existing active utilities. For cultural resource assessment, please refer to the project archaeologist's report for a review of the sonar, magnetic, and subbottom data acquired as well as historical information for the area. Table 8 below summarizes the results of the OSI geophysical data review and search of existing maritime information from publicly available sources. Figure 26 shows examples of the man-made hazards identified in the BITS survey corridor.

Table 8
Man-Made Hazards Summary

Hazard	Definition	Identified / Description
Debris	Miscellaneous man-made objects that have been discarded in the ocean and are found on and below the seafloor.	Present; low to moderate concentration
Shipwrecks	Wreckage of ships ranging from intact to debris fields, from recent times or having historical significance.	Not present; but dependent upon further review by project archaeologist
Cables	Refers to power or telecommunications cables; commonly 3-8 inches in diameter and may be bundled together.	Present; possibly five submarine cables cross the route
Pipelines	Usually steel, concrete or both forming a linear conduit (pipe) used for the transport of water, natural gas, sewage, fuel oil, or other commodity.	Not present
Ordnance	Exploded or unexploded ammunitions; from wartime activities or near test facilities.	Not present; would require further investigation to verify
Cultural resources	Any man-made object or feature having historical significance	Undetermined; requires review by project archaeologist

8.0 CONCLUSIONS AND RECOMMENDATIONS

The detailed, multi-disciplinary site characterization study completed for the proposed BITS submarine cable successfully surveyed and delineated surface and subsurface conditions along a preferred and an alternate route through Rhode Island Sound. Extensive geophysical coverage was achieved of the 300 m survey corridor connecting Block Island with the mainland. Seafloor and subsurface characterization of project areas were completed through analysis and interpretation of survey information, including water depths and bottom topography, side scan sonar imagery, marine magnetic intensity data, high and low frequency subbottom profiles, and geotechnical data (vibratory core samples).

Table 9 below summarizes the general geologic conditions evident along the proposed BITS primary and alternate routes.

Table 9
Summary of Route Conditions

Route Location	Water Depths	Surficial Geology	Subsurface Geology (upper 10-15 ft)
Primary Route			
MP 0-2.2	0-118 ft	Sand with gravel and some silt	Sand with gravel and some silt, cobbles and boulders possible
MP 2.2-7.6	118-129 ft	Silt and sand with scattered coarse material	Silt and sand with coarser material less likely, isolated patches possible
MP 7.6-12.6	85-128 ft	Sand with gravel on shoals, silt-sand in swales	Sand with gravel and coarser material possible
MP 12.6-20.7	59-103 ft	Silt-sand in deeper areas, sand with gravel on shoal	Silt-sand in deeper areas, sand with gravel and possibly coarser material below shoal
MP 20.7-21.7	0-59 ft	Silt and sand offshore, sand and gravel nearshore	Silt and sand offshore, sand, gravel, and possibly coarser material nearshore
Alternate Route			
MP 18.0-24.3	45-99 ft	Silt and sand with scattered coarse material	Silt and sand with coarser material less likely, isolated patches possible
MP 24.3-26.0	0-48 ft	Sand and silt with coarse material possible	Sand and silt with scattered gravel, coarse glacial till subcrop in upper 3-10 ft nearshore

Note: Water depths are referenced to MLLW. Subsurface depths are relative to the seafloor.

As a broad site overview of the BITS route alignments, unconsolidated sediments comprise the upper 10-15 ft of the stratigraphic column with finer sediments (silt, clay, fine sand) dominant in deeper areas and coarser sediments (medium-coarse sand, gravel, cobble, and boulders) more common on shoals and nearshore. There are, of course, localized areas of coarse material at a number of places in Rhode Island Sound noted in the detailed route discussion, as well as the possibility of isolated boulders along the entire route. This is particularly true of the subsurface which cannot be imaged with the same resolution as the seafloor.

Areas of interest for construction include those locations where coarser materials may be present, particularly in higher concentrations. These include the nearshore slopes and offshore shoals where a mixture of coarser sediments (sand, gravel) form a more compact surface. Specifically, the shoal from MP 11 to MP 12.5 south-southeast of the Point Judith Shoal extension contains more coarse material than adjacent route segments. Many of these shoals develop a dynamic equilibrium with the tidal currents over the years, after much of the finer materials have been transported away. Another area of concentrated coarse material is just offshore from the Alternate Route URI landfall, where in addition to a mixture of gravel and sand layers on the slope, a coarse glacial till or bedrock subcrop rises to within 3-5 ft of the seafloor in the vicinity of MP 25.5. Additional ground truthing of this structure and sediment overburden may be warranted to refine the geophysical mapping.

Table 10 below outlines man-made features and regulated areas of interest along the route that could impact the cable installation or the project in some way. This table is meant to highlight man-made features and regulated areas not necessarily related to the geology and natural features along the route discussed previously.

A typical distribution of man-made objects is apparent along the route whereby the abundance of debris increases with proximity to human activities (i.e. navigation channels, traffic lanes, harbors). While the majority of sonar targets and magnetic anomalies are positioned off the route centerline, some are located on or immediately adjacent to the BITS alignment. Inspection of some of these locations may allow the objects to be identified and a decision made as to how to mitigate the existing object. Once target locations are ruled out as potential cultural resource sites, the targets can be designated as obstructions and dealt with accordingly (relocation, removal, avoidance). Industry standard techniques will be applied to bridge the existing in-service utility cables when the BITS cable is installed.

Table 10
Man-Made Features of Interest

Route Crossing Location	Feature	Description
MP 0.85	Block Island ferry route	Charted route for daily ferry service between Block Island (Old Harbor) and Galilee, RI (Point Judith Harbor)
MP 5.2	TAT-10 cable	Submarine telecommunications cable
MP 6.7	TAT-12 cable	Submarine telecommunications cable
MP 7.3	Charted cable	Submarine cable (unidentified)
MP 7.9	CB-1 cable	Submarine telecommunications cable
MP 10.3	TAT-6 cable	Submarine telecommunications cable
MP 4.9 to 13.9	Federal waters beyond three nautical miles	Offshore area under federal jurisdiction
MP 8.9 to 17.4	Narragansett Bay outbound traffic lane	Charted lane for outbound commercial ship traffic from Narragansett Bay
MP 24.7 to 25.5	Charted cable area	Just offshore from alternate landfall; may include submarine cable close to BITS route

Geophysical data and results also provided marine scientific information in support of benthic habitat analysis, cultural resource review, and shallow hazards mapping. While benthic and archaeological assessments were handled by other team members, OSI performed a review and documentation of shallow hazards for BOEM requirements. Some hazards are not common to the project site and the inner shelf off southern New England, and were, therefore, not discussed in the data review. Of the natural seafloor hazards examined, bedforms (sand waves) and water scour are present in the survey areas. Inspection of data for natural subsurface hazards identified small scale slumps, shallow gas, and buried channels. Finally, man-made hazards identified include debris and submarine cables. None of the hazards documented in the survey areas are believed to pose any significant impediment to the planned installation of the BITS power cable, as major routing issues were addressed following the reconnaissance phase of the project.

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U.S. Geological Survey website http://woodshole.er.usgs.gov/

APPENDIX 1

REPORT FIGURES

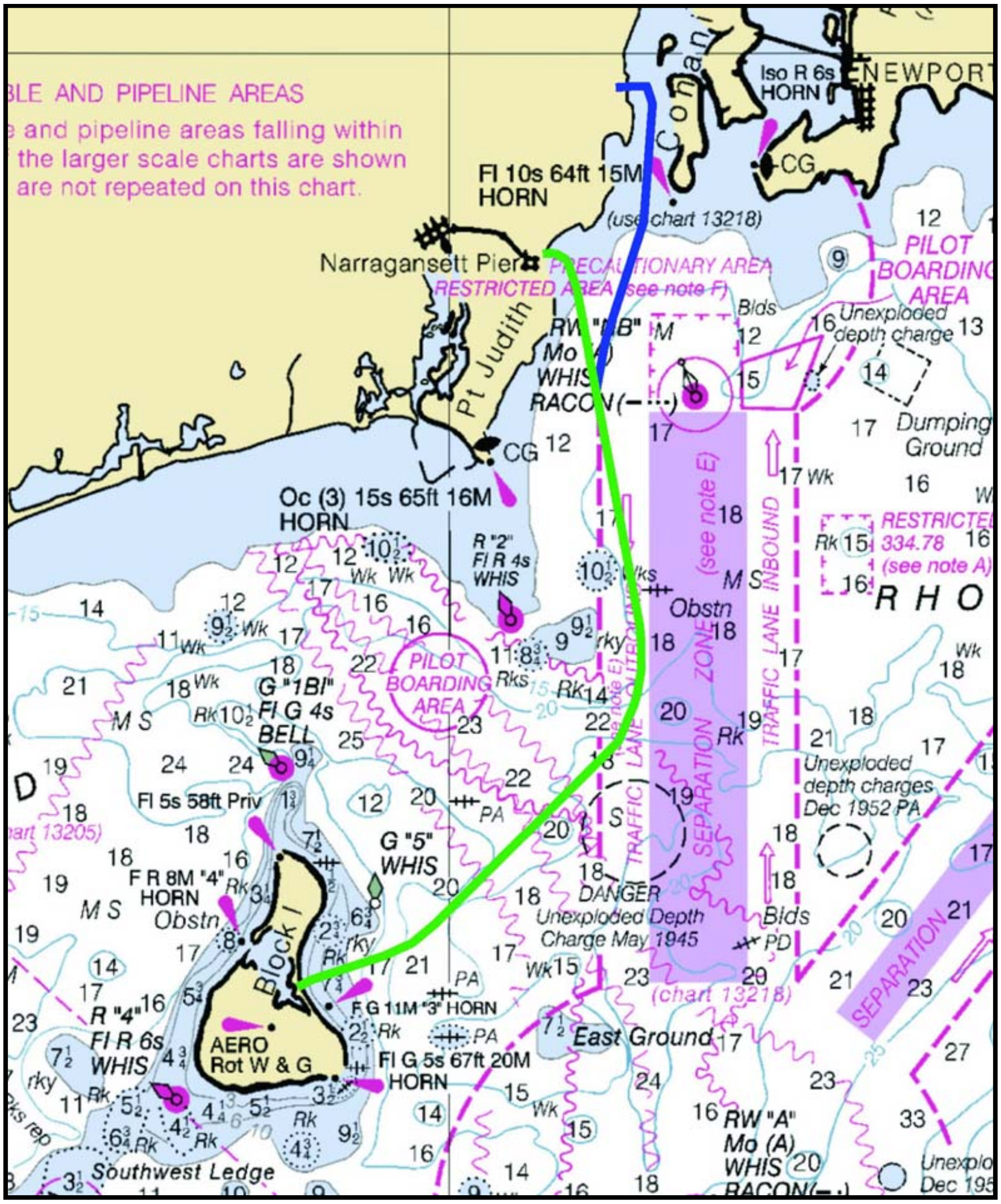


Figure 1. Location map of the areas surveyed in support of the BITS submarine cable route. Green line = primary route, blue line = alternate route. NOAA chart #12300 in background.

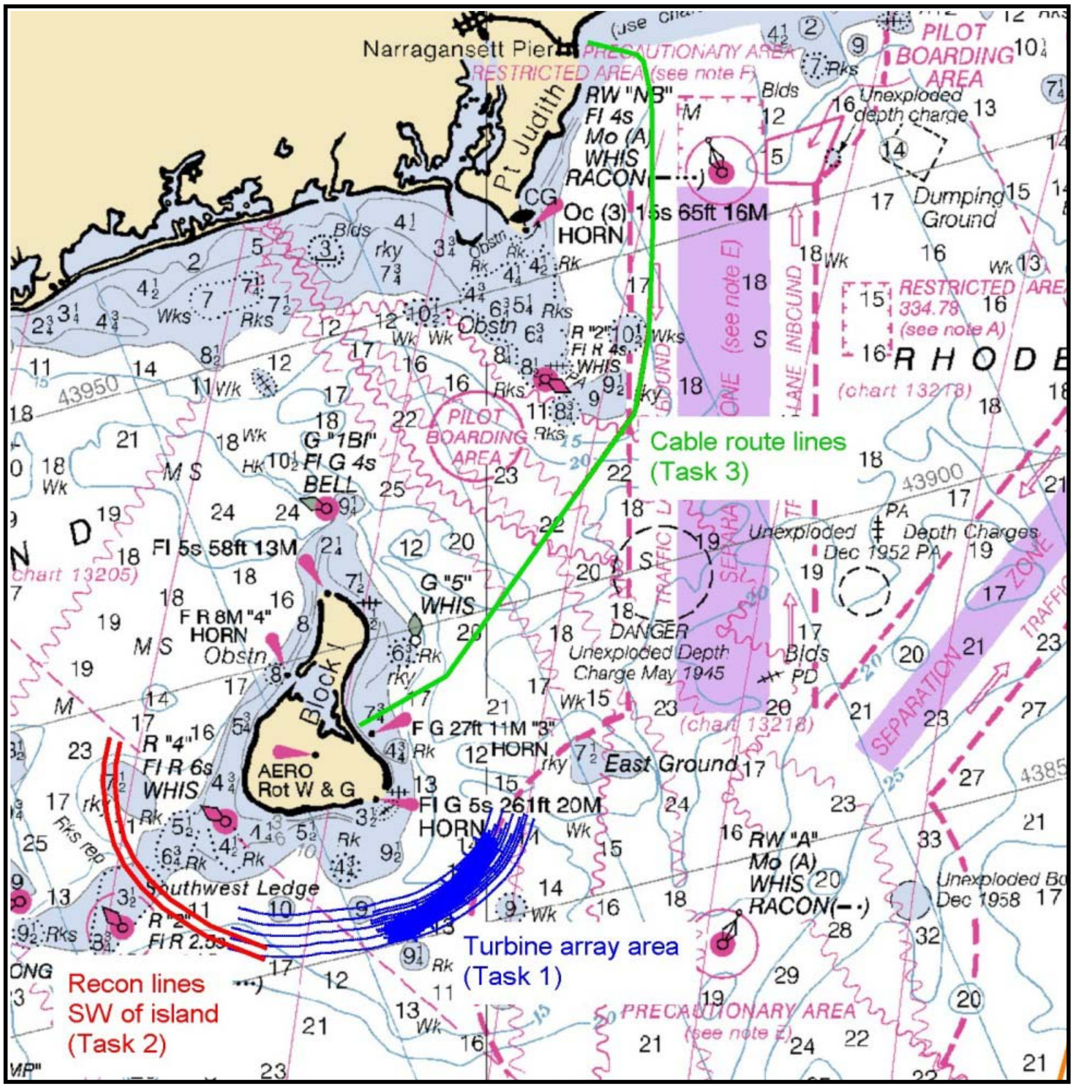


Figure 2. Areas surveyed around Block Island in the summer of 2009 (task numbers relate to the reconnaissance phase scope of work discussed in the text). NOAA chart #12300 in background.

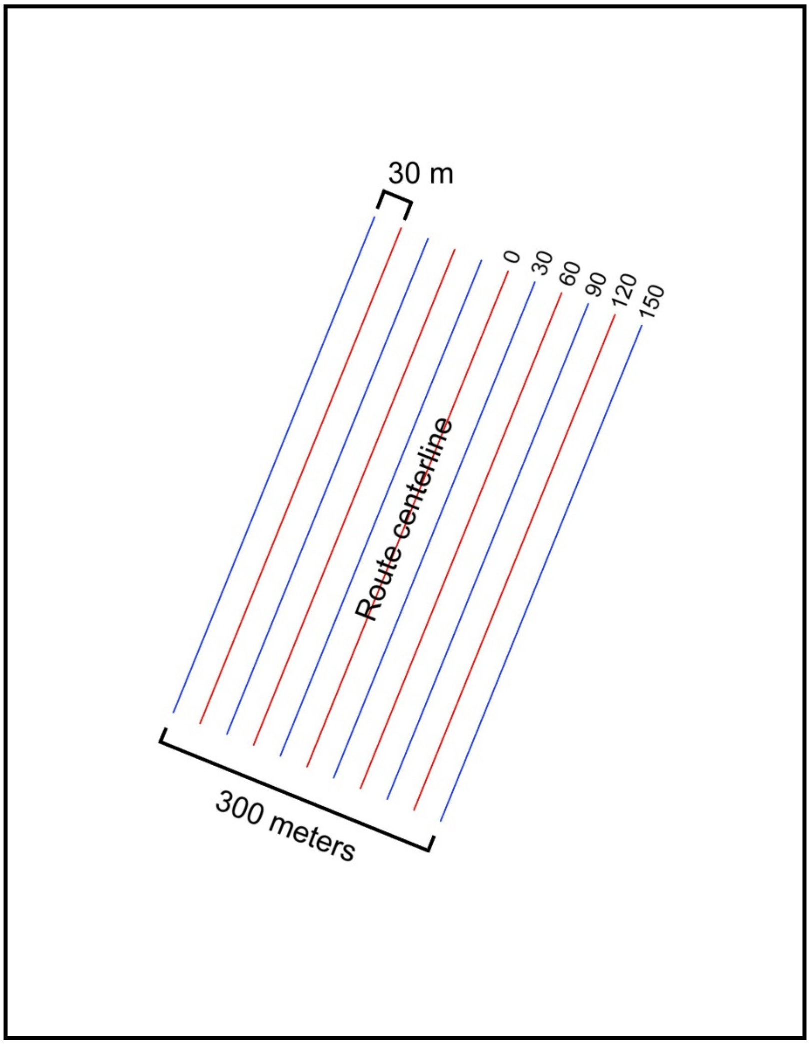


Figure 3. Schematic of planned survey lines in the 300m corridor. Chirp subbottom and magnetic intensity data collected on all lines (red and blue, 30 m spacing), side scan sonar imagery acquired along red lines only (60 m spacing, 75 m sweep range). Boomer profiles were collected on the route centerline and 60 m offsets where hard bottom or surficial coarse material was suspected.

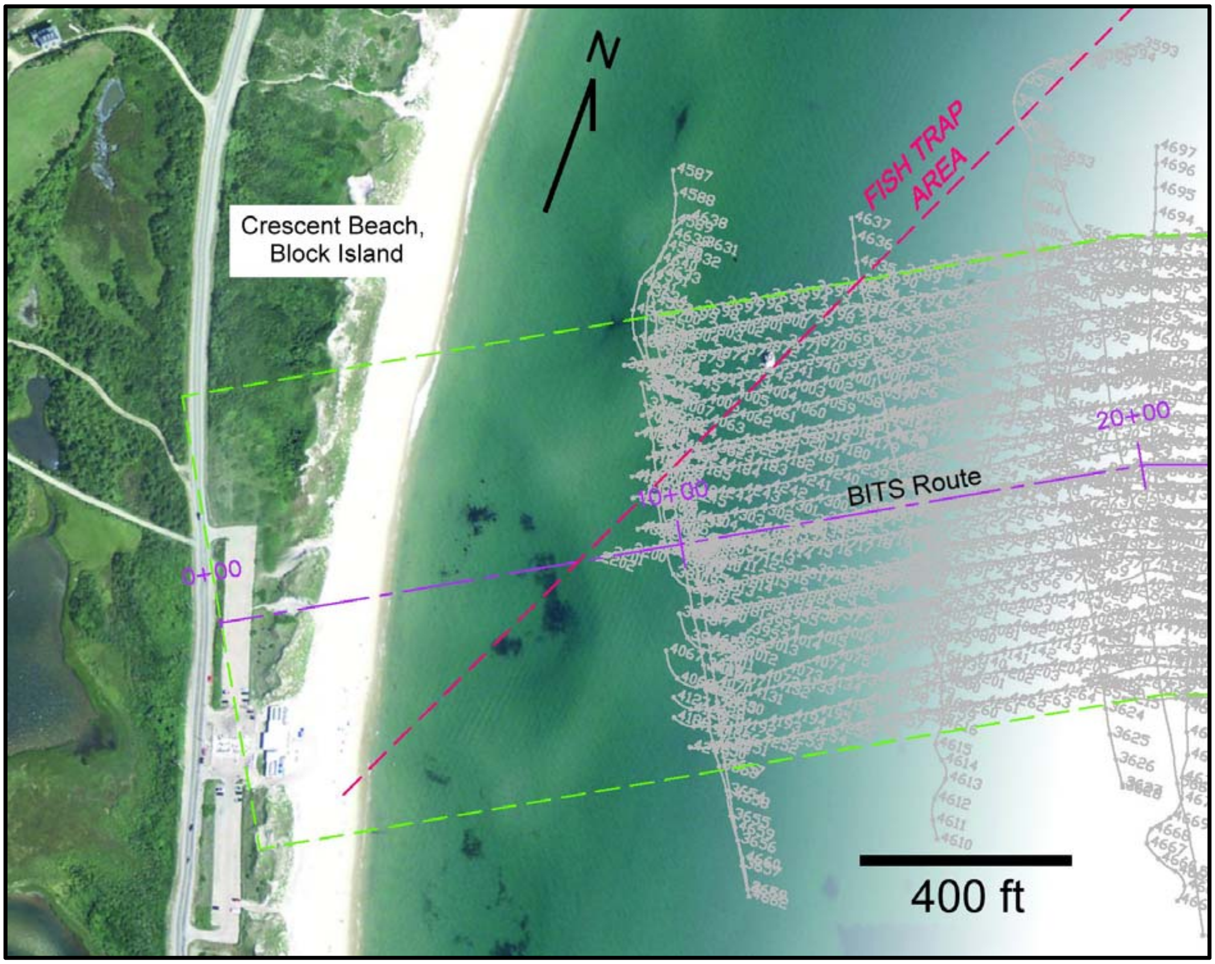


Figure 4. Survey tracklines (gray) covering the landfall approach to the east shore of Block Island. Inaccessible distance along the centerline, due to shallow water in the surf zone, is approximately 450 ft. USGS aerial photograph in background.

Figure 5. Survey tracklines (gray) covering the landfall approach to the mainland in Narragansett, Rhode Island. Inaccessible distance along the centerline, due to shallow water in the surf zone, is approximately 300 ft. USGS aerial photograph in background.

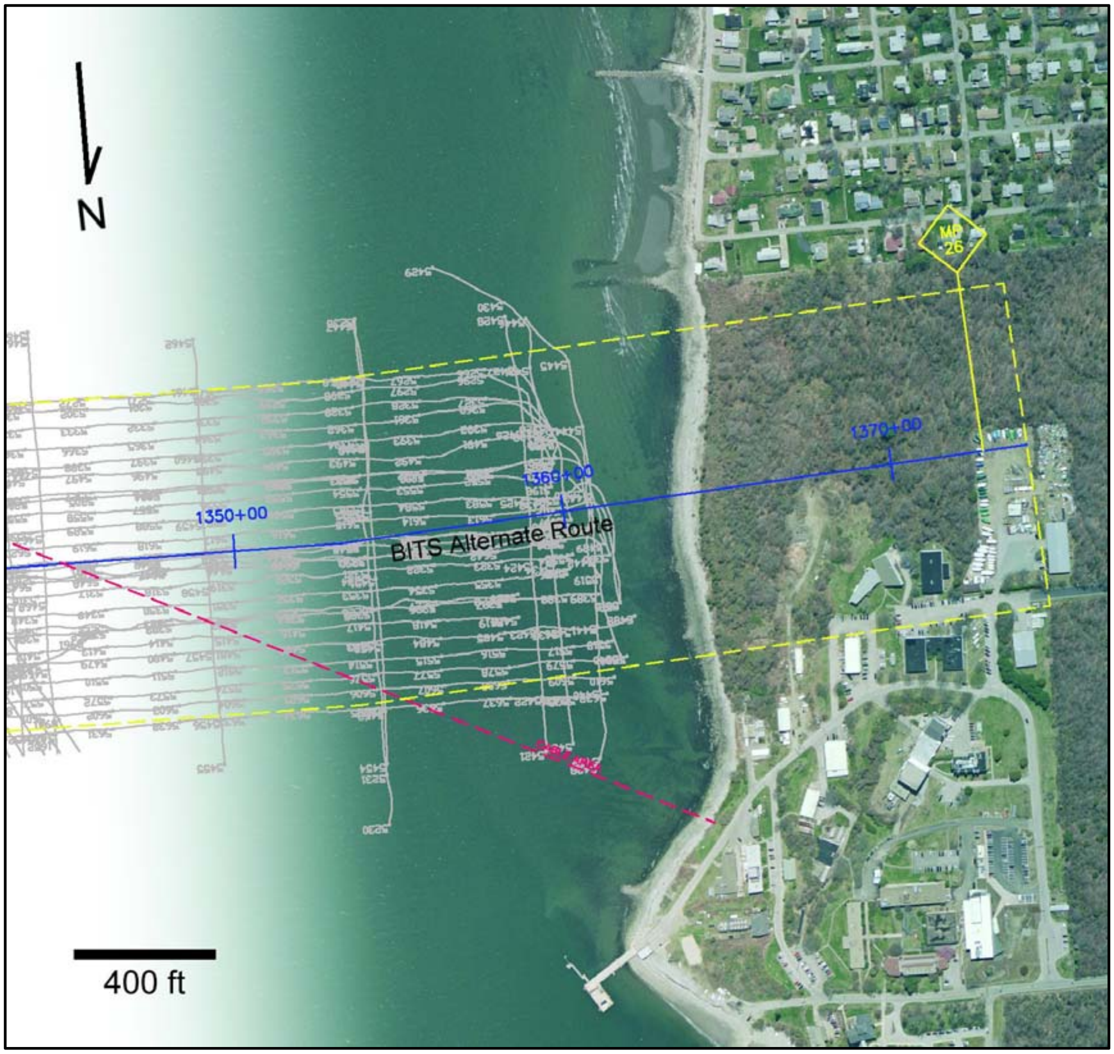


Figure 6. Survey tracklines (gray) covering the BITS Alternate Route landfall approach to the mainland. Inaccessible distance along the centerline, due to shallow water in the surf zone, is approximately 200 ft. USGS aerial photograph in background.

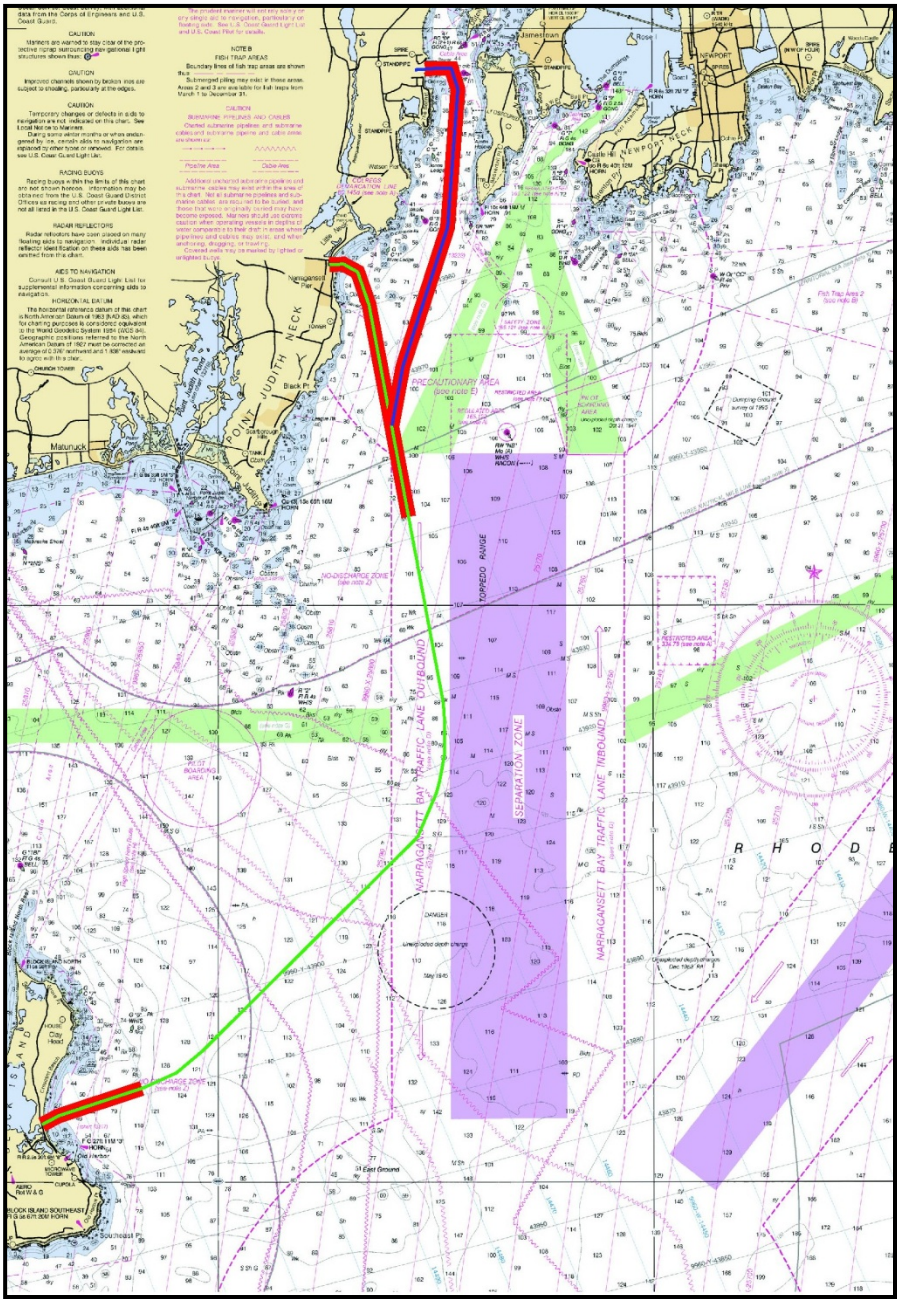


Figure 7. Areas of potential post-contact period archaeological sensitivity (red), designated by the project archaeologist as any portion of the survey corridor less than 100 feet deep. Survey trackline spacing was tightened to 15 m in these areas. NOAA chart #13218 in background.

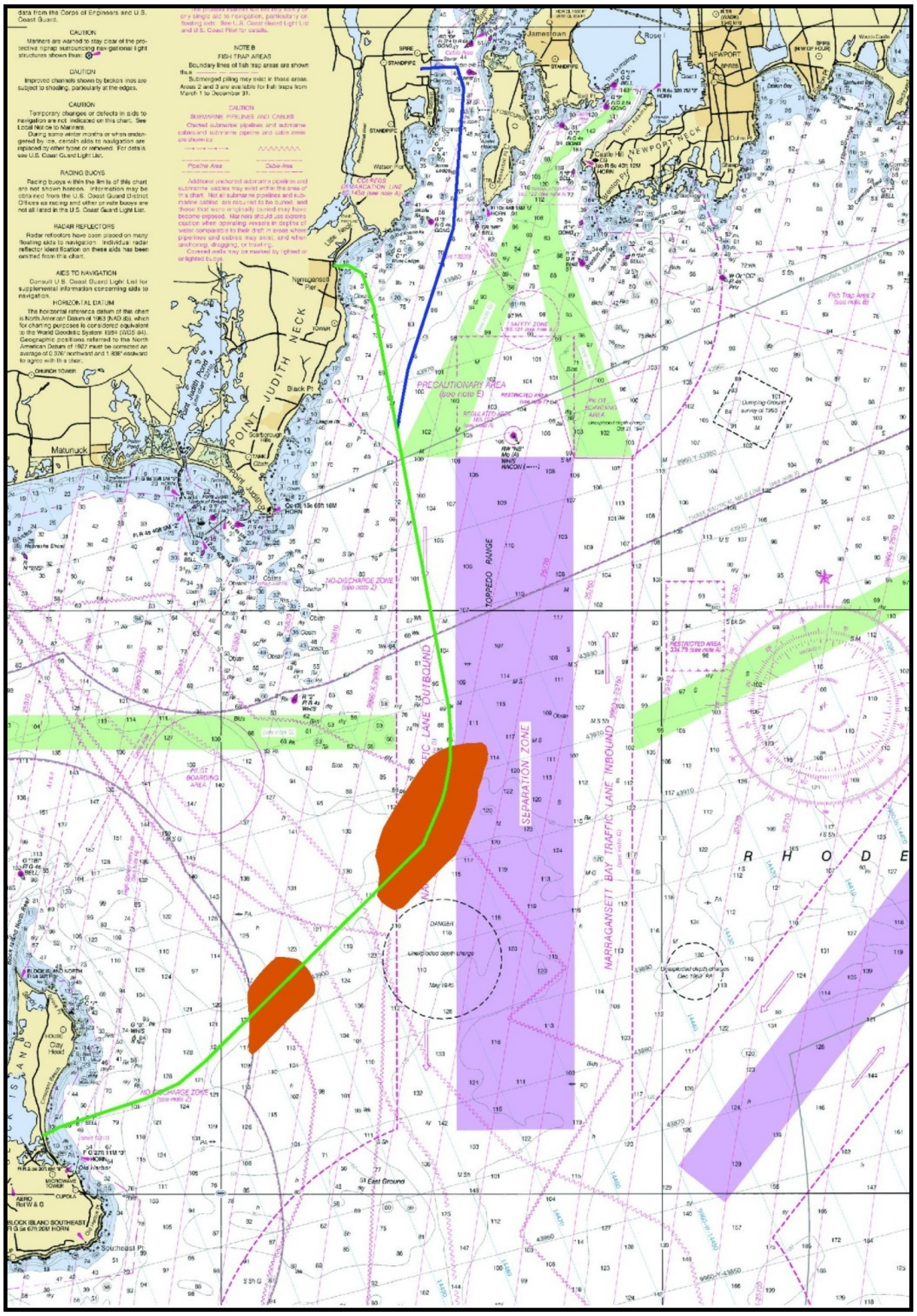


Figure 8. Areas along the BITS route designated for additional benthic habitat mapping (brown) beyond the 300 meter corridor. NOAA chart #13218 in background.

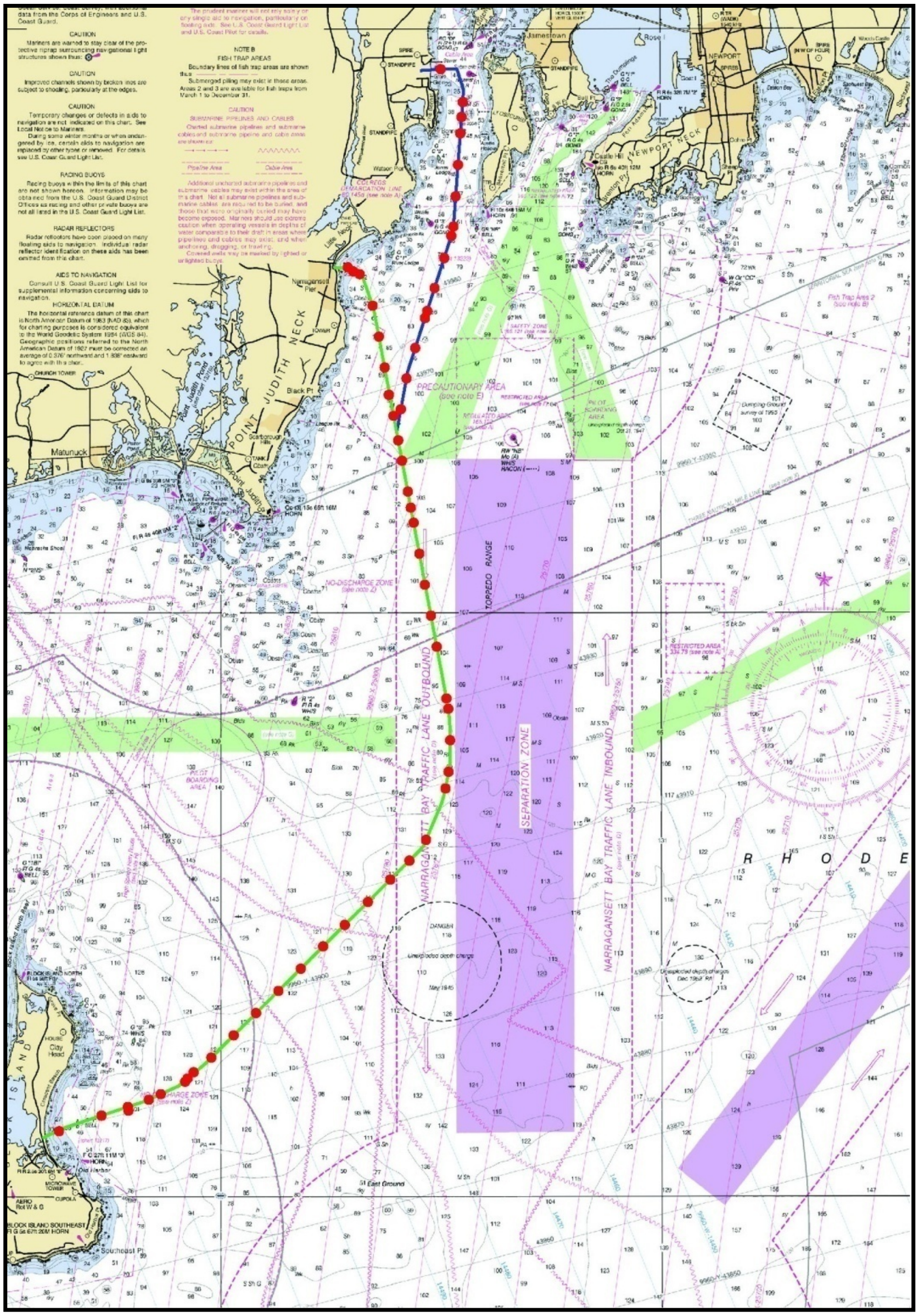
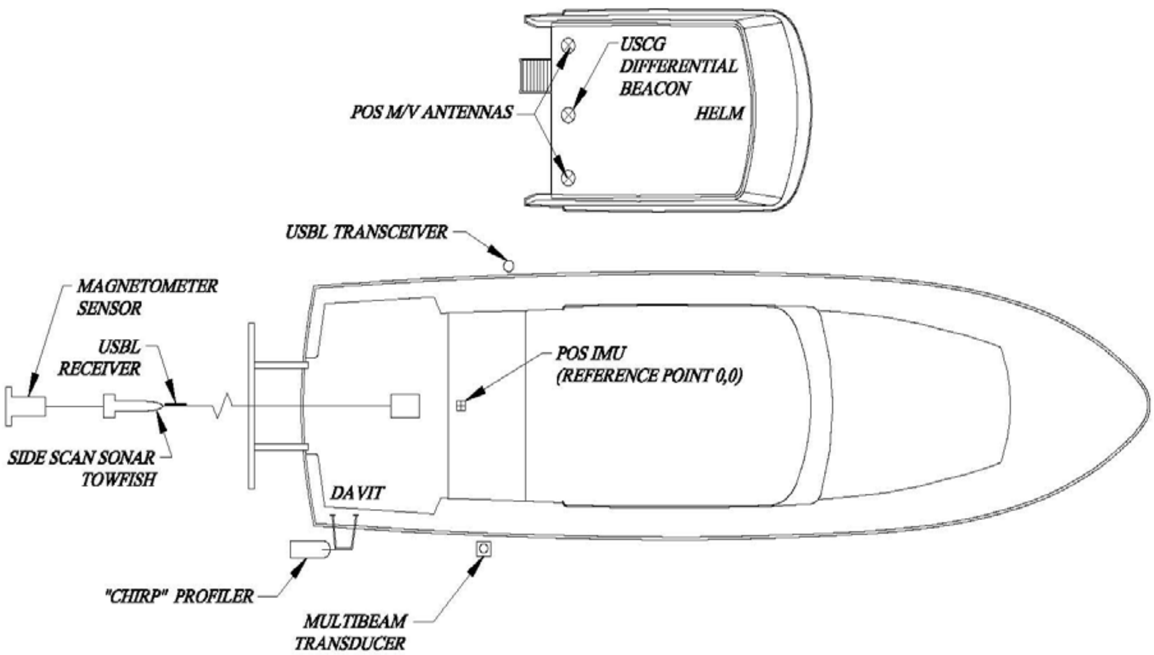


Figure 9. Layout of the vibratory core stations along the BITS alignment. NOAA chart #13218 in background.

Figure 10. R/V Ocean Explorer.

Figure 11. R/V West Cove.

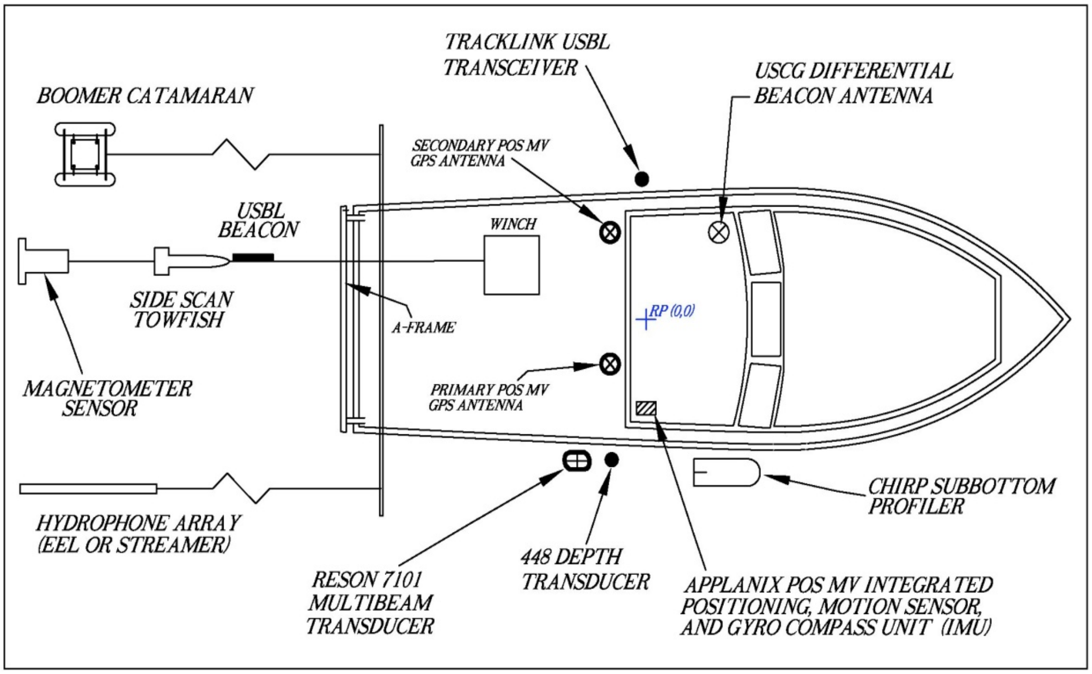
Figure 12. R/V Connecticut.



Survey Vessel Equipment Offsets Relative to Reference Point (RP)	Starboard Positive (ft)	Forward Positive (ft)
RP – Center of Vessel	0.0	0.0
POS MV GPS Primary Antenna	3.8	16.1
POS MV Secondary Antenna	-4.2	16.1
POS MV IMU Center	0.0	0.0
Multibeam Transducer	9.4	1.6
Magnetometer*	0.0	-61/-336
Side Scan Sonar Towfish*	0.0	-25/-300
Shallow Subbottom Profiler (chirp)	8.0	-10.0
TrackLink USBL Transceiver	-8.3	3.4

** Magnetometer and side scan sonar sensors included variable layback; positions calculated real-time with the Tracklink USBL underwater acoustic positioning system. Range of forward offsets (laybacks) given for approximate minimum and maximum values observed during survey (above diagram not to scale)*

Figure 13. General equipment configuration aboard the *R/V Ocean Explorer*.



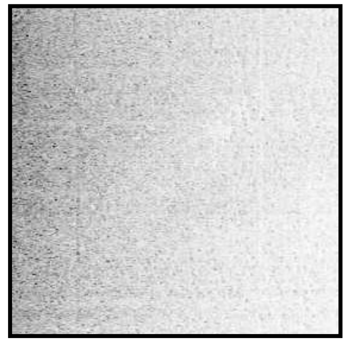
Survey Vessel Equipment Offsets Relative to Reference Point (RP)	Starboard Positive (ft)	Forward Positive (ft)
RP – Center of Vessel	0.00	0.00
POS MV GPS Primary Antenna	2.55	-2.21
POS MV Secondary Antenna	-4.22	-2.21
POS MV IMU Center	5.97	-0.05
Multibeam Transducer	7.9	-4.4
Single beam Transducer	7.9	-2.2
Magnetometer*	NA	-61/-336
Side Scan Sonar Towfish*	NA	-25/-300
Intermediate Subbottom Profiler (boomer)	0.0	-50.0
Shallow Subbottom Profiler (chirp)	8.0	3.0
TrackLink USBL Transceiver	-7.5	0.0

** Magnetometer and side scan sonar sensors included variable layback; positions calculated real-time with the Tracklink USBL underwater acoustic positioning system. Range of forward offsets (laybacks) given for approximate minimum and maximum values observed during survey. (above diagram not to scale)*

Figure 14. General equipment configuration aboard the *R/V West Cove*.

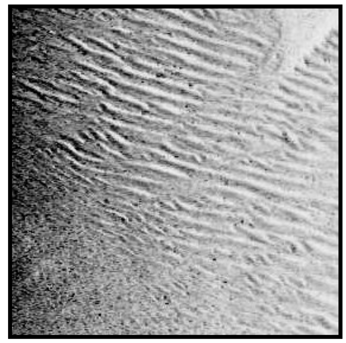
TYPE 1:

Mainly silt with clay and fine sand



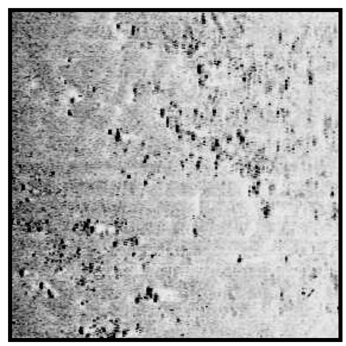
TYPE 2:

Mainly sand with bedforms, some gravel, silt



TYPE 3:

Mainly sand and gravel, with cobbles, boulders



TYPE 4:

Mainly gravel, cobbles, boulders in sand matrix

Figure 15. Sonar image captures of interpreted surficial sediment categories.

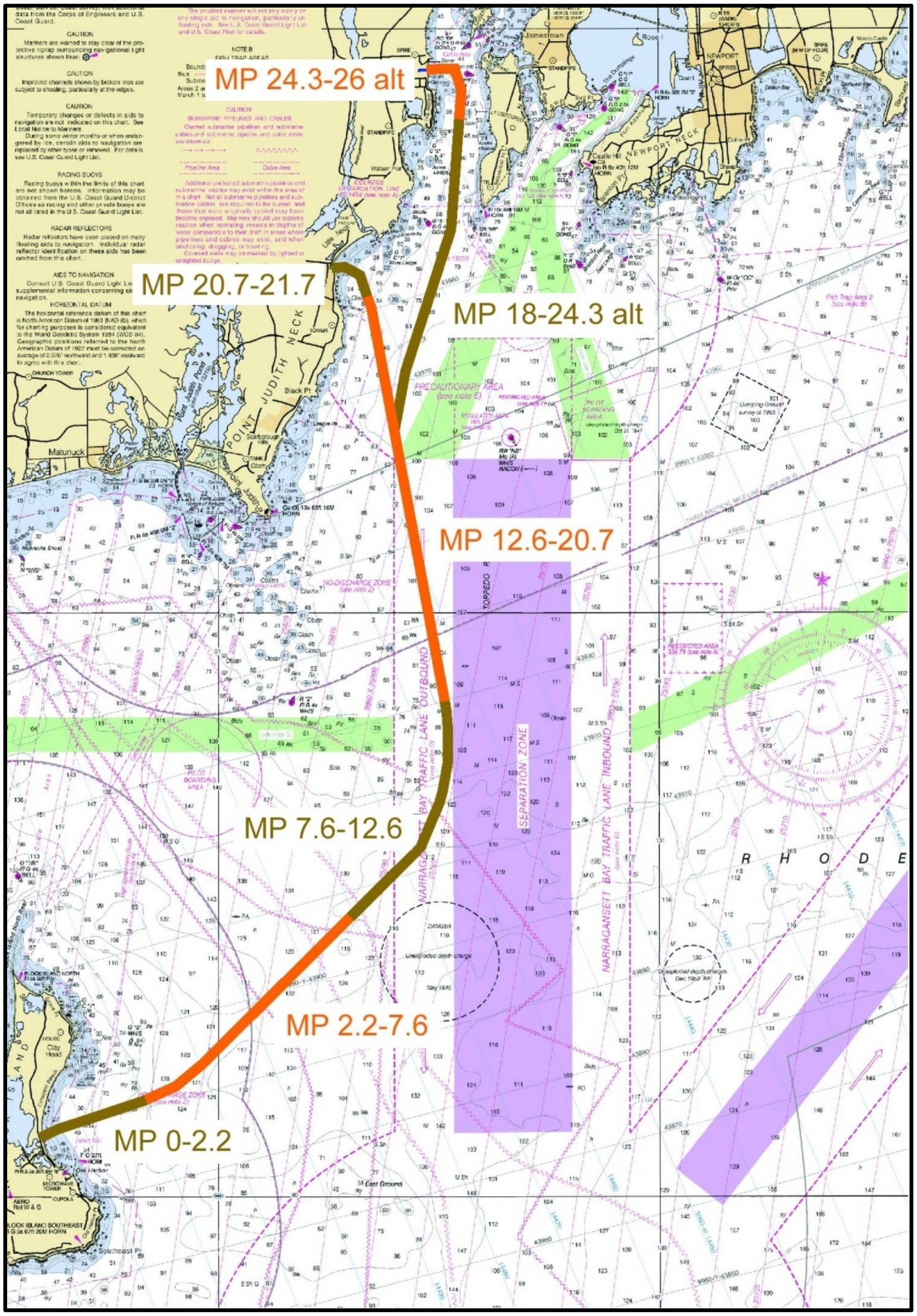


Figure 16. Subdivision of the BITS route for discussion purposes. NOAA chart 13218 in background. Milepost numbers referenced to statute miles (5,280 feet/mile).

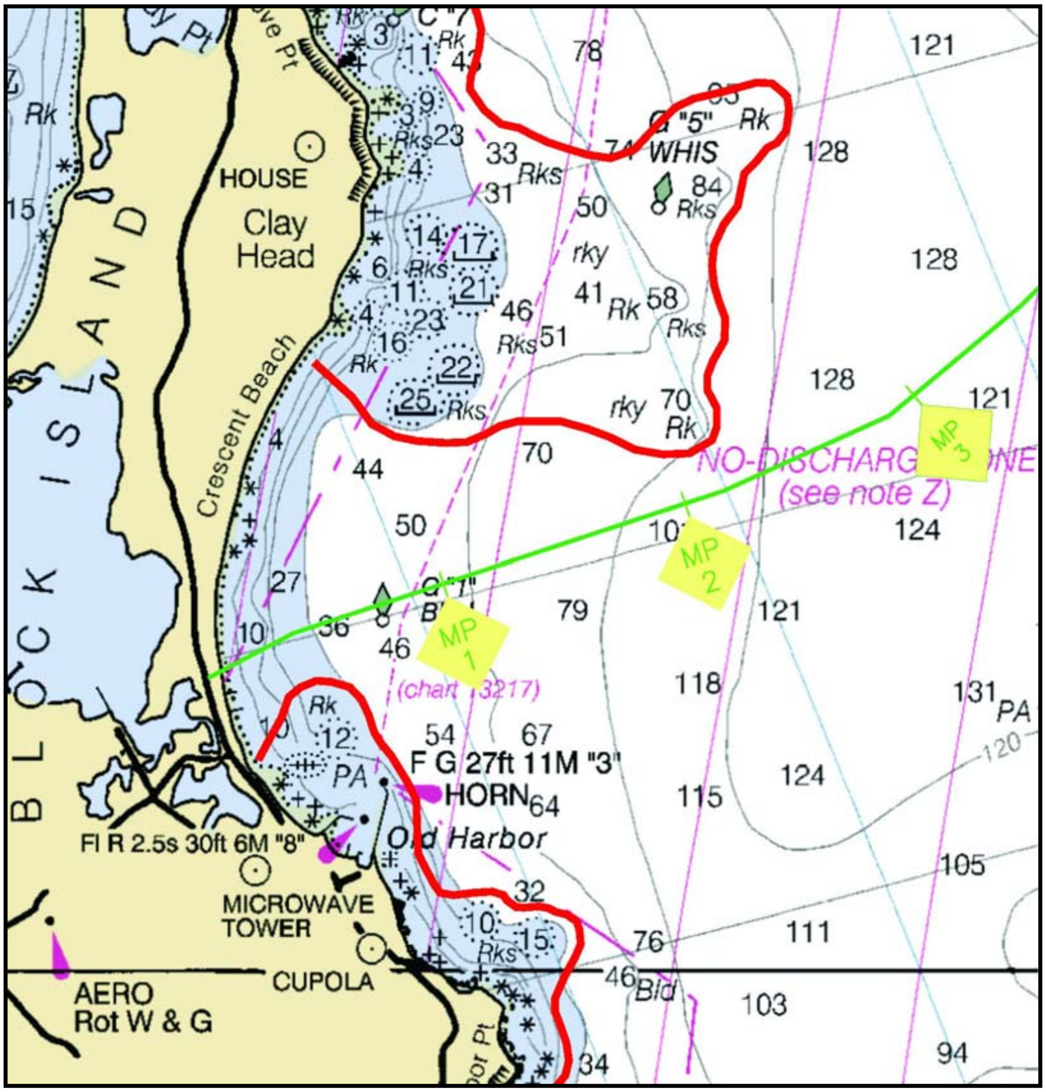


Figure 17. Rocky seafloor areas (outlined in red) in the Block Island nearshore zone located north and south of the BITS route. These areas contain abundant large glacial erratic (boulders). NOAA chart #13218 in background.

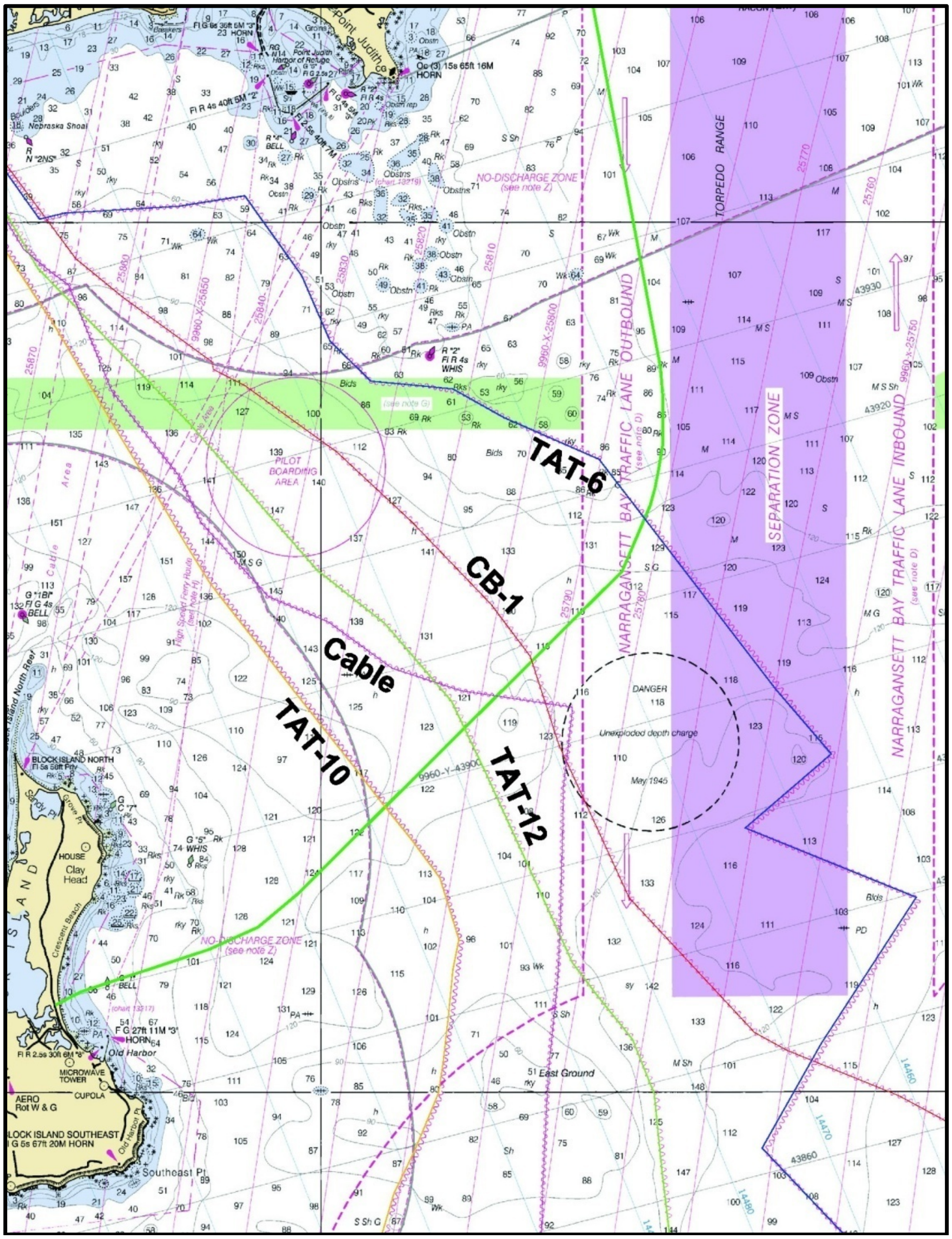


Figure 18. Existing submarine cables crossing the BITS alignment; three Trans-Atlantic telecommunications (TAT) cables, one cable that traverses to Bermuda (CB-1), and one unknown cable at this time ("Cable"). NOAA chart #13218 in background.

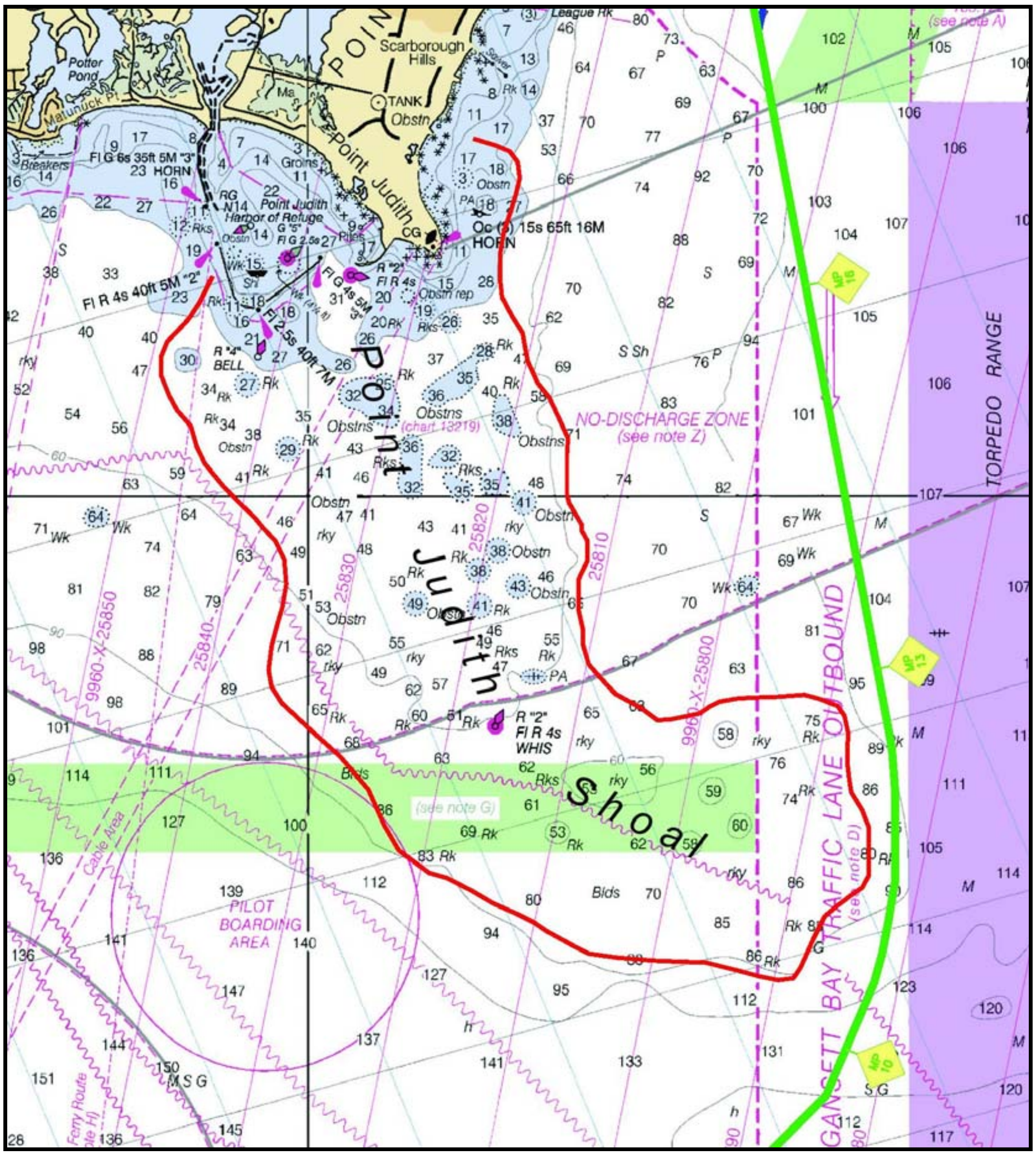


Figure 19. Hard bottom, rocky promontory that extends south from Point Judith. Shoal outline based on nautical chart annotations. NOAA chart #13218 in background.

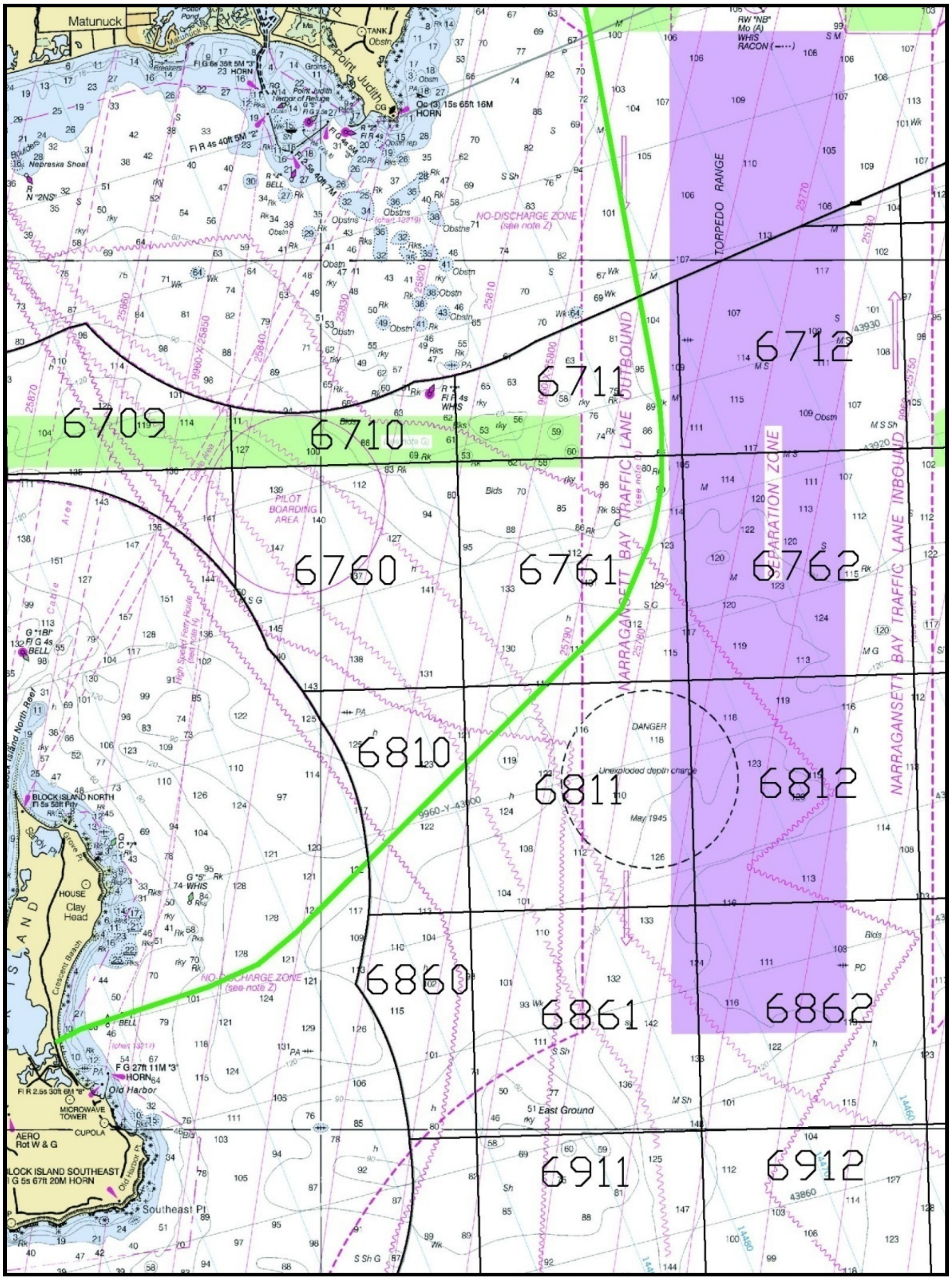


Figure 20. OCS lease blocks traversed by the BITS submarine cable route (6810, 6811, 6761, 6711). NOAA chart #13218 in background.

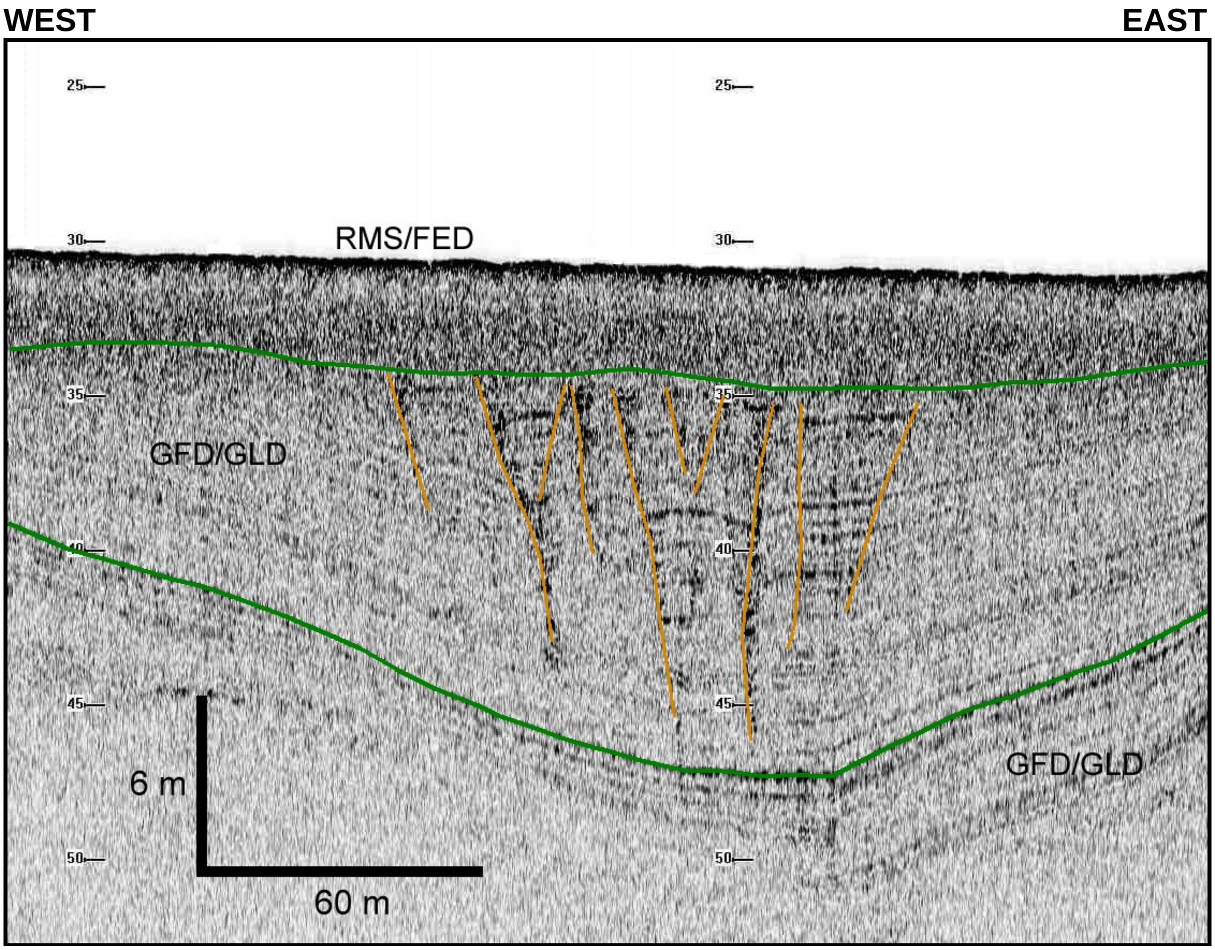


Figure 21. Chirp profile (2-12 kHz) oriented perpendicular to the route (W-E) near MP 14; west end of profile approximately 100 ft east of BITS route. Multiple slip planes evident within the laminated fine grained deposits, where small blocks of sediment have slumped down 0.5-3 ft. RMS/FED=recent marine sediments, fluvial/estuarine deposits, GFD/GLD=glaciofluvial deposits, glaciolacustrine deposits.

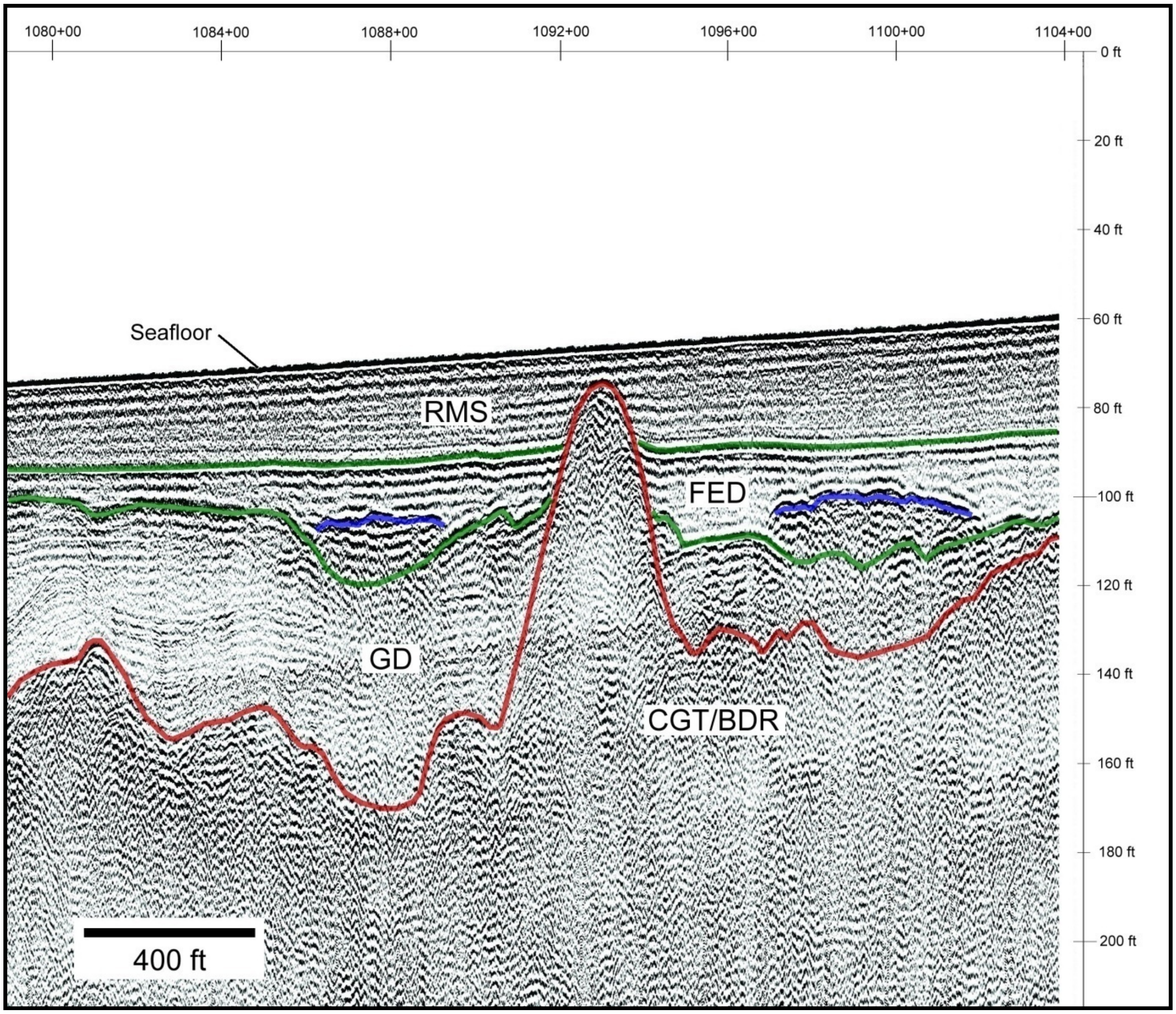


Figure 22. Boomer profile (0.8-4 kHz) revealing a subcrop at MP 20.7 that rises abruptly from deeper below the seafloor. The subcrop material may be coarse glacial till (CGT) or bedrock (BDR). Glacial drift (GD), fluvial and estuarine deposits (FED), and recent marine sediments (RMS) overlie the basement reflector. Blue lines mark small pockets of shallow gas that developed in the organic-rich estuarine deposits. Stationing for BITS primary route along the top of the image. Depth scale (right) is not tide corrected.

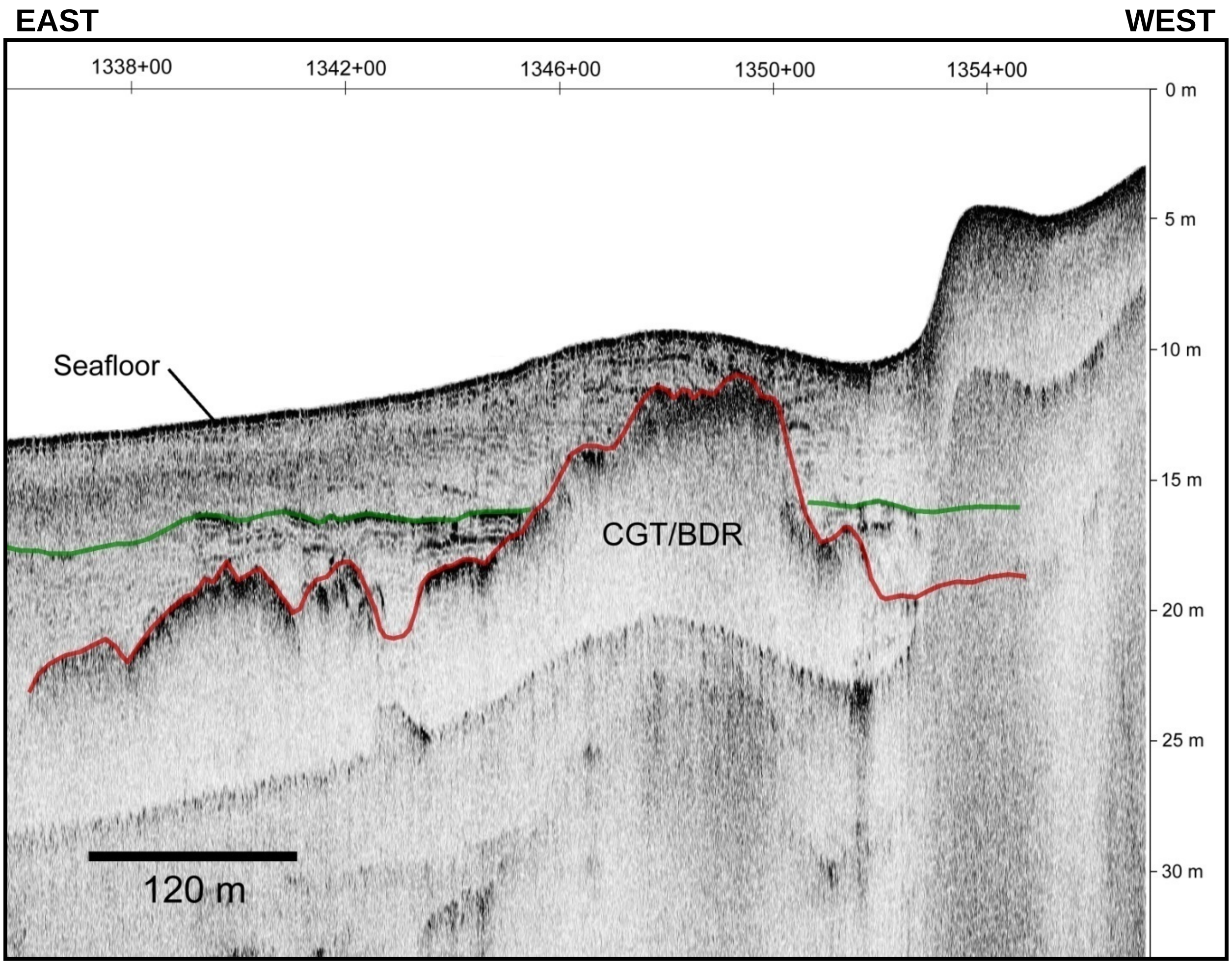


Figure 23. Chirp profile (2-12 kHz) revealing a subcrop at MP 20.7 that rises abruptly from deeper below the seafloor. The subcrop material may be coarse glacial till (CGT) or bedrock.

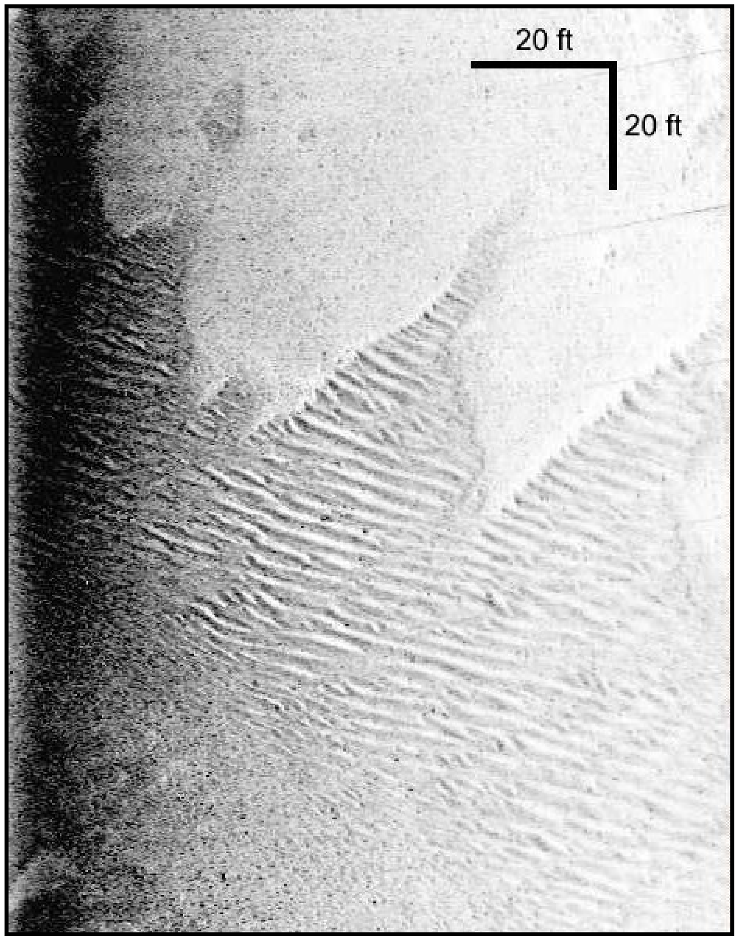


Figure 24. Example of the natural seafloor hazards identified along the BITS route; bedforms (sand waves) and localized, small scale water scour, always found together in the marine environment.

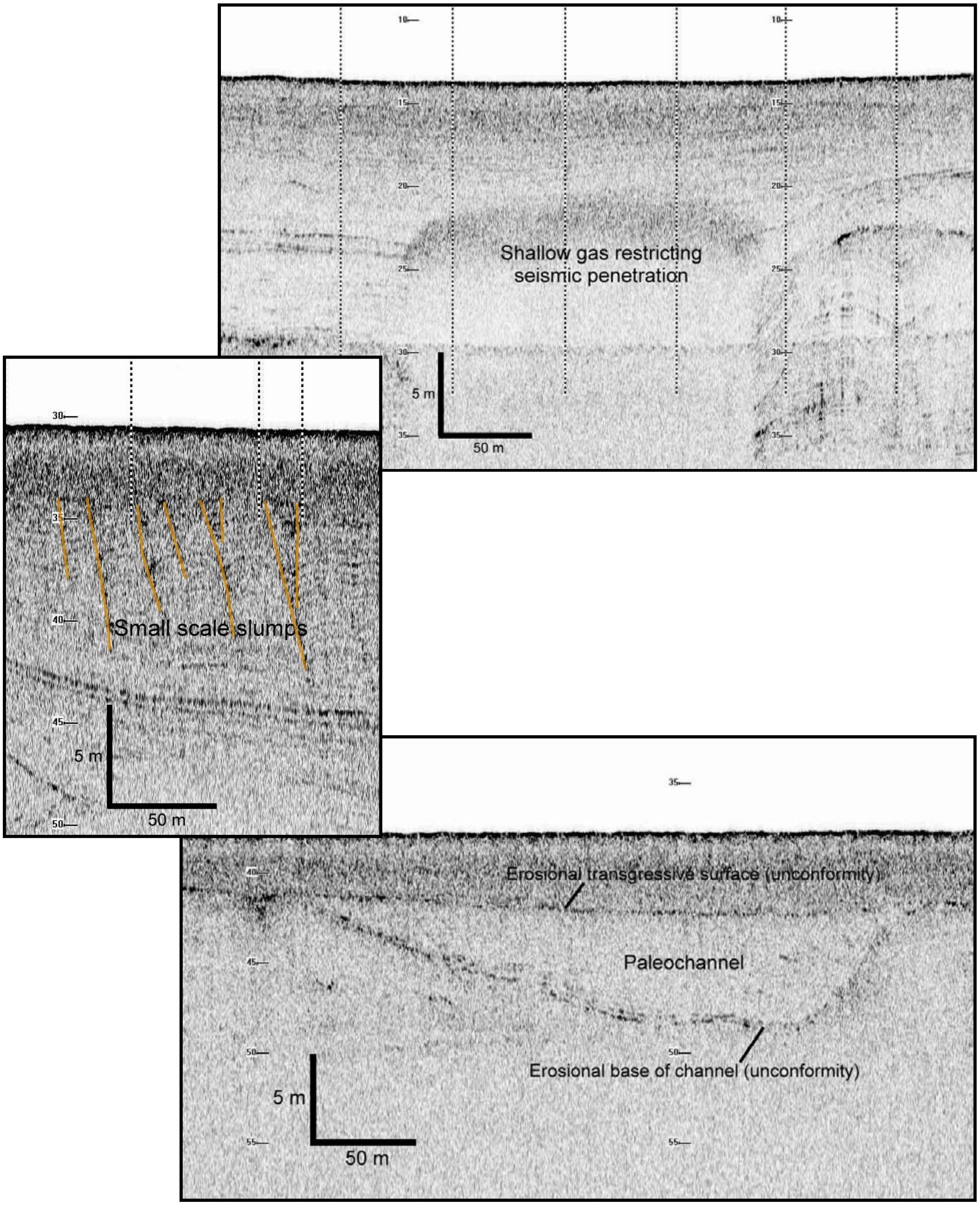
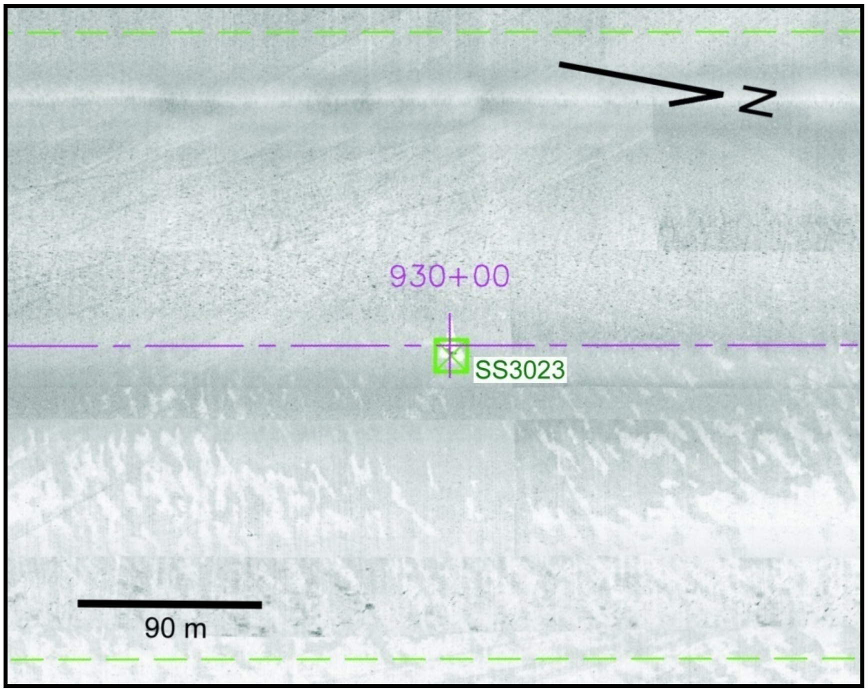


Figure 25. Examples of the natural subsurface hazards identified along the BITS route.



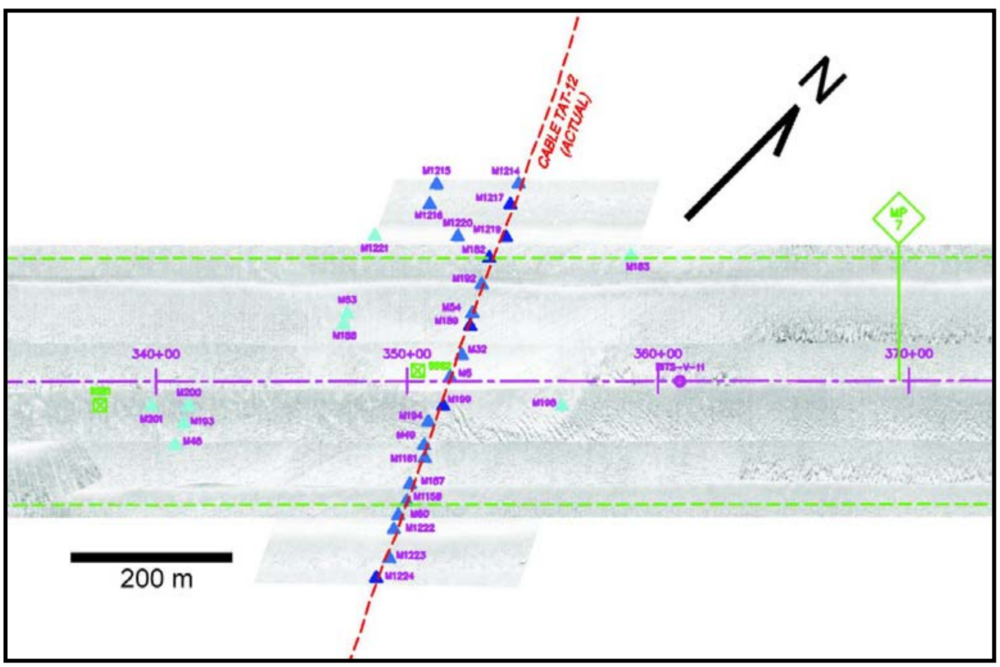


Figure 26. Examples of the man-made hazards identified along the BITS route, including scattered debris (Target SS3023) and existing submarine cables (TAT-12).

APPENDIX 2

GEOTECHNICAL DATA SUMMARY TABLE

Geotechnical Data Summary; BITS Route Vibratory Cores						
Core ID	Easting	Northing	Water Depth	Pene-tration	Recovery	Description
	feet	feet	feet	feet	feet	depth ranges in feet
BITS-V-1	311307.2	37154.9	25	8	8	0.0 - 4.5 : Silty Sand 4.5 - 6.0 : Silty sand with gravel 6.0 - 8.0 : Silty sand
BITS-V-2	315721.7	38777.8	69	3.4	2.5	0.0 - 2.5 : Well graded sand
BITS-ARCH1	318519.7	39294.9	98	10	9.9	0.0 – 0.4 : Fine sand 0.4 – 6.4 : Silt 6.4 – 9.9 : Sandy silt
BITS-V-3	318460.8	39682.0	97	9.7	8.5	0.0 - 2.0 : Silty sand 2.0 - 8.0 : Silt 8.0 - 8.5 : Lean clay
BITS-ARCH2	320643.8	40432.8	120	10	9.8	0.0 – 0.9 : Sand 0.9 – 9.8 : Sandy silt
BITS-V-4	321874.6	41004.3	128	10	9.8	0.0 - 2.5 : Sandy silt 2.5 - 4.5 : Silt 4.5 - 8.0 : Sandy lean clay 8.0 - 9.8 : Silt
BITS-ARCH3	324415.0	42292.5	131	10	9.9	0.0 – 9.9 : Silt
BITS-V-5	324687.7	42646.6	129	10	9.8	0.0 - 5.0 : Sandy silt 5.0 - 9.8 : Silt
BITS-ARCH4	325303.4	43288.8	129	10	9.4	0.0 – 9.4 : Silt
BITS-V-6	327151.2	44808.3	128	10	9.3	0 - 9.3 : Silt
BITS-V-7	329480.0	47123.6	124	10	9.6	0 - 4.5 : Sandy silt 4.5 - 9.5 : Lean clay
BITS-V-8	331799.9	49437.7	120	10	9.2	0.0 - 2.0 : Silty sand 2.0 - 9.2 : Silt
BITS-V-9	334130.1	51749.4	120	10	9.6	0.0 - 9.6 : Silty sand
BITS-V-10	336453.6	54065.3	123	10	9.3	0.0 - 9.3 : Silt
BITS-V-11	338779.7	56375.5	122	10	9.7	0.0 - 4.5 : Silty sand 4.5 - 9.7 : Lean clay
BITS-V-12	341030.2	58611.2	120	8	7.7	0.0 - 7.7 : Silty sand
BITS-V-13	343429.8	60996.4	116	10	8.6	0.0 - 8.6 : Poorly graded sand
BITS-V-14	345762.6	63323.7	114	9.9	7.6	0.0 - 5.0 : Poorly graded sand 5.0 - 7.6 : Graded sand with gravel
BITS-V-15	347748.6	65296.6	115	10.0	8.5	0.0 - 4.0 : Silty Sand 4.0 - 8.5 : Lean clay
BITS-V-16	349482.7	67466.1	127	10.0	8.5	0.0 - 8.5 : Sandy silt
BITS-V-17	351504.5	72804.7	104	9.9	6.8	0.0 - 6.8 : Poorly graded sand

Geotechnical Data Summary; BITS Route Vibratory Cores						
Core ID	Easting	Northing	Water Depth	Pene-tration	Recovery	Description
	feet	feet	feet	feet	feet	depth ranges in feet
BITS-V-18	351822.0	74551.0	98	10.0	9.4	0.0 - 6.5 : Poorly graded sand 6.5 - 9.4 - Silty sand
BITS-V-19	351981.0	77819.0	89	10.0	9.4	0.0 - 6.0 : Graded sand with gravel 6.0 - 9.4 : Graded gravel with sand
BITS-V-20	351798.0	81091.0	102	10.0	9.7	0.0 - 9.7 : Silt
BITS-V-21	351600.0	82164.0	104	10.0	9.2	0.0 - 9.2 : Silt
BITS-V-22	350594.0	87541.0	104	10.0	9.7	0.0 - 9.7 : Silt
BITS-V-23	349991.0	90766.0	103	10.0	9.6	0.0 - 9.6 : Silt
BITS-V-24	349389.0	93991.0	104	10.0	9.5	0.0 - 9.5 : Silt
BITS-V24 (DUP)	349394.0	93982.7	104	10.0	9.0	0.0 - 9.0 : Silt
BITS-V-25	348787.2	97215.7	104	10.0	9.7	0.0 - 9.7 : Silt
BITS-V-26	348182.3	100442.9	103	10.0	10.0	0.0 - 10.0 : Silt
BITS-ARCH6	347814.8	102418.3	96	10.0	9.8	0.0 – 9.8 : Silt
BITS-V-27	347585.5	103668.9	93	10.0	9.0	0.0 - 9.0 : Graded sand with gravel
BITS-V-28	346977.1	106891.0	92	8.0	6.5	0.0 - 1.0 : Silty sand 1.0 - 5.0 : Sandy silt 5.0 - 6.5 : Graded sand with gravel
BITS-V-29	346584.7	109003.3	98	10.0	8.3	0.0 - 8.3 : Lean clay
BITS-V-30	345775.7	113340.1	97	10.0	8.7	0.0 - 8.7 : Silt
BITS-ARCH7	345604.2	113733.8	97	10.0	8.0	0.0 – 8.0 : Silt
BITS-V-31	345176.0	116565.1	92	10.0	8.6	0.0 - 8.5 : Silt
BITS-V-32	344572.4	119788.6	81	10.0	9.2	0.0 - 9.2 : Silt with sand
BITS-V-33	343924.3	123003.8	66	10.0	9.6	0.0 - 9.6 : Silt
BITS-V-34	342588.3	126281.7	41	3.1	2.6	0.0 - 2.6 : Silty sand
BITS-ARCH8	342425.6	126315.9	40	7.0	6.3	0.0 – 6.2 : Silt
BITS-ARCH9	341913.5	126561.7	33	2.9	2.3	0.0 – 2.3 : Sand
ALT-V-48	346856.3	112232.0	99	10.0	8.8	0.0 - 8.8 : Lean clay
ALT-V-49	347447.6	115453.2	98	10.0	9.7	0.0 - 6.0 : Silt with sand 6.0 - 9.7 : Lean clay with sand
ALT-V-50	348359.0	118601.9	94	10.0	9.8	0.0 - 9.8 : Silt
ALT-V-51	349362.6	121725.8	89	7.8	7.0	0.0 - 7.0 : Silt
ALT-ARCH12	349599.1	122456.2	87	10.0	9.9	0.0 – 9.9 : Silt
ALT-V-52	350368.7	124844.7	83	10.0	10.0	0.0 - 10.0 : Silt

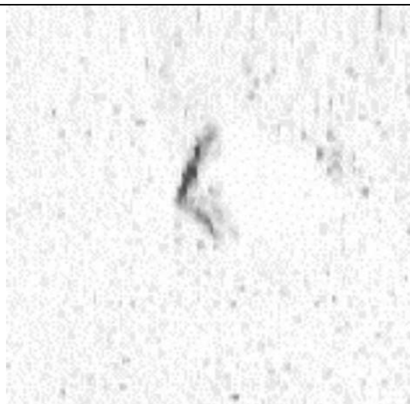
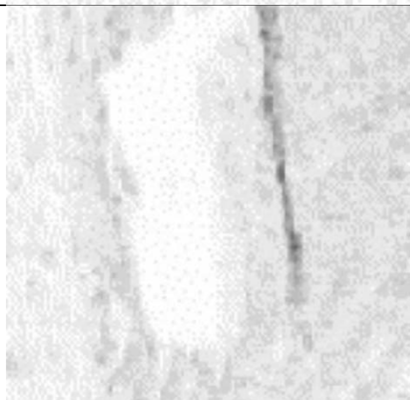
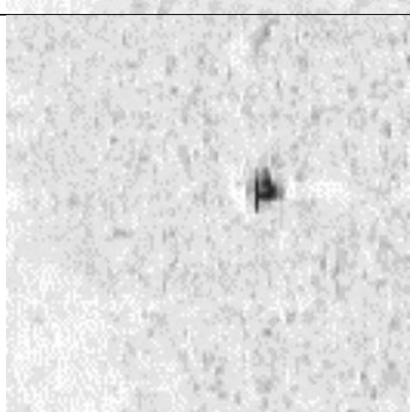
Geotechnical Data Summary; BITS Route Vibratory Cores						
Core ID	**Easting**	**Northing**	**Water Depth**	**Pene-tration**	**Recovery**	**Description**
	feet	feet	feet	feet	feet	depth ranges in feet
ALT-V-53	351372.1	127968.7	73	10.0	9.5	0.0 - 9.5 : Silt
ALT-V-54	352104.4	130263.1	68	10.0	9.5	0.0 - 9.5 : Silt
ALT-ARCH13	352332.9	131234.4	66	10.0	9.6	0.0 – 9.6 : Silt
ALT-V-55	352563.6	134375.0	56	10.0	8.5	0.0 - 8.5 : Silt
ALT-V-56	352806.5	137646.1	50	10.0	9.6	0.0 - 9.6 : Sandy silt
ALT-V-57	353049.0	140916.1	49	10.0	9.6	0.0 - 9.6 : Silt
ALT-ARCH14	353171.2	142626.4	45	10.0	9.9	0.0 – 9.9 : Sandy silt
ALT-ARCH15	353208.7	143056.4	44	10.0	8.1	0.0 – 4.0 : Silt 4.0 – 8.1 : Silt
ALT-ARCH16	353258.4	143766.9	40	10.0	8.6	0.0 – 4.0 : Silty sand 4.0 – 8.1 : Sand
ALT-V-58	353287.8	144183.2	39	10.0	8.8	0.0 - 4.0 : Silt 4.0 - 8.8 : Silty sand
ALT-V-60	350967.1	147599.9	22	7.5	7.1	0.0 - 4.0 : Silty sand 4.0 - 7.1 : Silty gravel with sand

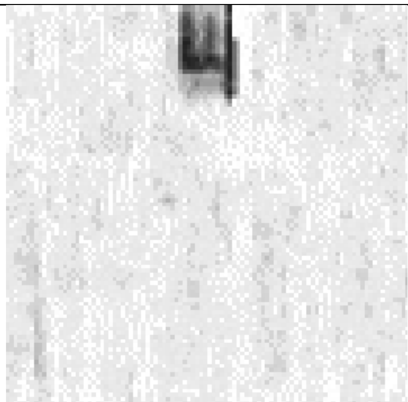
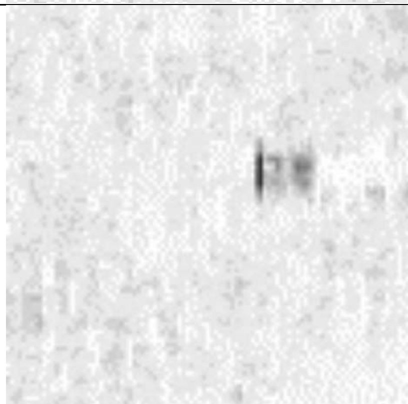
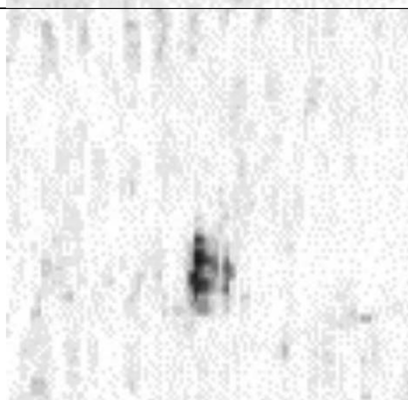
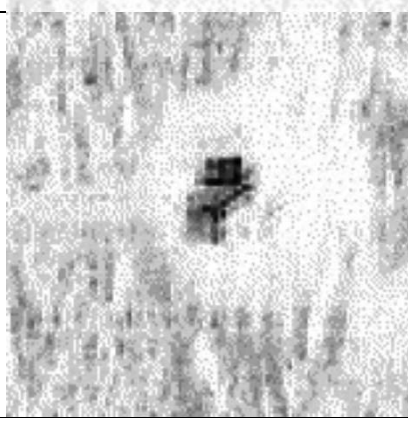
Notes:

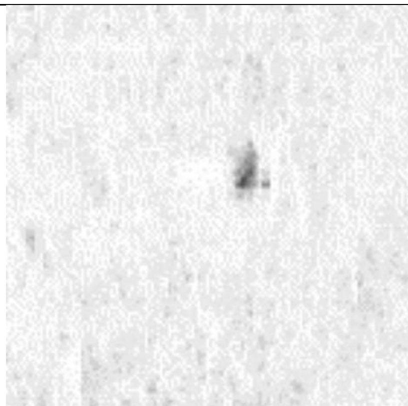
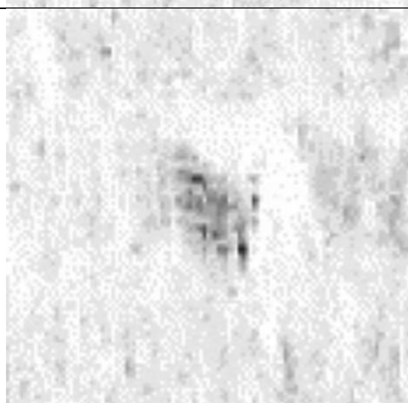
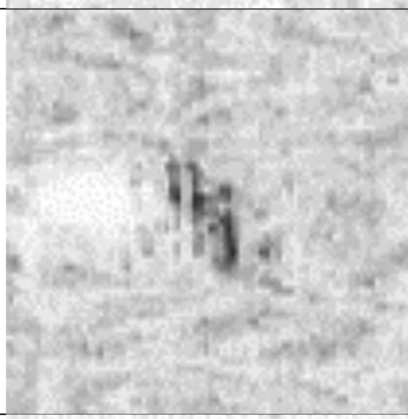
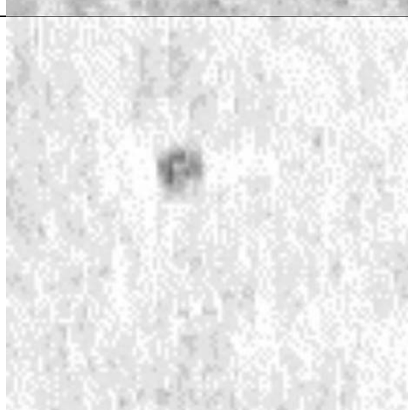
1. Coordinates are referenced to RI State Plane, Zone 3800, NAD83, in feet.
2. Water depths recorded at the time of sample collection; not tide corrected.
3. Descriptions are summarized from the AECOM and Fathom Research (archy) core logs.

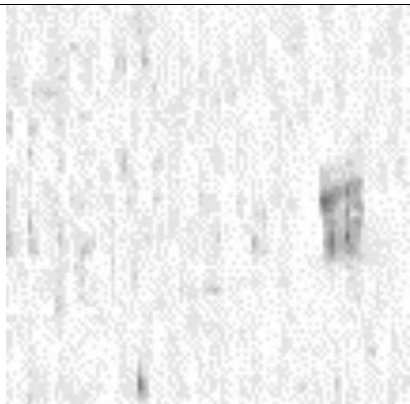
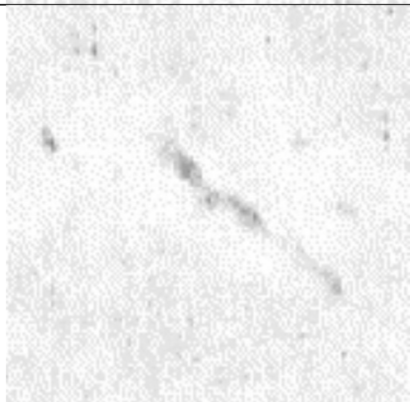
APPENDIX 3

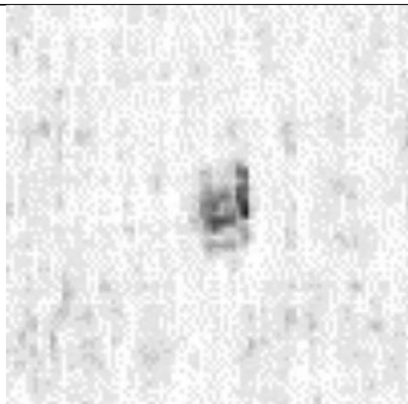
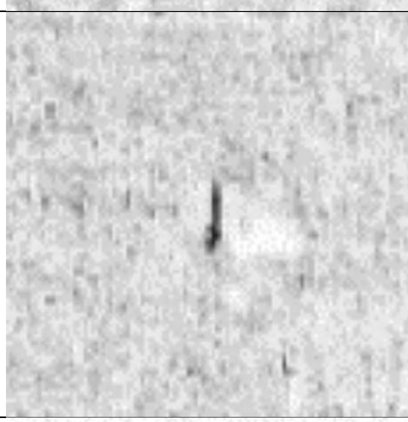
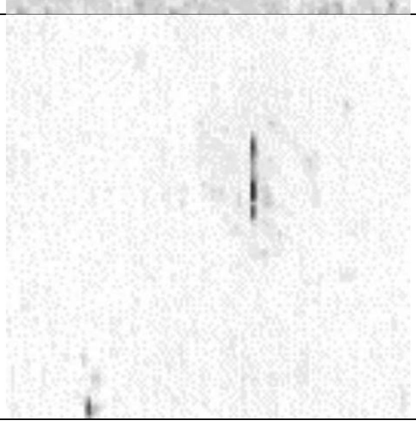
SIDE SCAN SONAR TARGET REPORTS AND LISTINGS

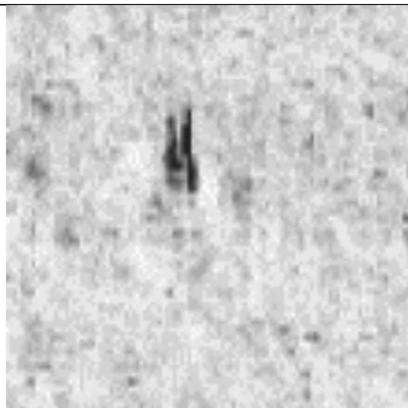
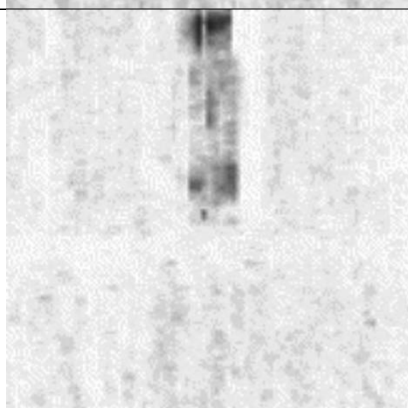
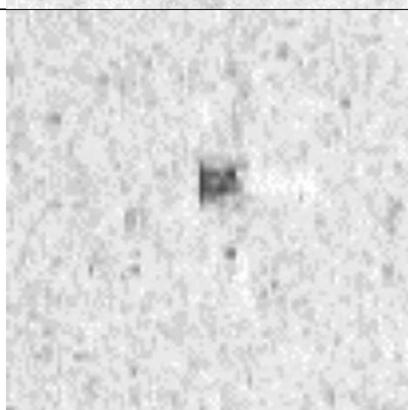
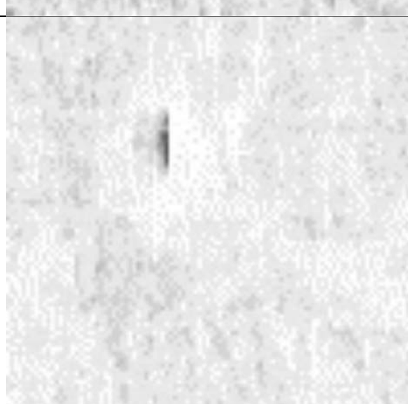
Side Scan Sonar Target Report; BITS Primary Route		
Contact Image	**Contact Info**	**User Entered Info**
	**SS3004** • (X) 341516 (Y) 126595	**Dimensions** Target Height: 1.7 US Feet Target Length: 11.7 US Feet Target Width: 4.3 US Feet Description: Oblong target
	**SS3006** • (X) 340913 (Y) 126536	**Dimensions** Target Height: 4.3 US Feet Target Length: 22.0 US Feet Target Width: 5.5 US Feet Description: Linear target
	**SS3008** • (X) 347243 (Y) 106946	**Dimensions** Target Height: 1.0 US Feet Target Length: 4.0 US Feet Target Width: 3.6 US Feet Description: Oblong target

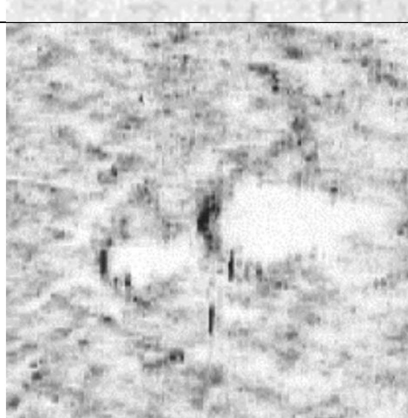
	**SS3009** • (X) 350539 (Y) 90785	**Dimensions** Target Height: 0.0 US Feet Target Length: 5.9 US Feet Target Width: 4.4 US Feet Description: Oblong target
	**SS3010** • (X) 350328 (Y) 90449	**Dimensions** Target Height: 0.9 US Feet Target Length: 3.3 US Feet Target Width: 4.5 US Feet Description: Oblong target
	**SS3013** • (X) 350433 (Y) 89398	**Dimensions** Target Height: 0.0 US Feet Target Length: 6.4 US Feet Target Width: 3.5 US Feet Description: Oblong target
	**SS3014** • (X) 351147 (Y) 87559	**Dimensions** Target Height: 0.8 US Feet Target Length: 10.1 US Feet Target Width: 6.0 US Feet Description: Oblong target

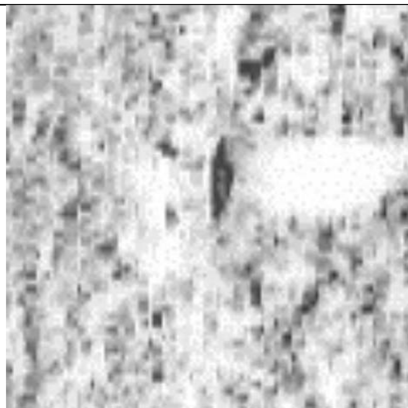
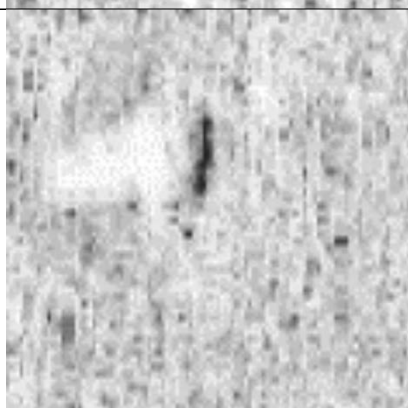
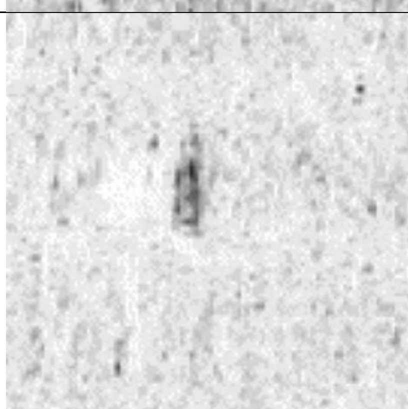
	**SS3015** • (X) 351910 (Y) 83221	**Dimensions** Target Height: 1.1 US Feet Target Length: 6.2 US Feet Target Width: 2.0 US Feet Description: Oblong target
	**SS3016** • (X) 352302 (Y) 81339	**Dimensions** Target Height: 0.0 US Feet Target Length: 9.7 US Feet Target Width: 6.5 US Feet Description: Oblong target
	**SS3017** • (X) 352468 (Y) 79819	**Dimensions** Target Height: 0.9 US Feet Target Length: 7.6 US Feet Target Width: 4.3 US Feet Description: Oblong target
	**SS3019** • (X) 349014 (Y) 97588	**Dimensions** Target Height: 0.9 US Feet Target Length: 3.6 US Feet Target Width: 3.9 US Feet Description: Oblong target

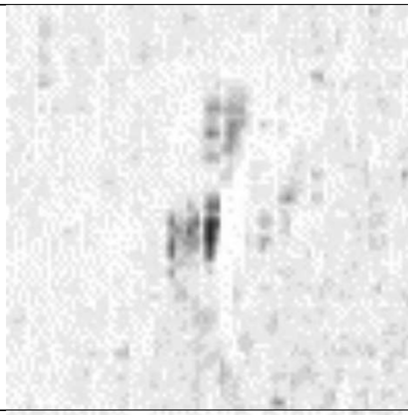
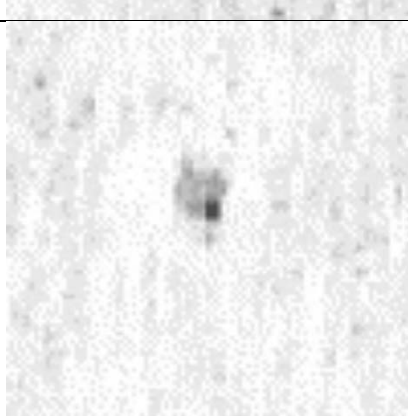
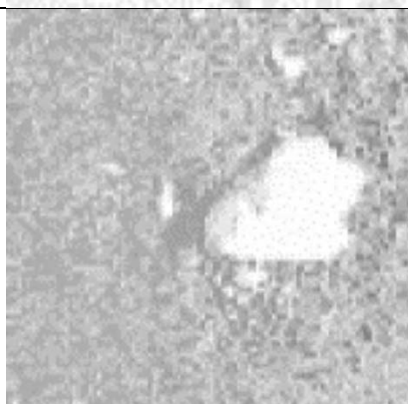
	**SS3020** • (X) 349688 (Y) 93434	**Dimensions** Target Height: 0.0 US Feet Target Length: 8.9 US Feet Target Width: 4.1 US Feet Description: Oblong target
	**SS3022** • (X) 345307 (Y) 116144	**Dimensions** Target Height: 0.0 US Feet Target Length: 24.8 US Feet Target Width: 2.4 US Feet Description: Linear target
	**SS3023** • (X) 346788 (Y) 108014	**Dimensions** Target Height: 4.0 US Feet Target Length: 25.9 US Feet Target Width: 4.8 US Feet Description: Oblong target
	**SS3024** • (X) 347499 (Y) 104789	**Dimensions** Target Height: 4.3 US Feet Target Length: 11.8 US Feet Target Width: 6.6 US Feet Description: Oblong target

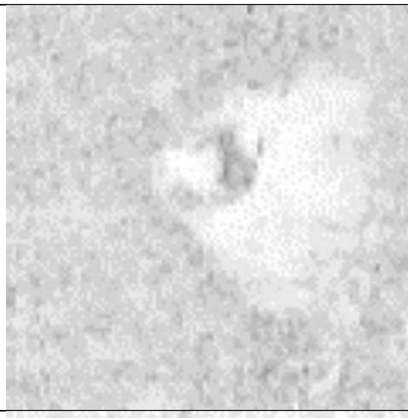
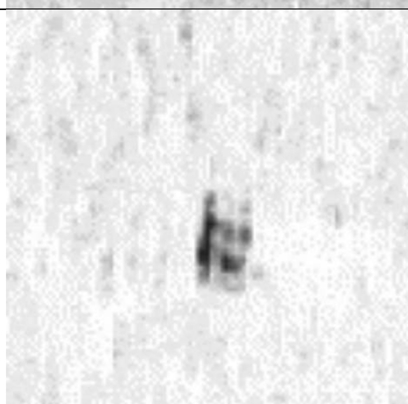
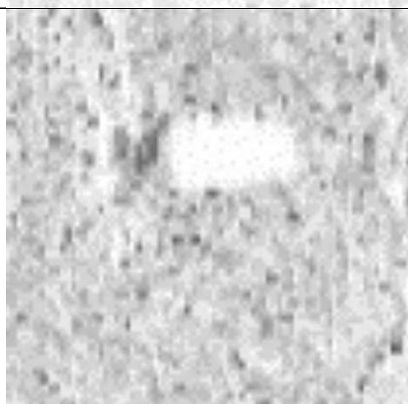
	**SS3027** • (X) 350422 (Y) 90511	**Dimensions** Target Height: 0.0 US Feet Target Length: 5.1 US Feet Target Width: 4.1 US Feet Description: Oblong target
	**SS3029** • (X) 351833 (Y) 80610	**Dimensions** Target Height: 0.0 US Feet Target Length: 22.2 US Feet Target Width: 2.1 US Feet Description: Linear target
	**SS3031** • (X) 352025 (Y) 79191	**Dimensions** Target Height: 0.9 US Feet Target Length: 7.1 US Feet Target Width: 1.4 US Feet Description: Linear target
	**SS3033** • (X) 344685 (Y) 120422	**Dimensions** Target Height: 0.0 US Feet Target Length: 9.8 US Feet Target Width: 0.7 US Feet Description: Linear target

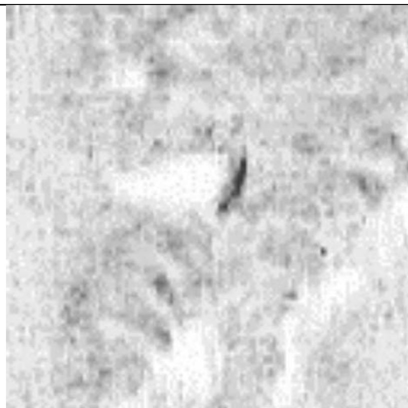
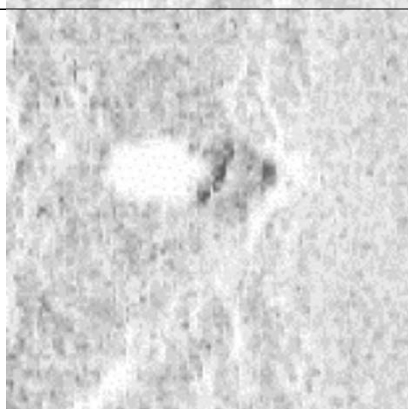
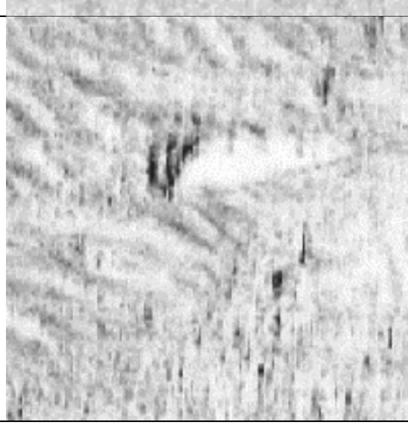
	**SS3036** • (X) 346914 (Y) 106490	**Dimensions** Target Height: 0.7 US Feet Target Length: 8.2 US Feet Target Width: 2.5 US Feet Description: Oblong target
	**SS3037** • (X) 349039 (Y) 94904	**Dimensions** Target Height: 0.6 US Feet Target Length: 17.1 US Feet Target Width: 3.9 US Feet Description: Oblong target
	**SS3042** • (X) 347099 (Y) 104558	**Dimensions** Target Height: 1.1 US Feet Target Length: 3.5 US Feet Target Width: 3.2 US Feet Description: Oblong target
	**SS3043** • (X) 348642 (Y) 97648	**Dimensions** Target Height: 0.0 US Feet Target Length: 5.8 US Feet Target Width: 1.1 US Feet Description: Oblong target

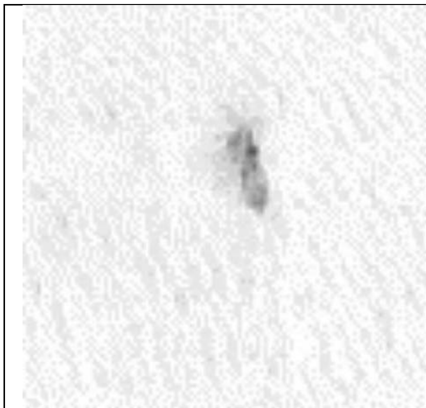
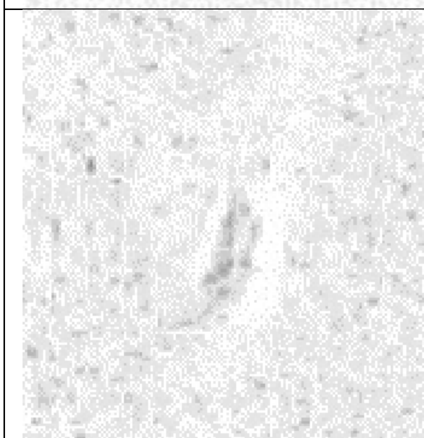
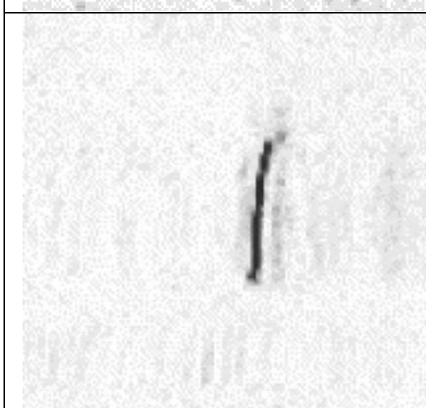
	**SS3044** • (X) 349873 (Y) 89858	**Dimensions** Target Height: 0.9 US Feet Target Length: 5.8 US Feet Target Width: 3.0 US Feet Description: Oblong target
	**SS3046** • (X) 351419 (Y) 82664	**Dimensions** Target Height: 1.2 US Feet Target Length: 10.9 US Feet Target Width: 7.3 US Feet Description: Oblong target
	**SS3047** • (X) 351571 (Y) 80057	**Dimensions** Target Height: 4.0 US Feet Target Length: 10.0 US Feet Target Width: 4.3 US Feet Description: Oblong target
	**SS3048** • (X) 351794 (Y) 79566	**Dimensions** Target Height: 3.3 US Feet Target Length: 4.7 US Feet Target Width: 2.0 US Feet Description: Oblong target

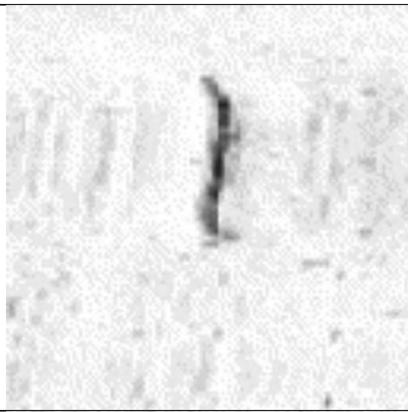
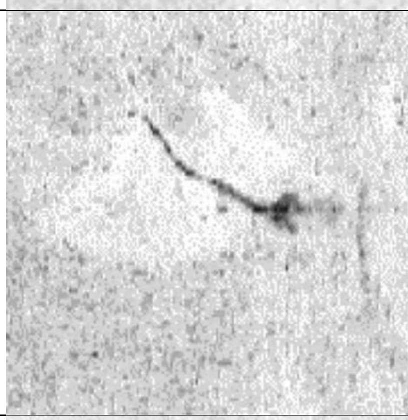
	**SS3049** • (X) 351666 (Y) 79273	**Dimensions** Target Height: 3.0 US Feet Target Length: 8.9 US Feet Target Width: 2.5 US Feet Description: Oblong target
	**SS3050** • (X) 351923 (Y) 79075	**Dimensions** Target Height: 2.0 US Feet Target Length: 9.3 US Feet Target Width: 1.4 US Feet Description: Oblong target
	**SS3053** • (X) 346539 (Y) 106428	**Dimensions** Target Height: 0.8 US Feet Target Length: 9.1 US Feet Target Width: 2.4 US Feet Description: Oblong target
	**SS3054** • (X) 349253 (Y) 93633	**Dimensions** Target Height: 0.0 US Feet Target Length: 4.8 US Feet Target Width: 3.5 US Feet Description: Oblong target

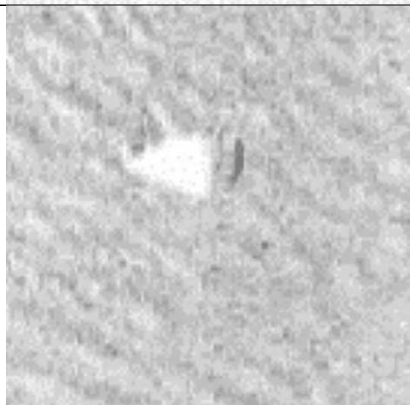
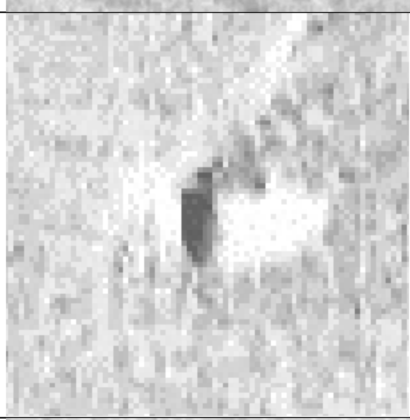
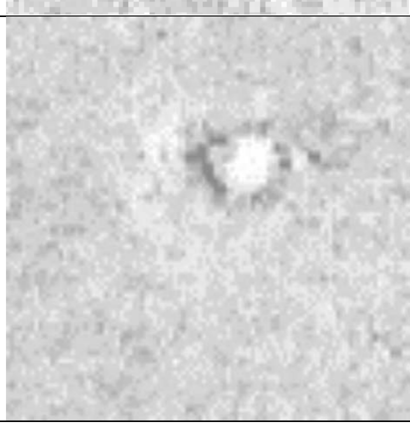
	**SS3055** • (X) 348853 (Y) 93865	**Dimensions** Target Height: 0.0 US Feet Target Length: 6.0 US Feet Target Width: 3.6 US Feet Description: Oblong target
	**SS3056** • (X) 349083 (Y) 94639	**Dimensions** Target Height: 0.2 US Feet Target Length: 4.4 US Feet Target Width: 4.1 US Feet Description: Oblong target
	**SS3064** • (X) 351595 (Y) 79608	**Dimensions** Target Height: 4.6 US Feet Target Length: 18.9 US Feet Target Width: 3.8 US Feet Description: Linear target
	**SS3066** • (X) 351466 (Y) 80148	**Dimensions** Target Height: 5.2 US Feet Target Length: 5.3 US Feet Target Width: 3.8 US Feet Description: Oblong target

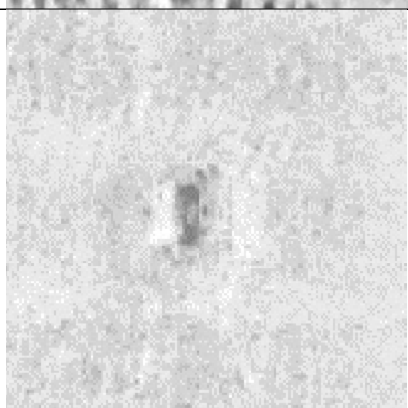
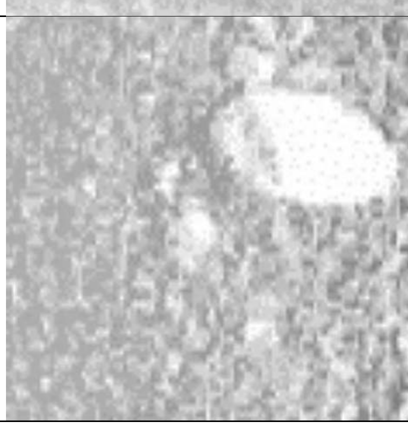
	**SS3068** • (X) 351413 (Y) 80587	**Dimensions** Target Height: 1.5 US Feet Target Length: 7.0 US Feet Target Width: 3.5 US Feet : Description: Oblong target
	**SS3069** • (X) 350533 (Y) 89429	**Dimensions** Target Height: 1.3 US Feet Target Length: 7.0 US Feet Target Width: 4.5 US Feet Description: Oblong target
	**SS1** • (X) 352307 (Y) 78378	**Dimensions** Target Height: 2.0 US Feet Target Length: 4.7 US Feet Target Width: 3.4 US Feet Description: Oblong target
	**SS4** • (X) 352475 (Y) 77644	**Dimensions** Target Height: 3.2 US Feet Target Length: 7.3 US Feet Target Width: 2.6 US Feet Description: Oblong target

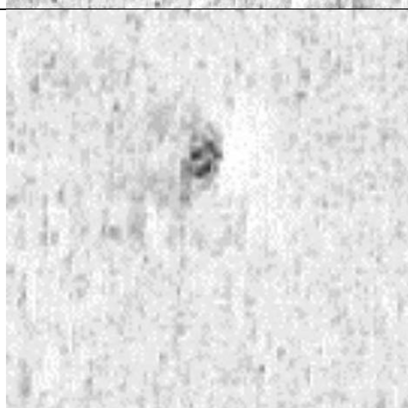
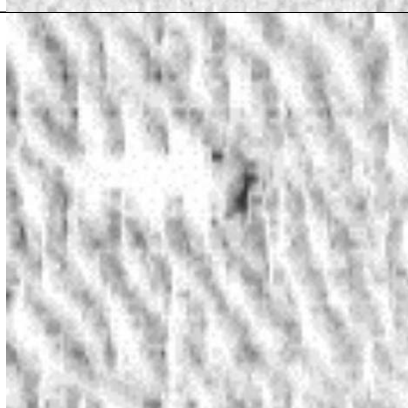
	**SS5** • (X) 352512 (Y) 77449	**Dimensions** Target Height: 1.6 US Feet Target Length: 7.3 US Feet Target Width: 1.9 US Feet Description: Oblong target
	**SS6** • (X) 352481 (Y) 76087	**Dimensions** Target Height: 2.3 US Feet Target Length: 8.9 US Feet Target Width: 7.4 US Feet Description: Oblong target
	**SS7** • (X) 352361 (Y) 74894	**Dimensions** Target Height: 3.8 US Feet Target Length: 9.5 US Feet Target Width: 4.0 US Feet Description: Oblong target
	**SS8** • (X) 352063 (Y) 74650	**Dimensions** Target Height: 2.4 US Feet Target Length: 10.2 US Feet Target Width: 9.9 US Feet Description: Oblong target

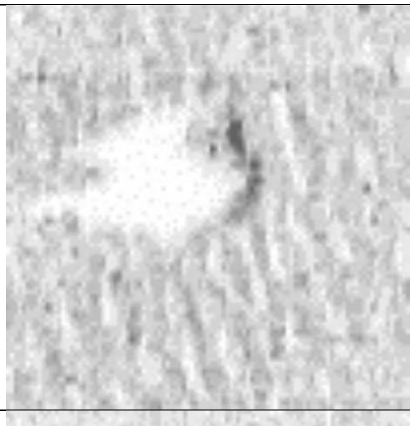
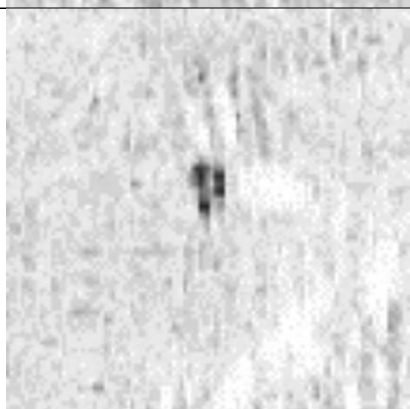
	**SS9** • (X) 310703 (Y) 36693	**Dimensions** Target Height: 0.0 US Feet Target Length: 5.5 US Feet Target Width: 1.8 US Feet Description: Oblong target
	**SS10** • (X) 311839 (Y) 37886	**Dimensions** Target Height: 0.2 US Feet Target Length: 7.3 US Feet Target Width: 2.9 US Feet Description: Oblong target
	**SS11** • (X) 311155 (Y) 36709	**Dimensions** Target Height: 0.0 US Feet Target Length: 10.9 US Feet Target Width: 0.8 US Feet Description: Linear target
	**SS12** • (X) 311118 (Y) 36756	**Dimensions** Target Height: 0.5 US Feet Target Length: 8.3 US Feet Target Width: 4.1 US Feet Description: Oblong target

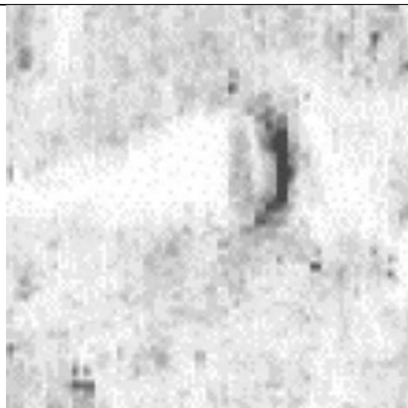
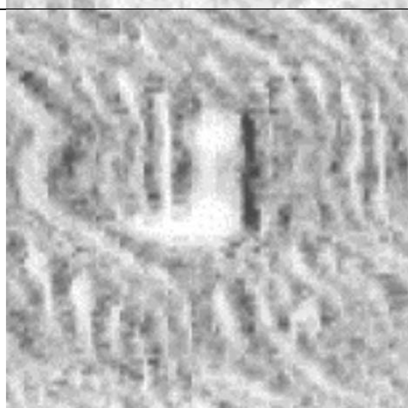
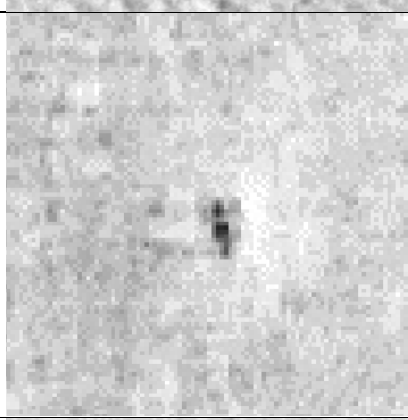
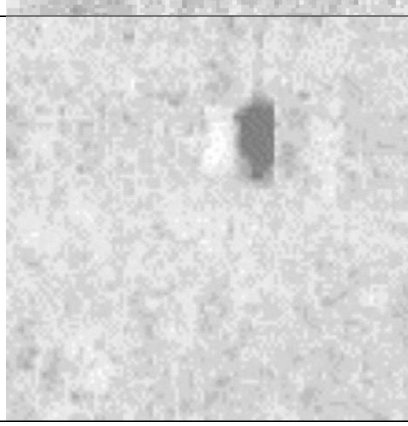
	**SS13** • (X) 311338 (Y) 36655	**Dimensions** Target Height: 0.0 US Feet Target Length: 9.5 US Feet Target Width: 2.1 US Feet Description: Linear target
	**SS14** • (X) 313318 (Y) 37666	**Dimensions** Target Height: 1.1 US Feet Target Length: 7.8 US Feet Target Width: 5.2 US Feet Description: Oblong target
	**SS15** • (X) 313199 (Y) 37663	**Dimensions** Target Height: 2.1 US Feet Target Length: 26.7 US Feet Target Width: 5.3 US Feet Description: Linear target
	**SS16** • (X) 313255 (Y) 37603	**Dimensions** Target Height: 0.6 US Feet Target Length: 7.6 US Feet Target Width: 3.3 US Feet Description: Oblong target

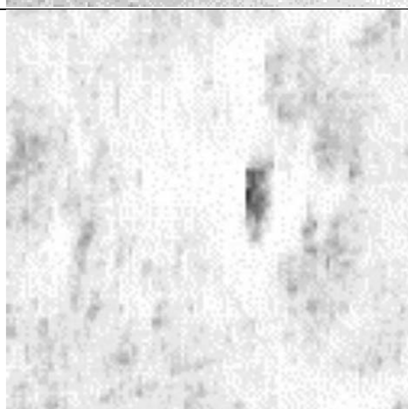
	**SS18** • (X) 350542 (Y) 68770	**Dimensions** Target Height: 0.1 US Feet Target Length: 1.1 US Feet Target Width: 0.0 US Feet Description: Linear target
	**SS19** • (X) 349495 (Y) 66359	**Dimensions** Target Height: 3.8 US Feet Target Length: 8.2 US Feet Target Width: 4.1 US Feet Description: Oblong target
	**SS20** • (X) 349330 (Y) 66304	**Dimensions** Target Height: 1.9 US Feet Target Length: 7.2 US Feet Target Width: 2.8 US Feet Description: Oblong target
	**SS21** • (X) 344063 (Y) 60983	**Dimensions** Target Height: 0.7 US Feet Target Length: 7.2 US Feet Target Width: 7.6 US Feet Description: Oblong target

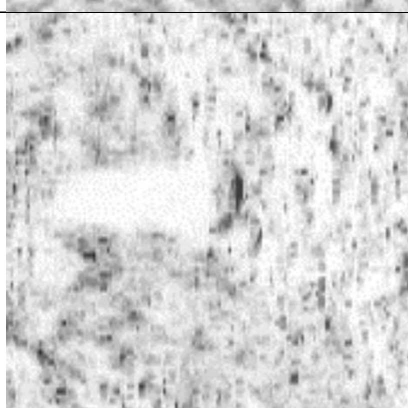
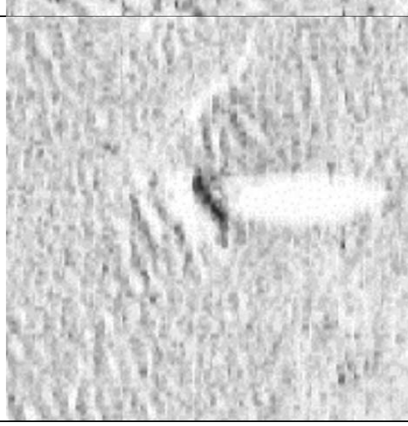
	**SS22** • (X) 344974 (Y) 62147	**Dimensions** Target Height: 1.9 US Feet Target Length: 4.7 US Feet Target Width: 3.6 US Feet Description: Oblong target
	**SS23** • (X) 329839 (Y) 46873	**Dimensions** Target Height: 1.2 US Feet Target Length: 6.9 US Feet Target Width: 3.2 US Feet Description: Oblong target
	**SS24** • (X) 352247 (Y) 78261	**Dimensions** Target Height: 2.6 US Feet Target Length: 5.9 US Feet Target Width: 3.9 US Feet Description: Oblong target
	**SS25** • (X) 352142 (Y) 77318	**Dimensions** Target Height: 3.7 US Feet Target Length: 11.6 US Feet Target Width: 8.8 US Feet Description: Oblong target

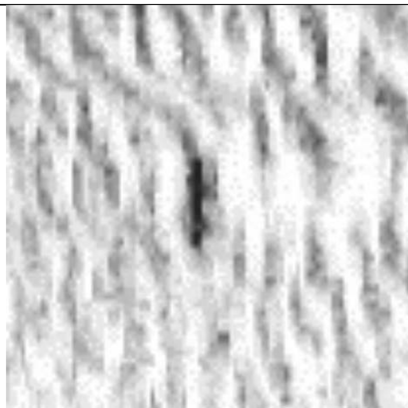
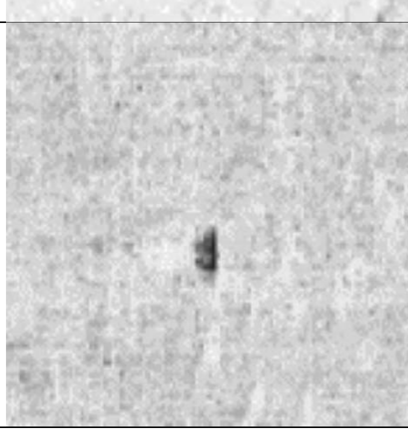
	**SS26** • (X) 351863 (Y) 74179	**Dimensions** Target Height: 2.9 US Feet Target Length: 9.5 US Feet Target Width: 4.4 US Feet Description: Oblong target
	**SS27** • (X) 349773 (Y) 67210	**Dimensions** Target Height: 0.0 US Feet Target Length: 5.5 US Feet Target Width: 4.1 US Feet Description: Oblong target
	**SS29** • (X) 349016 (Y) 66068	**Dimensions** Target Height: 2.1 US Feet Target Length: 6.3 US Feet Target Width: 3.1 US Feet Description: Oblong target
	**SS30** • (X) 347159 (Y) 64513	**Dimensions** Target Height: 3.8 US Feet Target Length: 8.9 US Feet Target Width: 6.6 US Feet Description: Oblong target

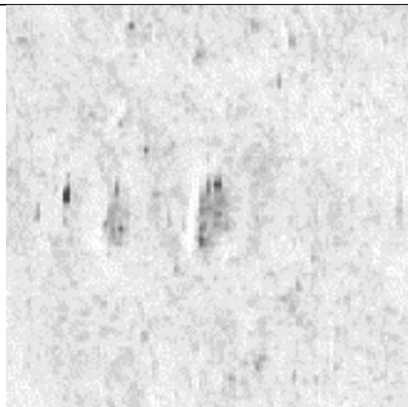
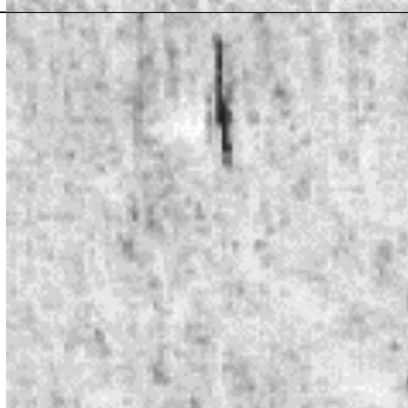
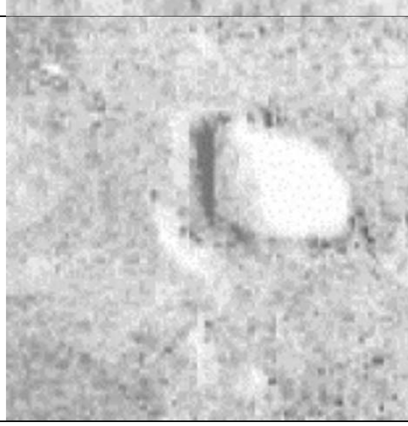
	**SS31** • (X) 346549 (Y) 63676	**Dimensions** Target Height: 2.5 US Feet Target Length: 10.7 US Feet Target Width: 4.1 US Feet Description: Oblong target
	**SS33** • (X) 342926 (Y) 60069	**Dimensions** Target Height: 0.9 US Feet Target Length: 5.1 US Feet Target Width: 3.4 US Feet Description: Oblong target
	**SS34** • (X) 351877 (Y) 76746	**Dimensions** Target Height: 3.0 US Feet Target Length: 8.8 US Feet Target Width: 2.9 US Feet Description: Linear target
	**SS35** • (X) 351815 (Y) 73890	**Dimensions** Target Height: 1.8 US Feet Target Length: 9.3 US Feet Target Width: 3.1 US Feet Description: Linear target

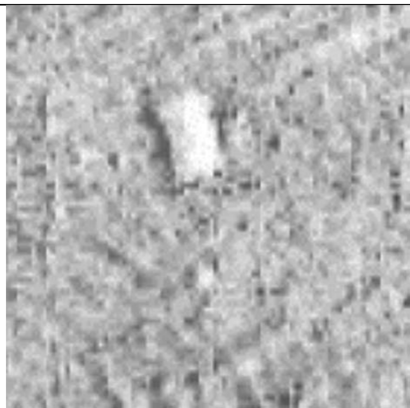
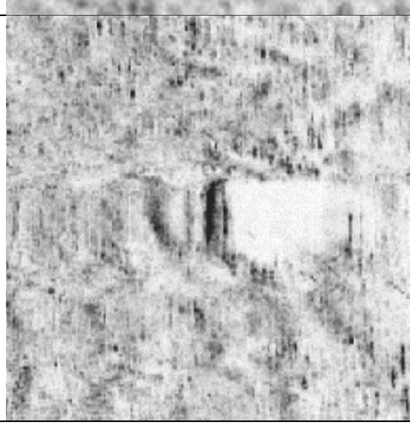
	**SS36** • (X) 351633 (Y) 74092	**Dimensions** Target Height: 4.1 US Feet Target Length: 9.5 US Feet Target Width: 6.7 US Feet Description: Oblong target
	**SS38** • (X) 341999 (Y) 59762	**Dimensions** Target Height: 2.3 US Feet Target Length: 12.3 US Feet Target Width: 1.6 US Feet Description: Linear target
	**SS39** • (X) 327142 (Y) 45022	**Dimensions** Target Height: 0.4 US Feet Target Length: 4.6 US Feet Target Width: 2.4 US Feet Description: Oblong target
	**SS40** • (X) 319464 (Y) 40303	**Dimensions** Target Height: 0.7 US Feet Target Length: 7.4 US Feet Target Width: 3.3 US Feet Description: Oblong target

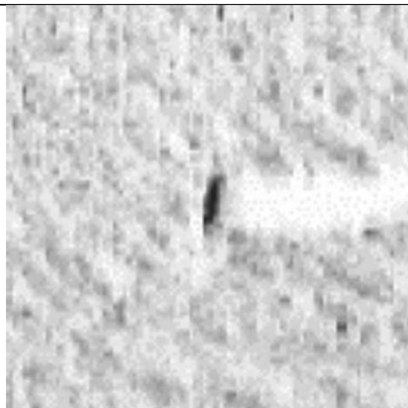
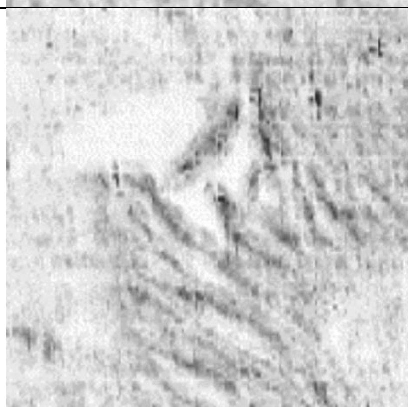
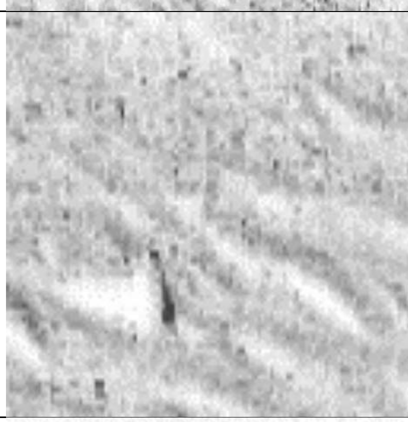
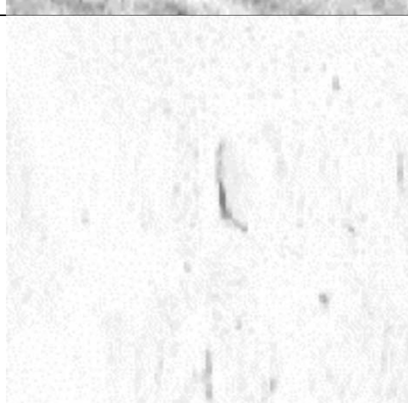
	**SS41** • (X) 351846 (Y) 78838	**Dimensions** Target Height: 4.3 US Feet Target Length: 9.3 US Feet Target Width: 4.5 US Feet Description: Oblong target
	**SS42** • (X) 351475 (Y) 75000	**Dimensions** Target Height: 0.7 US Feet Target Length: 8.4 US Feet Target Width: 2.9 US Feet Description: Oblong target
	**SS43** • (X) 351492 (Y) 74737	**Dimensions** Target Height: 2.0 US Feet Target Length: 12.6 US Feet Target Width: 8.9 US Feet Description: Oblong target
	**SS46** • (X) 351098 (Y) 73041	**Dimensions** Target Height: 4.0 US Feet Target Length: 10.1 US Feet Target Width: 4.2 US Feet Description: Oblong target

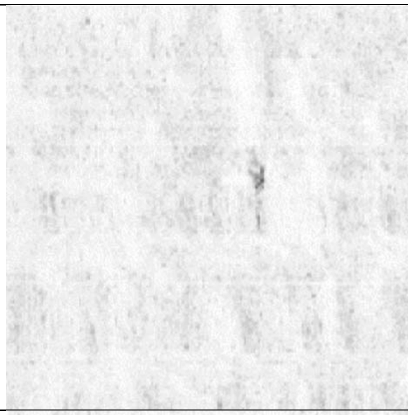
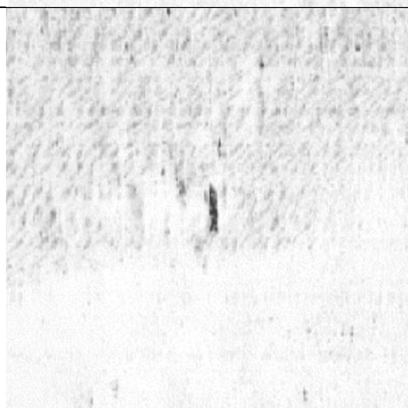
	**SS47** • (X) 351448 (Y) 74134	**Dimensions** Target Height: 3.2 US Feet Target Length: 7.8 US Feet Target Width: 6.0 US Feet Description: Oblong target
	**SS48** • (X) 351724 (Y) 75765	**Dimensions** Target Height: 3.5 US Feet Target Length: 7.5 US Feet Target Width: 4.9 US Feet Description: Oblong target
	**SS49** • (X) 351492 (Y) 76484	**Dimensions** Target Height: 2.8 US Feet Target Length: 11.6 US Feet Target Width: 4.7 US Feet Description: Oblong target
	**SS50** • (X) 346819 (Y) 64700	**Dimensions** Target Height: 2.9 US Feet Target Length: 10.9 US Feet Target Width: 5.6 US Feet Description: Oblong target

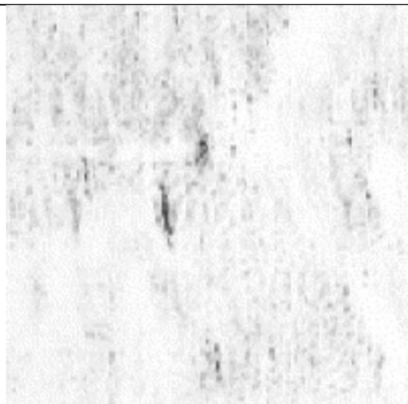
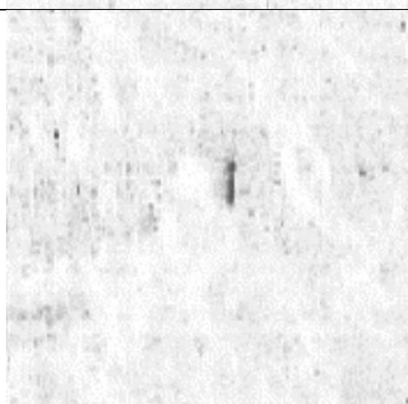
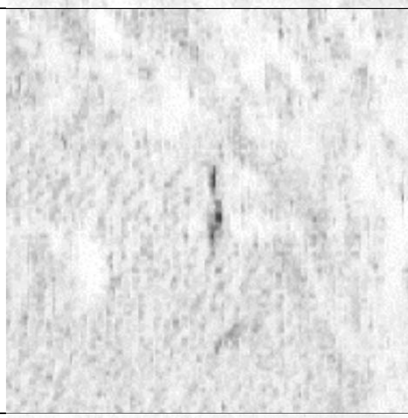
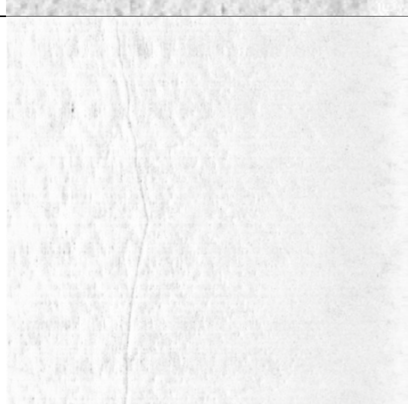
	**SS51** • (X) 346244 (Y) 64055	**Dimensions** Target Height: 0.0 US Feet Target Length: 9.2 US Feet Target Width: 2.8 US Feet Description: Linear target
	**SS52** • (X) 342603 (Y) 60933	**Dimensions** Target Height: 2.4 US Feet Target Length: 21.6 US Feet Target Width: 8.4 US Feet Description: Oblong target
	**SS53** • (X) 335804 (Y) 54061	**Dimensions** Target Height: 1.1 US Feet Target Length: 5.5 US Feet Target Width: 2.8 US Feet Description: Oblong target
	**SS54** • (X) 328250 (Y) 45712	**Dimensions** Target Height: 1.2 US Feet Target Length: 5.1 US Feet Target Width: 2.7 US Feet Description: Oblong target

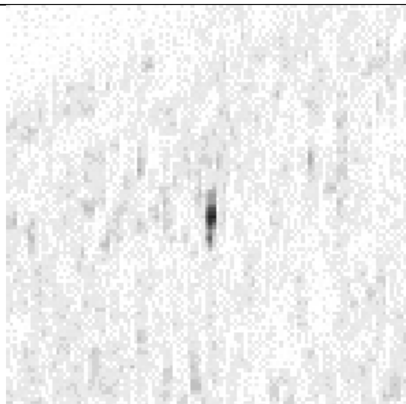
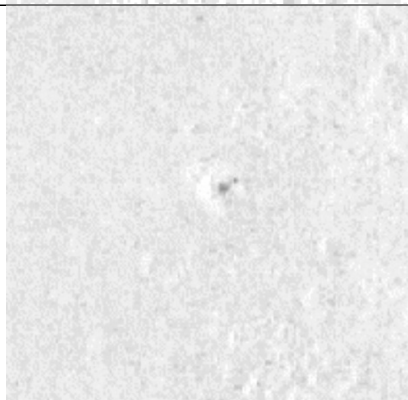
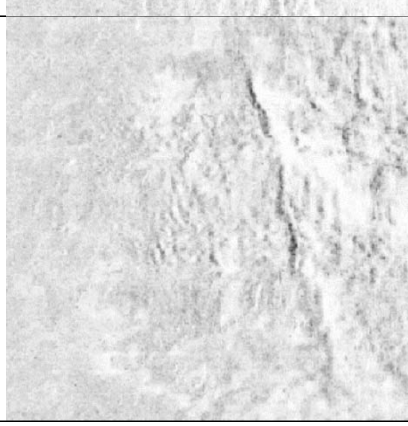
	**SS55** • (X) 330369 (Y) 47451	**Dimensions** Target Height: 0.0 US Feet Target Length: 9.9 US Feet Target Width: 3.5 US Feet Description: Oblong target
	**SS56** • (X) 346826 (Y) 64676	**Dimensions** Target Height: 2.8 US Feet Target Length: 11.8 US Feet Target Width: 4.7 US Feet Description: Oblong target
	**SS57** • (X) 351437 (Y) 73711	**Dimensions** Target Height: 0.9 US Feet Target Length: 12.3 US Feet Target Width: 1.2 US Feet Description: Linear target
	**SS58** • (X) 351807 (Y) 74561	**Dimensions** Target Height: 3.1 US Feet Target Length: 12.8 US Feet Target Width: 5.1 US Feet Description: Oblong target

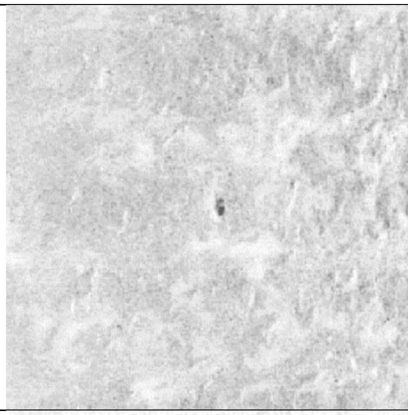
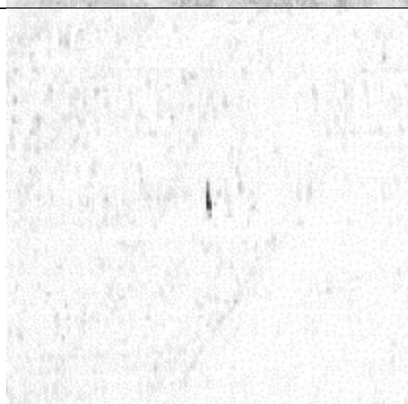
	**SS59** • (X) 351905 (Y) 75099	**Dimensions** Target Height: 1.2 US Feet Target Length: 9.6 US Feet Target Width: 4.4 US Feet Description: Oblong target
	**SS60** • (X) 351969 (Y) 76015	**Dimensions** Target Height: 4.4 US Feet Target Length: 6.1 US Feet Target Width: 4.2 US Feet Description: Oblong target
	**SS61** • (X) 352015 (Y) 76498	**Dimensions** Target Height: 2.3 US Feet Target Length: 11.4 US Feet Target Width: 2.6 US Feet Description: Linear target
	**SS62** • (X) 352079 (Y) 77933	**Dimensions** Target Height: 4.7 US Feet Target Length: 17.1 US Feet Target Width: 6.7 US Feet Description: Oblong target

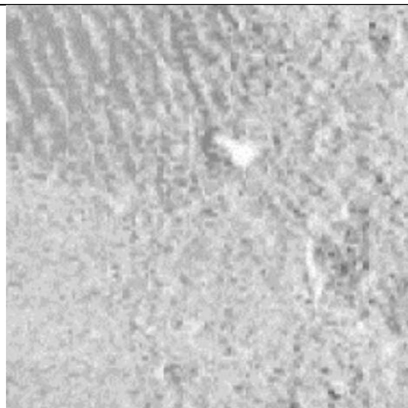
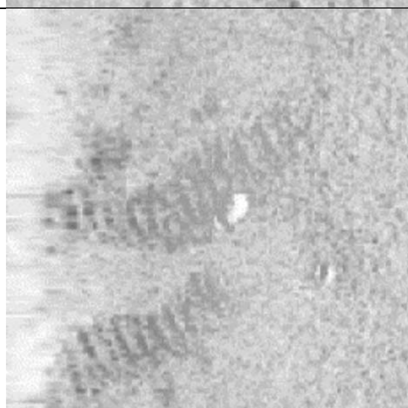
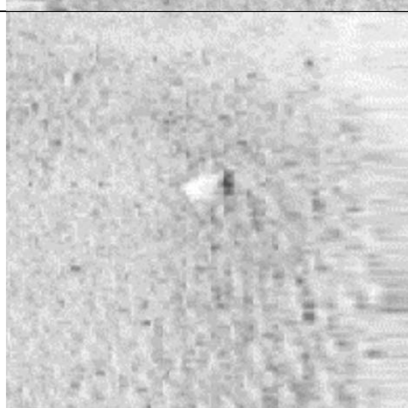
	**SS64** • (X) 352210 (Y) 74617	**Dimensions** Target Height: 2.2 US Feet Target Length: 6.7 US Feet Target Width: 2.3 US Feet Description: Oblong target
	**SS65** • (X) 351685 (Y) 74822	**Dimensions** Target Height: 2.5 US Feet Target Length: 19.9 US Feet Target Width: 5.9 US Feet Description: Oblong target
	**SS66** • (X) 351865 (Y) 75537	**Dimensions** Target Height: 2.1 US Feet Target Length: 9.0 US Feet Target Width: 1.4 US Feet Description: Linear target
	**SS67** • (X) 311156 (Y) 36481	**Dimensions** Target Height: 0.0 US Feet Target Length: 9.6 US Feet Target Width: 1.1 US Feet Description: Linear target

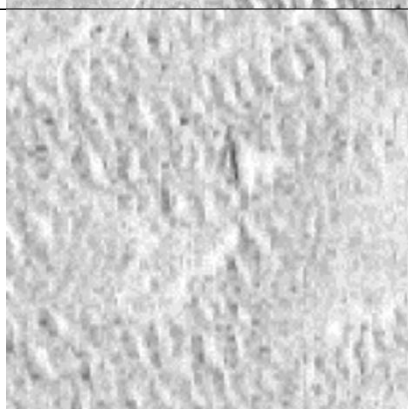
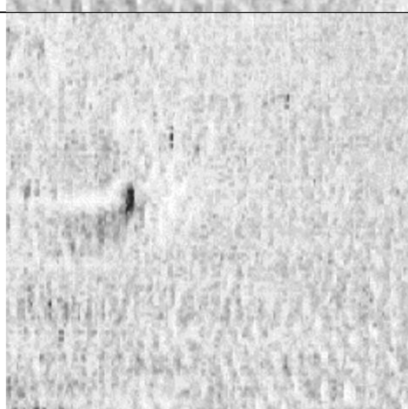
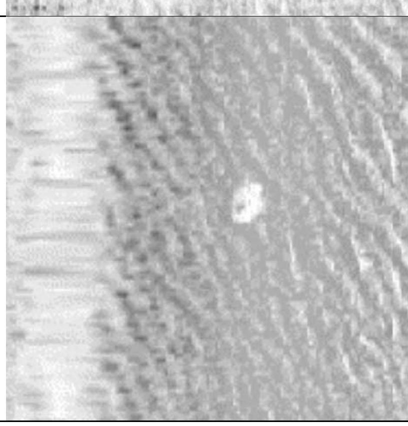
	**SS68** • (X) 313649 (Y) 38577	**Dimensions** Target Height: 0.5 US Feet Target Length: 7.0 US Feet Target Width: 2.2 US Feet Description: Oblong target
	**SS69** • (X) 314504 (Y) 38568	**Dimensions** Target Height: 0.6 US Feet Target Length: 46.4 US Feet Target Width: 7.9 US Feet Description: Oblong target
	**SS70** • (X) 315547 (Y) 38338	**Dimensions** Target Height: 0.2 US Feet Target Length: 13.5 US Feet Target Width: 3.1 US Feet Description: Oblong target
	**SS71** • (X) 315681 (Y) 38973	**Dimensions** Target Height: 1.5 US Feet Target Length: 4.7 US Feet Target Width: 3.1 US Feet Description: Oblong target

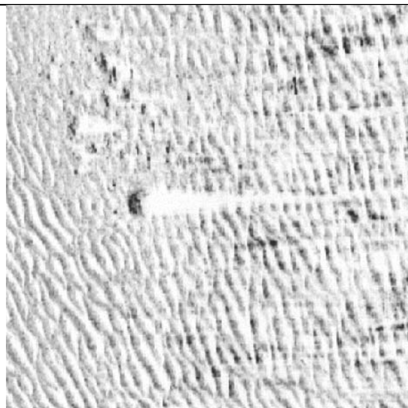
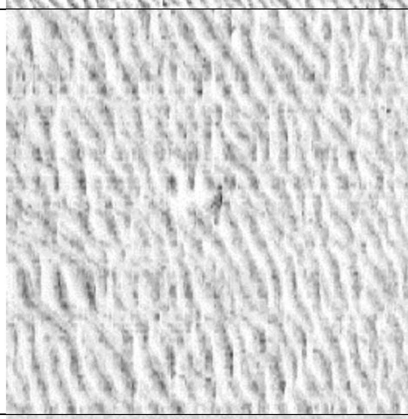
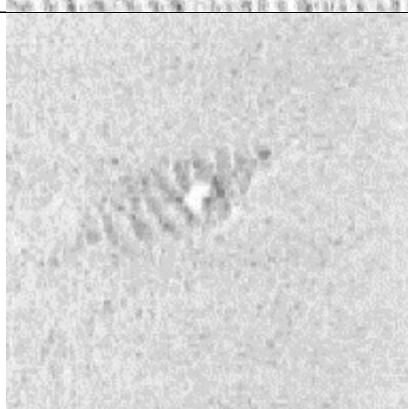
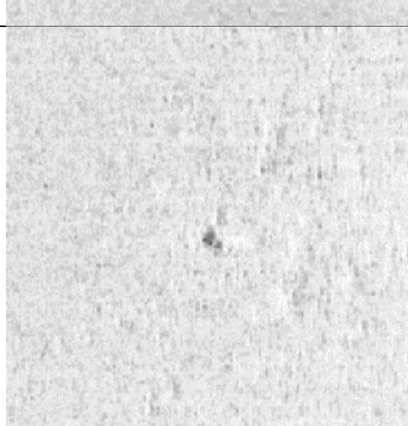
	**SS72** • (X) 315671 (Y) 38961	**Dimensions** Target Height: 0.1 US Feet Target Length: 9.9 US Feet Target Width: 1.7 US Feet Description: Linear target
	**SS73** • (X) 316243 (Y) 38638	**Dimensions** Target Height: 0.8 US Feet Target Length: 7.2 US Feet Target Width: 1.9 US Feet Description: Linear target
	**SS74** • (X) 316466 (Y) 38820	**Dimensions** Target Height: 0.6 US Feet Target Length: 4.9 US Feet Target Width: 1.8 US Feet Description: 2 oblong targets
	**SS75** • (X) 319288 (Y) 39395	**Dimensions** Target Height: 0.0 US Feet Target Length: 236.3 US Feet Target Width: 1.9 US Feet Description: Long linear target over 750 ft

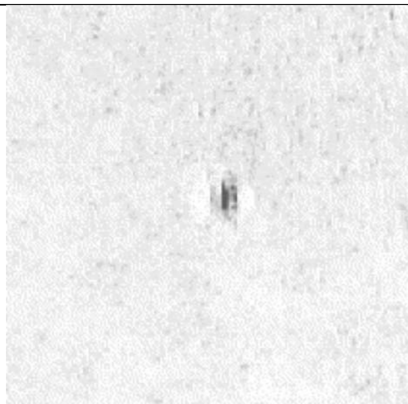
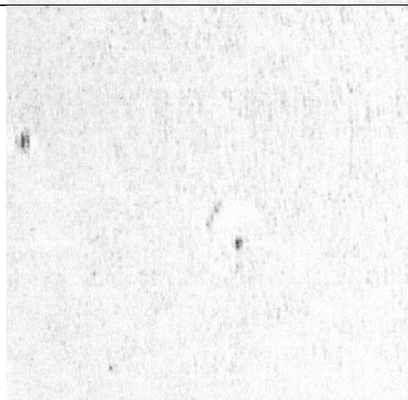
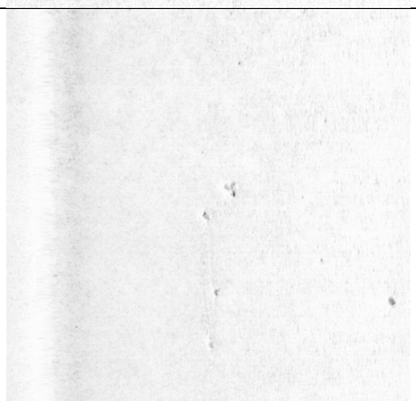
	**SS77** • (X) 322062 (Y) 41337	**Dimensions** Target Height: 0.1 US Feet Target Length: 4.8 US Feet Target Width: 1.1 US Feet Description: Linear target
	**SS78** • (X) 327817 (Y) 45679	**Dimensions** Target Height: 0.6 US Feet Target Length: 5.6 US Feet Target Width: 3.2 US Feet Description: Oblong target
	**SS79** • (X) 328511 (Y) 46556	**Dimensions** Target Height: 0.3 US Feet Target Length: 8.5 US Feet Target Width: 4.1 US Feet Description: Oblong target
	**SS80** • (X) 336903 (Y) 54314	**Dimensions** Target Height: 0.7 US Feet Target Length: 69.7 US Feet Target Width: 4.6 US Feet Description: Linear target

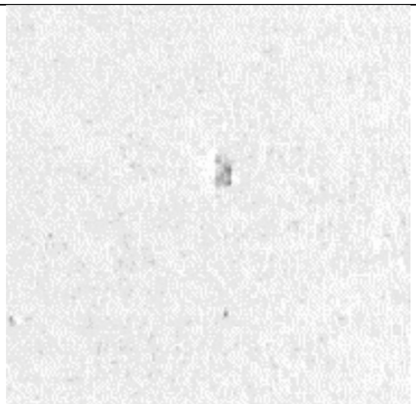
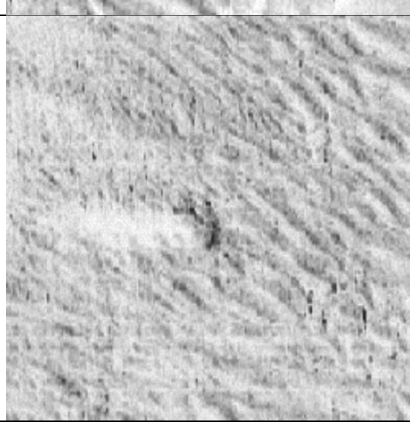
	**SS81** • (X) 337208 (Y) 54680	**Dimensions** Target Height: 0.0 US Feet Target Length: 7.7 US Feet Target Width: 2.7 US Feet Description: Oblong target
	**SS82** • (X) 338010 (Y) 55670	**Dimensions** Target Height: 0.0 US Feet Target Length: 6.5 US Feet Target Width: 0.8 US Feet Description: Linear target
	**SS83** • (X) 342916 (Y) 61181	**Dimensions** Target Height: 1.7 US Feet Target Length: 6.3 US Feet Target Width: 2.3 US Feet Description: Oblong target
	**SS84** • (X) 343884 (Y) 62213	**Dimensions** Target Height: 0.6 US Feet Target Length: 6.8 US Feet Target Width: 3.5 US Feet Description: Oblong target

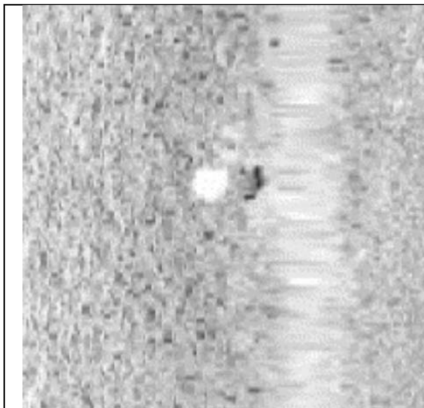
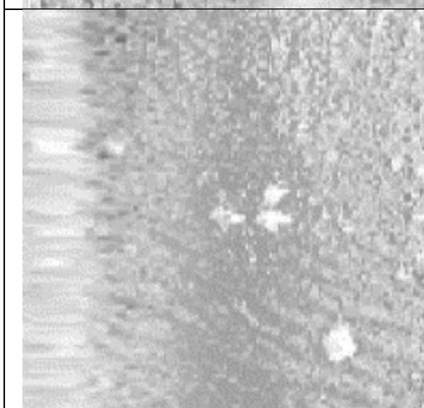
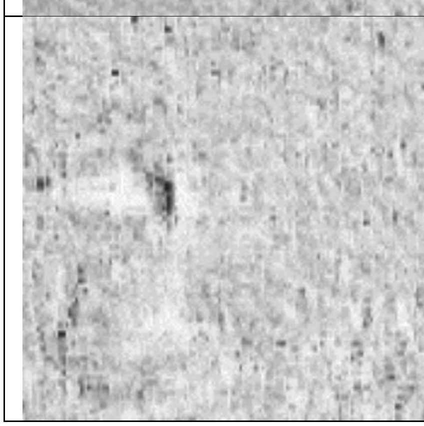
	**SS85** • (X) 346374 (Y) 64008	**Dimensions** Target Height: 1.2 US Feet Target Length: 7.3 US Feet Target Width: 3.5 US Feet Description: Oblong target
	**SS86** • (X) 346489 (Y) 64160	**Dimensions** Target Height: 1.4 US Feet Target Length: 7.3 US Feet Target Width: 2.8 US Feet Description: Oblong target
	**SS87** • (X) 346931 (Y) 64664	**Dimensions** Target Height: 2.4 US Feet Target Length: 4.3 US Feet Target Width: 1.9 US Feet Description: Oblong target
	**SS88** • (X) 346681 (Y) 64863	**Dimensions** Target Height: 1.1 US Feet Target Length: 7.7 US Feet Target Width: 3.5 US Feet Description: Oblong target

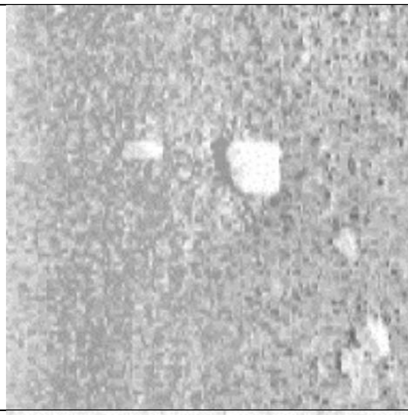
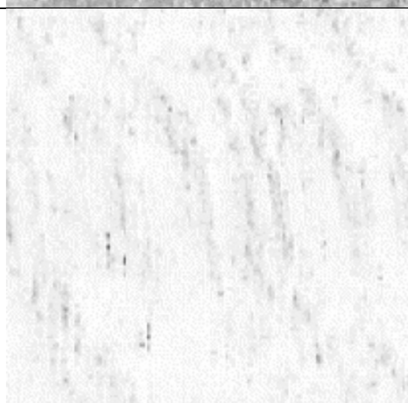
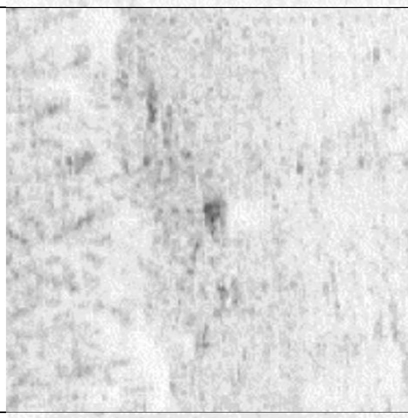
	**SS89** • (X) 346792 (Y) 64764	**Dimensions** Target Height: 1.2 US Feet Target Length: 7.4 US Feet Target Width: 3.3 US Feet Description: Oblong target
	**SS91** • (X) 346768 (Y) 64685	**Dimensions** Target Height: 0.3 US Feet Target Length: 5.4 US Feet Target Width: 2.1 US Feet Description: Oblong target
	**SS90** • (X) 346866 (Y) 65140	**Dimensions** Target Height: 1.3 US Feet Target Length: 6.4 US Feet Target Width: 2.5 US Feet Description: Oblong target
	**SS93** • (X) 347046 (Y) 65088	**Dimensions** Target Height: 2.4 US Feet Target Length: 8.0 US Feet Target Width: 4.6 US Feet Description: Oblong target

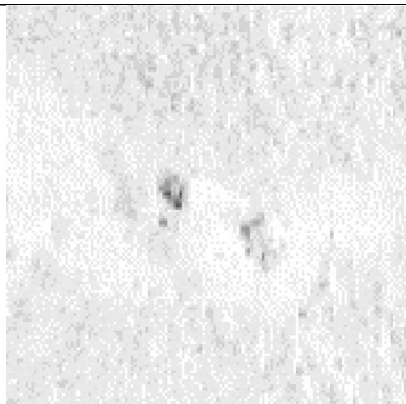
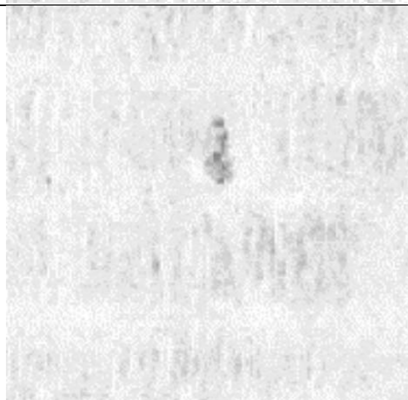
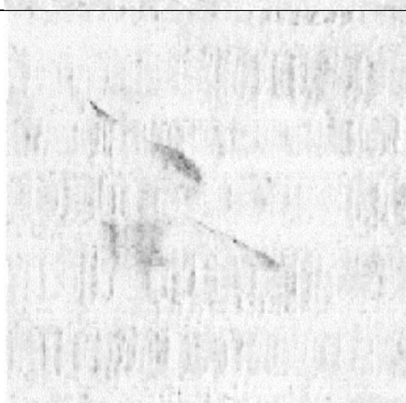
	**SS94** • (X) 348843 (Y) 65644	**Dimensions** Target Height: 5.9 US Feet Target Length: 9.3 US Feet Target Width: 5.7 US Feet Description: Oblong target
	**SS95** • (X) 348857 (Y) 65838	**Dimensions** Target Height: 0.7 US Feet Target Length: 8.3 US Feet Target Width: 2.5 US Feet Description: Oblong target
	**SS96** • (X) 348341 (Y) 66488	**Dimensions** Target Height: 0.9 US Feet Target Length: 6.4 US Feet Target Width: 2.1 US Feet Description: Oblong target
	**SS97** • (X) 349146 (Y) 67275	**Dimensions** Target Height: 0.6 US Feet Target Length: 5.9 US Feet Target Width: 3.4 US Feet Description: Oblong target

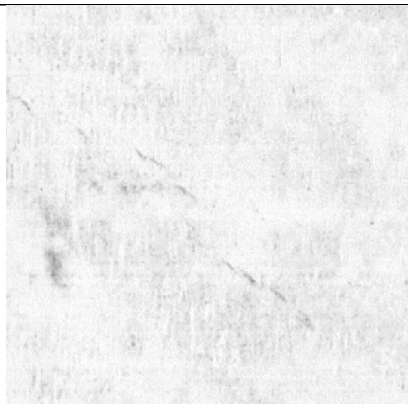
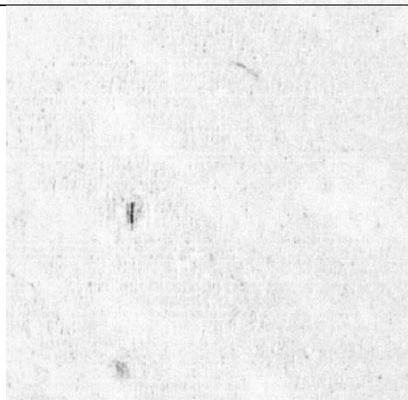
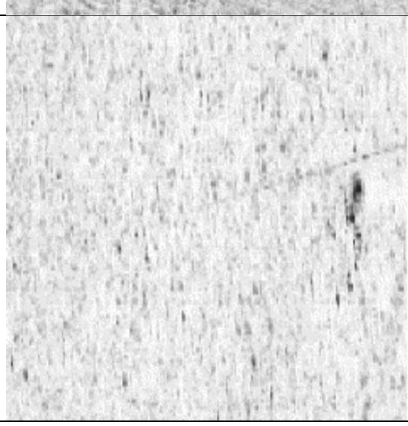
	**SS98** • (X) 349732 (Y) 67552	**Dimensions** Target Height: 0.4 US Feet Target Length: 5.5 US Feet Target Width: 3.1 US Feet Description: Oblong target
	**SS99** • (X) 349794 (Y) 67549	**Dimensions** Target Height: 0.9 US Feet Target Length: 8.7 US Feet Target Width: 3.3 US Feet Description: Oblong target
	**SS100** • (X) 349805 (Y) 67696	**Dimensions** Target Height: 0.0 US Feet Target Length: 0.0 US Feet Target Width: 0.0 US Feet Description: Lobster pots?
	**SS101** • (X) 350068 (Y) 67886	**Dimensions** Target Height: 0.9 US Feet Target Length: 20.5 US Feet Target Width: 3.9 US Feet Description: Oblong target

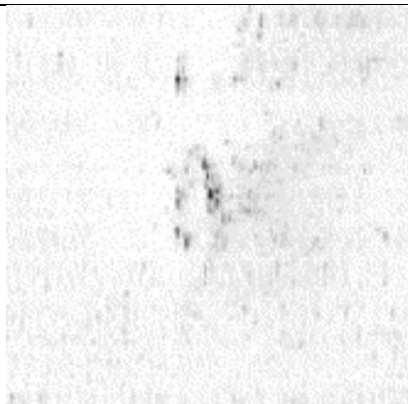
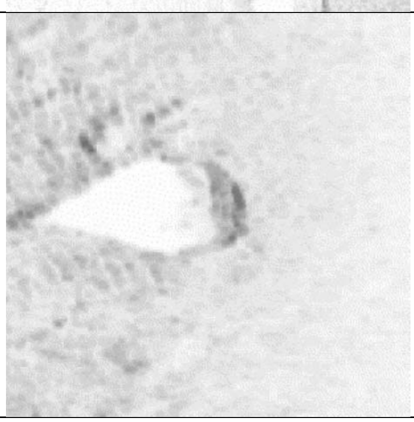
	**SS102** • (X) 350483 (Y) 69244	**Dimensions** Target Height: 0.3 US Feet Target Length: 5.5 US Feet Target Width: 2.4 US Feet Description: Oblong target
	**SS103** • (X) 351806 (Y) 72304	**Dimensions** Target Height: 0.2 US Feet Target Length: 7.1 US Feet Target Width: 4.7 US Feet Description: Oblong target
	**SS104** • (X) 351819 (Y) 74680	**Dimensions** Target Height: 1.0 US Feet Target Length: 14.4 US Feet Target Width: 3.3 US Feet Description: Linear target
	**SS105** • (X) 351800 (Y) 75704	**Dimensions** Target Height: 2.0 US Feet Target Length: 12.9 US Feet Target Width: 5.9 US Feet Description: Oblong target

	**SS106** • (X) 351966 (Y) 76942	**Dimensions** Target Height: 4.2 US Feet Target Length: 7.3 US Feet Target Width: 5.7 US Feet Description: Oblong target
	**SS107** • (X) 352010 (Y) 76628	**Dimensions** Target Height: 1.9 US Feet Target Length: 5.1 US Feet Target Width: 2.4 US Feet Description: Oblong target
	**SS108** • (X) 352045 (Y) 76727	**Dimensions** Target Height: 1.7 US Feet Target Length: 7.2 US Feet Target Width: 2.7 US Feet Description: Oblong target
	**SS109** • (X) 351845 (Y) 77239	**Dimensions** Target Height: 1.2 US Feet Target Length: 9.9 US Feet Target Width: 4.4 US Feet Description: Oblong target

	**SS110** • (X) 352041 (Y) 77743	**Dimensions** Target Height: 2.9 US Feet Target Length: 11.2 US Feet Target Width: 4.1 US Feet Description: Oblong target
	**SS1072** • (X) 311488 (Y) 36930	**Dimensions** Target Height: 0.6 US Feet Target Length: 29.0 US Feet Target Width: 4.8 US Feet Description: Oblong target
	**SS3071** • (X) 351776 (Y) 80474	**Dimensions** Target Height: 0.4 US Feet Target Length: 6.3 US Feet Target Width: 4.2 US Feet Description: Oblong target
	**SS3072** • (X) 351647 (Y) 82716	**Dimensions** Target Height: 0.5 US Feet Target Length: 7.3 US Feet Target Width: 4.9 US Feet Description: Oblong target

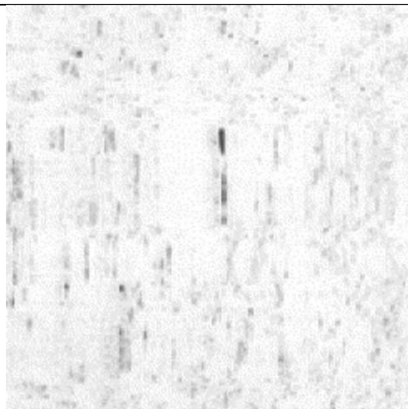
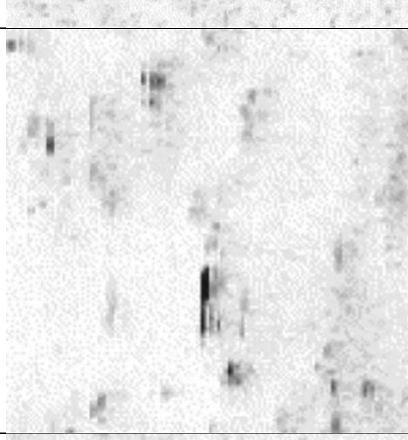
	**SS3073** • (X) 351271 (Y) 83959	**Dimensions** Target Height: 1.2 US Feet Target Length: 5.3 US Feet Target Width: 3.3 US Feet Description: 2 oblong targets
	**SS3074** • (X) 350219 (Y) 89598	**Dimensions** Target Height: 0.3 US Feet Target Length: 8.9 US Feet Target Width: 3.7 US Feet Description: Oblong target
	**SS3075** • (X) 350147 (Y) 89556	**Dimensions** Target Height: 0.0 US Feet Target Length: 34.8 US Feet Target Width: 0.9 US Feet Description: Linear target
	**SS3076** • (X) 349257 (Y) 94085	**Dimensions** Target Height: 0.0 US Feet Target Length: 25.2 US Feet Target Width: 3.6 US Feet Description: Oblong target

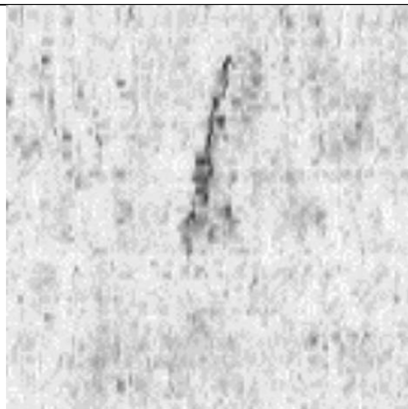
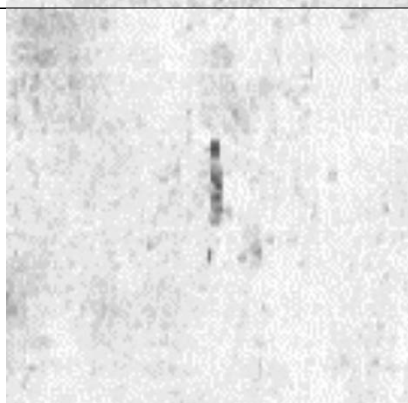
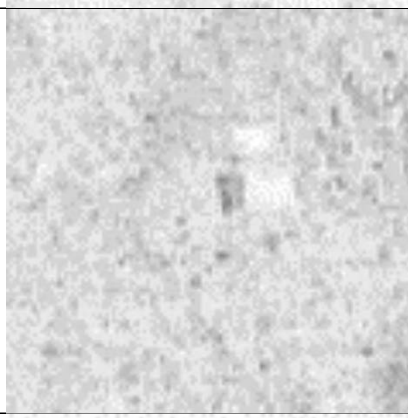
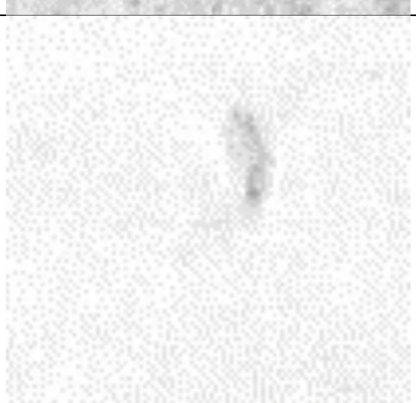
	**SS3077** • (X) 349103 (Y) 95209	**Dimensions** Target Height: 0.0 US Feet Target Length: 31.7 US Feet Target Width: 0.0 US Feet Description: Linear features
	**SS3078** • (X) 347610 (Y) 100401	**Dimensions** Target Height: 0.2 US Feet Target Length: 8.8 US Feet Target Width: 4.1 US Feet Description: Oblong target
	**SS3079** • (X) 347630 (Y) 103033	**Dimensions** Target Height: 0.3 US Feet Target Length: 54.0 US Feet Target Width: 2.9 US Feet Description: Linear target?
	**SS3080** • (X) 346851 (Y) 106849	**Dimensions** Target Height: 0.4 US Feet Target Length: 11.0 US Feet Target Width: 2.7 US Feet Description: Oblong target

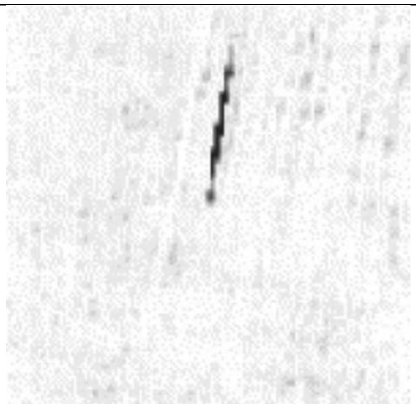
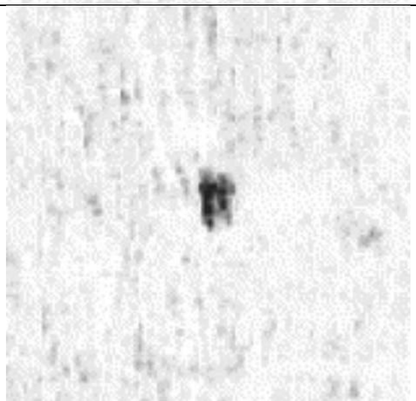
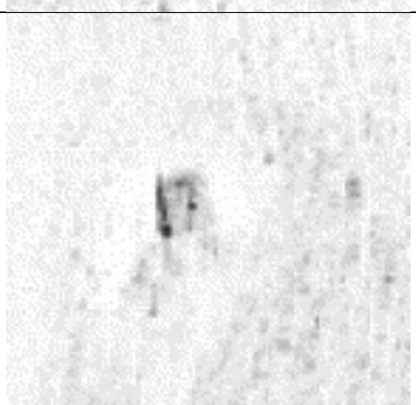
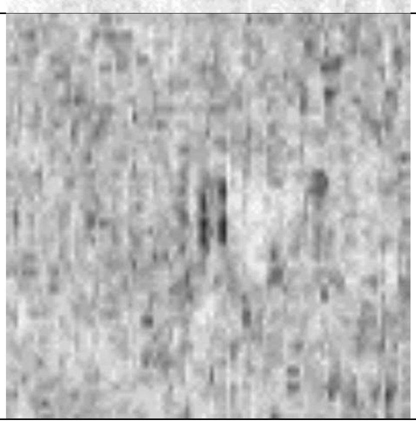
	**SS3003** • (X) 340594 (Y) 127046	**Dimensions** Target Height: 0.0 US Feet Target Length: 10.2 US Feet Target Width: 2.8 US Feet Description: Oblong target
	**SS3005** • (X) 340899 (Y) 126557	**Dimensions** Target Height: 0.1 US Feet Target Length: 13.7 US Feet Target Width: 0.9 US Feet Description: Linear target
	**SS3092** • (X) 341923 (Y) 60586	**Dimensions** Target Height: 5.5 US Feet Target Length: 10.4 US Feet Target Width: 7.1 US Feet Description: Oblong target

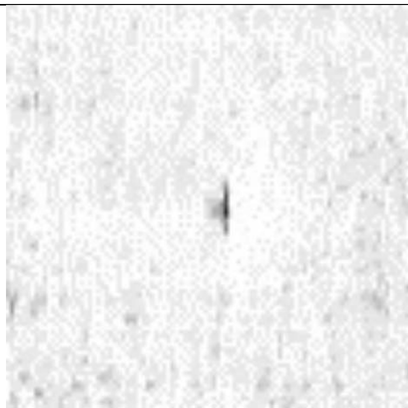
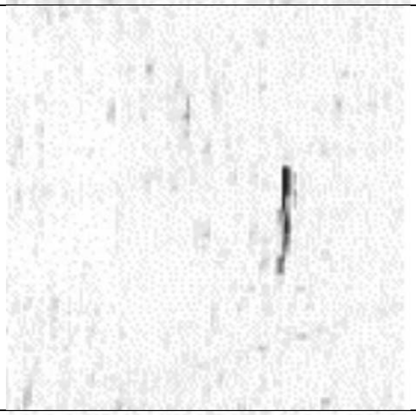
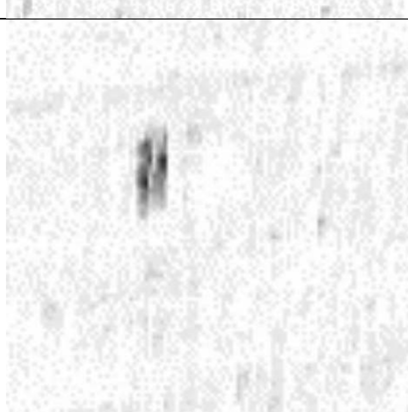
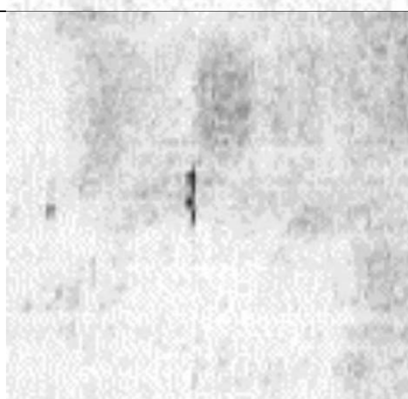
Notes:

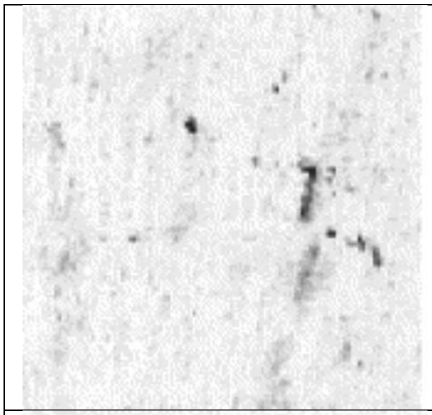
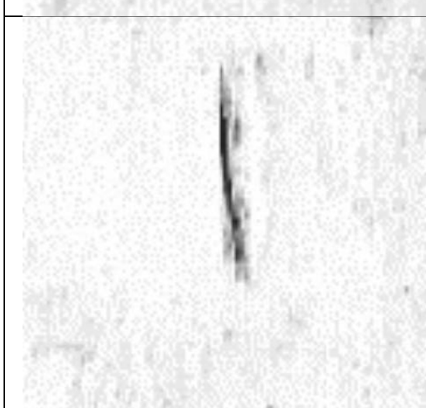
1. Coordinates are referenced to RI State Plane, Zone 3800, NAD83, in feet.
2. Target dimensions are based on the acoustic reflection and may not represent the actual size of the object (due to orientation of object relative to sonar, partial burial of object, etc.).

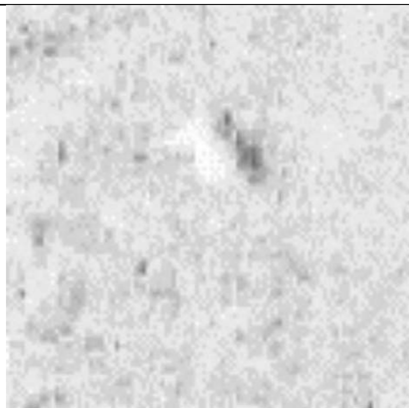
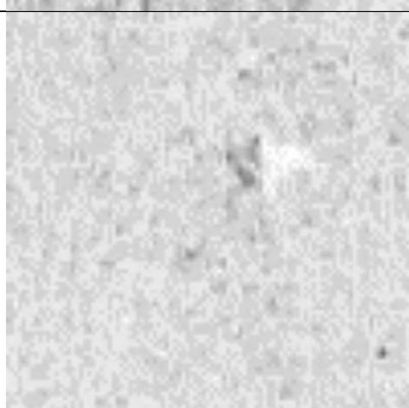
Side Scan Sonar Target Report; BITS Alternate Route		
Contact Image	**Contact Info**	**User Entered Info**
	**SS2009** (X) 350306 (Y) 147992	**Dimensions** Target Height: 0.4 US Feet Target Length: 12.6 US Feet Target Width: 0.8 US Feet Description: Linear target
	**SS2010** (X) 350129 (Y) 147854	**Dimensions** Target Height: 0.0 US Feet Target Length: 6.0 US Feet Target Width: 0.9 US Feet Description: Linear target
	**SS2022** (X) 353103 (Y) 134464	**Dimensions** Target Height: 0.0 US Feet Target Length: 9.7 US Feet Target Width: 1.7 US Feet Description: Linear target

	**SS2033** (X) 351898 (Y) 127826	**Dimensions** Target Height: 0.0 US Feet Target Length: 23.8 US Feet Target Width: 2.4 US Feet Description: Linear target
	**SS2035** (X) 348184 (Y) 116297	**Dimensions** Target Height: 0.0 US Feet Target Length: 10.8 US Feet Target Width: 1.4 US Feet Description: Linear target
	**SS2038** (X) 353351 (Y) 145897	**Dimensions** Target Height: 1.0 US Feet Target Length: 4.1 US Feet Target Width: 2.2 US Feet Description: Oblong target
	**SS2044** (X) 349187 (Y) 120324	**Dimensions** Target Height: 1.4 US Feet Target Length: 8.3 US Feet Target Width: 3.3 US Feet Description: Oblong target

	**SS2045** (X) 348694 (Y) 118739	**Dimensions** Target Height: 0.0 US Feet Target Length: 16.5 US Feet Target Width: 1.1 US Feet Description: Linear target
	**SS2046** (X) 349650 (Y) 121604	**Dimensions** Target Height: 0.0 US Feet Target Length: 5.9 US Feet Target Width: 3.7 US Feet Description: Oblong target
	**SS2047** (X) 347913 (Y) 116105	**Dimensions** Target Height: 0.8 US Feet Target Length: 5.8 US Feet Target Width: 4.7 US Feet Description: Oblong target
	**SS2049** (X) 352946 (Y) 147271	**Dimensions** Target Height: 0.9 US Feet Target Length: 6.3 US Feet Target Width: 2.2 US Feet Description: Linear target

	**SS2051** (X) 350908 (Y) 125987	**Dimensions** Target Height: 0.0 US Feet Target Length: 5.5 US Feet Target Width: 1.2 US Feet Description: Linear target
	**SS2052** (X) 348627 (Y) 120046	**Dimensions** Target Height: 0.0 US Feet Target Length: 13.1 US Feet Target Width: 1.8 US Feet Description: Linear target
	**SS2053** (X) 348370 (Y) 119060	**Dimensions** Target Height: 1.0 US Feet Target Length: 8.1 US Feet Target Width: 3.3 US Feet Description: Oblong target
	**SS2055** (X) 346965 (Y) 111766	**Dimensions** Target Height: 0.0 US Feet Target Length: 7.4 US Feet Target Width: 1.2 US Feet Description: Linear target

	**SS2060** (X) 349685 (Y) 123252	**Dimensions** Target Height: 0.0 US Feet Target Length: 7.2 US Feet Target Width: 2.2 US Feet Description: Linear target
	**SS2061** (X) 348306 (Y) 119874	**Dimensions** Target Height: 1.5 US Feet Target Length: 4.6 US Feet Target Width: 1.6 US Feet Description: Oblong target
	**SS2062** (X) 346666 (Y) 112428	**Dimensions** Target Height: 0.0 US Feet Target Length: 5.3 US Feet Target Width: 1.7 US Feet Description: Oblong target
	**SS2063** (X) 346959 (Y) 114037	**Dimensions** Target Height: 0.3 US Feet Target Length: 23.0 US Feet Target Width: 2.7 US Feet Description: Linear target

	**SS2064** (X) 352567 (Y) 139507	**Dimensions** Target Height: 0.7 US Feet Target Length: 6.6 US Feet Target Width: 2.5 US Feet Description: Oblong target
	**SS2067** (X) 353451 (Y) 145468	**Dimensions** Target Height: 0.0 US Feet Target Length: 5.1 US Feet Target Width: 4.8 US Feet Description: Oblong target
	**SS2068** (X) 353103.69 (Y) 138760.86	**Dimensions** Target Height: 1.1 US Feet Target Length: 4.8 US Feet Target Width: 3.0 US Feet Description: Oblong target

Notes:

1. Coordinates are referenced to RI State Plane, Zone 3800, NAD83, in feet.
2. Target dimensions are based on the acoustic reflection and may not represent the actual size of the object (due to orientation of object relative to sonar, partial burial of object, etc.).

Side Scan Sonar Targets; BITS Primary and Alternate Routes							
Sonar Target[1]	Easting[2]	Northing[2]	Length[3]	Width[3]	Height[3]	Description	Magnetic Association[4]
	feet	feet	feet	feet	feet		
PRIMARY ROUTE							
SS1	352307	78378	4.7	3.4	2.0	Oblong target	
SS4	352475	77644	7.3	2.6	3.2	Oblong target	
SS5	352512	77449	7.3	1.9	1.6	Oblong target	
SS6	352481	76087	8.9	7.4	2.3	Oblong target	
SS7	352361	74894	9.5	4.0	3.8	Oblong target	
SS8	352063	74650	10.2	9.9	2.4	Oblong target	
SS9	310703	36693	5.5	1.8	0.0	Oblong target	M1069
SS10	311839	37886	7.3	2.9	0.2	Oblong target	
SS11	311155	36709	10.9	0.8	0.0	Linear target	
SS12	311118	36756	8.3	4.1	0.5	Oblong target	M1079
SS13	311338	36655	9.5	2.1	0.0	Linear target	
SS14	313318	37666	7.8	5.2	1.1	Oblong target	M109, M1833
SS15	313199	37663	26.7	5.3	2.1	Linear target	M1832
SS16	313255	37603	7.6	3.3	0.6	Oblong target	
SS18	350542	68770	1.1	0.0	0.1	Linear target	
SS19	349495	66359	8.2	4.1	3.8	Oblong target	M225
SS20	349330	66304	7.2	2.8	1.9	Oblong target	
SS21	344063	60983	7.2	7.6	0.0	Oblong target	
SS22	344974	62147	4.7	3.6	1.9	Oblong target	
SS23	329839	46873	6.9	3.2	1.2	Oblong target	
SS24	352247	78261	5.9	3.9	2.6	Oblong target	
SS25	352142	77318	11.6	8.8	3.7	Oblong target	
SS26	351863	74179	9.5	4.4	2.9	Oblong target	
SS27	349773	67210	5.5	4.1	0.0	Oblong target	
SS29	349016	66068	6.3	3.1	2.1	Oblong target	
SS30	347159	64513	8.9	6.6	3.8	Oblong target	
SS31	346549	63676	10.7	4.1	2.5	Oblong target	
SS33	342926	60069	5.1	3.4	0.9	Oblong target	M1160
SS34	351877	76746	8.8	2.9	3.0	Linear target	
SS35	351815	73890	9.3	3.1	1.8	Linear target	
SS36	351633	74092	9.5	6.7	4.1	Oblong target	
SS38	341999	59762	12.3	1.6	2.3	Linear target	
SS39	327142	45022	4.6	2.4	0.4	Oblong target	
SS40	319464	40303	7.4	3.3	0.7	Oblong target	
SS41	351846	78838	9.3	4.5	4.3	Oblong target	
SS42	351475	75000	8.4	2.9	0.7	Oblong target	
SS43	351492	74737	12.6	8.9	2.0	Oblong target	
SS46	351098	73041	10.1	4.2	4.0	Oblong target	M250
SS47	351448	74134	7.8	6.0	3.2	Oblong target	M231

Side Scan Sonar Targets; BITS Primary and Alternate Routes							
Sonar Target[1]	Easting[2]	Northing[2]	Length[3]	Width[3]	Height[3]	Description	Magnetic Association[4]
	feet	feet	feet	feet	feet		
SS48	351724	75765	7.5	4.9	3.5	Oblong target	
SS49	351492	76484	11.6	4.7	2.8	Oblong target	
SS50	346819	64700	10.9	5.6	2.9	Oblong target	
SS51	346244	64055	9.2	2.8	0.0	Linear target	
SS52	342603	60933	21.6	8.4	2.4	Oblong target	M184
SS53	335804	54061	5.5	2.8	1.1	Oblong target	
SS54	328250	45712	5.1	2.7	1.2	Oblong target	
SS55	330369	47451	9.9	3.5	0.0	Oblong target	
SS56	346826	64676	11.8	4.7	2.8	Oblong target	
SS57	351437	73711	12.3	1.2	0.9	Linear target	
SS58	351807	74561	12.8	5.1	3.1	Oblong target	
SS59	351905	75099	9.6	4.4	1.2	Oblong target	
SS60	351969	76015	6.1	4.2	4.4	Oblong target	
SS61	352015	76498	11.4	2.6	2.3	Linear target	M268, M267
SS62	352079	77933	17.1	6.7	4.7	Oblong target	
SS64	352210	74617	6.7	2.3	2.2	Oblong target	
SS65	351685	74822	19.9	5.9	2.5	Oblong target	
SS66	351865	75537	9.0	1.4	2.1	Linear target	
SS67	311156	36481	9.6	1.1	0	Linear target	M1825
SS68	313649	38577	7	2.2	0.5	Oblong target	
SS69	314504	38568	46.4	7.9	0.6	Oblong target	M114?
SS70	315547	38338	13.5	3.1	0.2	Oblong target	
SS71	315681	38973	4.7	3.1	1.5	Oblong target	
SS72	315671	38961	9.9	1.7	0.1	Linear target	
SS73	316243	38638	7.2	1.9	0.8	Linear target	
SS74	316466	38820	4.9	1.8	0.6	2 oblong targets	
SS75	319288	39395	236.3	1.9	0	Long linear target over 750 ft	
SS77	322062	41337	4.8	1.1	0.1	Linear target	
SS78	327817	45679	5.6	3.2	0.6	Oblong target	
SS79	328511	46556	8.5	4.1	0.3	Oblong target	
SS80	336903	54314	69.7	4.6	0.7	Linear target	
SS81	337208	54680	7.7	2.7	0	Oblong target	
SS82	338010	55670	6.5	0.8	0	Linear target	
SS83	342916	61181	6.3	2.3	1.7	Oblong target	
SS84	343884	62213	6.8	3.5	0.6	Oblong target	
SS85	346374	64008	7.3	3.5	1.2	Oblong target	
SS86	346489	64160	7.3	2.8	1.4	Oblong target	
SS87	346931	64664	4.3	1.9	2.4	Oblong target	
SS88	346681	64863	7.7	3.5	1.1	Oblong target	
SS89	346792	64764	7.4	3.3	1.2	Oblong target	
SS91	346768	64685	5.4	2.1	0.3	Oblong target	

Side Scan Sonar Targets; BITS Primary and Alternate Routes							
Sonar Target[1]	Easting[2]	Northing[2]	Length[3]	Width[3]	Height[3]	Description	Magnetic Association[4]
	feet	feet	feet	feet	feet		
SS90	346866	65140	6.4	2.5	1.3	Oblong target	
SS93	347046	65088	8	4.6	2.4	Oblong target	
SS94	348843	65644	9.3	5.7	5.9	Oblong target	
SS95	348857	65838	8.3	2.5	0.7	Oblong target	
SS96	348341	66488	6.4	2.1	0.9	Oblong target	
SS97	349146	67275	5.9	3.4	0.6	Oblong target	
SS98	349732	67552	5.5	3.1	0.4	Oblong target	
SS99	349794	67549	8.7	3.3	0.9	Oblong target	
SS100	349805	67696	0	0	0	Lobster pots?	M245, M244
SS101	350068	67886	20.5	3.9	0.9	Oblong target	
SS102	350483	69244	5.5	2.4	0.3	Oblong target	
SS103	351806	72304	7.1	4.7	0.2	Oblong target	
SS104	351819	74680	14.4	3.3	1	Linear target	
SS105	351800	75704	12.9	5.9	2	Oblong target	
SS106	351966	76942	7.3	5.7	4.2	Oblong target	
SS107	352010	76628	5.1	2.4	1.9	Oblong target	
SS108	352045	76727	7.2	2.7	1.7	Oblong target	
SS109	351845	77239	9.9	4.4	1.2	Oblong target	
SS110	352041	77743	11.2	4.1	2.9	Oblong target	
SS111	352211	79065	7.1	3.2	0.5	Oblong target	
SS1072	311488	36930	29.0	4.8	0.6	Oblong target	
SS3003	340594	127046	10.2	2.8	0.0	Oblong target	
SS3004	341516	126595	11.7	4.3	1.7	Oblong target	M1180, M22? M1184?
SS3005	340899	126557	13.7	0.9	0.1	Linear target	M1195, M1191
SS3006	340913	126536	22.0	5.5	4.3	Linear target	M1195, M1191?
SS3008	347243	106946	4.0	3.6	1.0	Oblong target	M927
SS3009	350539	90785	5.9	4.4	0.0	Oblong target	
SS3010	350328	90449	3.3	4.5	0.9	Oblong target	
SS3013	350433	89398	6.4	3.5	0.0	Oblong target	
SS3014	351147	87559	10.1	6.0	0.8	Oblong target	
SS3015	351910	83221	6.2	2.0	1.1	Oblong target	
SS3016	352302	81339	9.7	6.5	0.0	Oblong target	
SS3017	352468	79819	7.6	4.3	0.9	Oblong target	
SS3019	349014	97588	3.6	3.9	0.9	Oblong target	
SS3020	349688	93434	8.9	4.1	0.0	Oblong target	M699
SS3022	345307	116144	24.8	2.4	0.0	Linear target	
SS3023	346788	108014	25.9	4.8	4.0	Oblong target	
SS3024	347499	104789	11.8	6.6	4.3	Oblong target	
SS3027	350422	90511	5.1	4.1	0.0	Oblong target	M390

Side Scan Sonar Targets; BITS Primary and Alternate Routes							
Sonar Target[1]	Easting[2]	Northing[2]	Length[3]	Width[3]	Height[3]	Description	Magnetic Association[4]
	feet	feet	feet	feet	feet		
SS3029	351833	80610	22.2	2.1	0.0	Linear target	
SS3031	352025	79191	7.1	1.4	0.9	Linear target	
SS3033	344685	120422	9.8	0.7	0.0	Linear target	
SS3036	346914	106490	8.2	2.5	0.7	Oblong target	
SS3037	349039	94904	17.1	3.9	0.6	Oblong target	
SS3042	347099	104558	3.5	3.2	1.1	Oblong target	M1053
SS3043	348642	97648	5.8	1.1	0.0	Oblong target	
SS3044	349873	89858	5.8	3.0	0.9	Oblong target	M730
SS3046	351419	82664	10.9	7.3	1.2	Oblong target	
SS3047	351571	80057	10.0	4.3	4.0	Oblong target	
SS3048	351794	79566	4.7	2.0	3.3	Oblong target	
SS3049	351666	79273	8.9	2.5	3.0	Oblong target	
SS3050	351923	79075	9.3	1.4	2.0	Oblong target	
SS3053	346539	106428	9.1	2.4	0.8	Oblong target	
SS3054	349253	93633	4.8	3.5	0.0	Oblong target	M28
SS3055	348853	93865	6.0	3.6	0.0	Oblong target	M866
SS3056	349083	94639	4.4	4.1	0.2	Oblong target	
SS3064	351595	79608	18.9	3.8	4.6	Linear target	
SS3066	351466	80148	5.3	3.8	5.2	Oblong target	
SS3068	351413	80587	7.0	3.5	1.5	Oblong target	
SS3069	350533	89429	7.0	4.5	1.3	Oblong target	
SS3071	351776	80474	6.3	4.2	0.4	Oblong target	
SS3072	351647	82716	7.3	4.9	0.5	Oblong target	
SS3073	351271	83959	5.3	3.3	1.2	2 oblong targets	M409
SS3074	350219	89598	8.9	3.7	0.3	Oblong target	M860, M403
SS3075	350147	89556	34.8	0.9	0	Linear target	M043?
SS3076	349257	94085	25.2	3.6	0	Oblong target	
SS3077	349103	95209	31.7	0	0	Linear features	
SS3079	347630	103033	54	2.9	0.3	Linear target	
SS3080	346851	106849	11	2.7	0.4	Oblong target	M910
ALTERNATE ROUTE							
SS2009	350306	147992	12.6	0.8	0.4	Linear target	
SS2010	350129	147854	6.0	0.9	0.0	Linear target	
SS2022	353103	134464	9.7	1.7	0.0	Linear target	
SS2033	351898	127826	23.8	2.4	0.0	Linear target	M524?
SS2035	348184	116297	10.8	1.4	0.0	Linear target	
SS2038	353351	145897	4.1	2.2	1.0	Oblong target	M427?
SS2044	349187	120324	8.3	3.3	1.4	Oblong target	
SS2045	348694	118739	16.5	1.1	0.0	Linear target	
SS2046	349650	121604	5.9	3.7	0.0	Oblong target	
SS2047	347913	116105	5.8	4.7	0.8	Oblong target	M966

Side Scan Sonar Targets; BITS Primary and Alternate Routes							
Sonar Target[1]	Easting[2]	Northing[2]	Length[3]	Width[3]	Height[3]	Description	Magnetic Association[4]
	feet	feet	feet	feet	feet		
SS2049	352946	147271	6.3	2.2	0.9	Linear target	M640
SS2051	350908	125987	5.5	1.2	0.0	Linear target	M796, M1002
SS2052	348627	120046	13.1	1.8	0.0	Linear target	M843?
SS2053	348370	119060	8.1	3.3	1.0	Oblong target	M948
SS2055	346965	111766	7.4	1.2	0.0	Linear target	
SS2060	349685	123252	7.2	2.2	0.0	Linear target	
SS2061	348306	119874	4.6	1.6	1.5	Oblong target	
SS2062	346666	112428	5.3	1.7	0.0	Oblong target	
SS2063	346959	114037	23.0	2.7	0.3	Linear target	M939, M559, M592?
SS2064	352567	139507	6.6	2.5	0.7	Oblong target	
SS2067	353451	145468	5.1	4.8	0.0	Oblong target	
SS2068	353104	138761	4.8	3.0	1.1	Oblong target	M442

Notes:

1. Target ID numbers are non-sequential.
2. Coordinates are referenced to RI State Plane, Zone 3800, NAD83, in feet.
3. Target dimensions are based on the acoustic reflection and may not represent the actual size of the object (due to orientation of object relative to sonar, partial burial of object, etc.).
4. ? symbolizes the magnetic anomaly is nearby, but not close enough to make a definitive correlation.

APPENDIX 4

MAGNETIC ANOMALY LISTINGS

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M1	318362	39657	8	79	m-	479.8	6	
M2	319551	40058	100	187	m+	486.3	6	
M3	332602	50254	12	109	m-	578.1	5	
M4	336628	54246	14	95	m-	608.8	6	
M5	338120	55741	48	186	d	619.2	5	
M6	340523	58126	16	131	d	636.1	5	
M7	341906	59496	10	117	d	645.9	5	
M8	344991	62719	13	140	d	666.0	5	
M9	345676	63393	10	115	m-	670.9	5	
M10	350565	70292	10	162	d	713.9	5	
M11	351455	73104	12	106	m-	728.2	5	
M12	350984	84926	12	155	d	793.9	6	
M13	350861	85598	5	72	m+	797.2	5	
M14	350689	86518	4	50	m-	802.0	5	
M15	350076	89761	54	430	m-	818.6	6	
M16	349008	96046	11	205	d	858.3	6	
M17	347364	104840	35	460	m+	903.0	5	
M18	346241	110869	13	313	d	933.5	5	
M19	345348	115607	7	138	m-	959.7	6	
M20	343978	122822	10	251	d	995.8	6	
M21	341343	126783	31	23	m+	1021.9	2	
M22	341465	126622	7	22	M+	1024.3	3	SS3004?
M23	344474	119815	26	2068	cd	1069.0	5	
M24	344789	118125	17	289	d	1078.0	6	
M25	345408	114835	4	97	m+	1095.0	5	
M26	346655	108111	11	108	m+	1129.3	5	
M27	348341	99083	10	195	d	1177.2	5	
M28	349250	93653	11	82	m+	1211.5	6	SS3054
M29	349949	89921	6	148	cd	1230.5	6	
M30	350510	70435	9	230	m-	1332.2	6	
M31	342811	60545	22	232	d	1407.9	6	
M32	338091	55837	41	274	d	1441.8	6	
M33	332533	50312	16	113	m+	1480.8	5	
M34	319585	40138	105	508	d	1567.2	5	
M35	311384	37452	34	78	m+	1609.1	3	
M36	311177	37329	55	66	m-	1610.4	4	
M37	311490	37095	13	52	m+	3073.2	3	
M38	311622	37119	16	86	m+	3073.9	3	
M39	311879	37215	20	106	m+	3075.3	4	
M40	312905	37547	7	57	d	3080.7	5	
M41	313771	37833	9	81	m-	3085.3	5	
M42	314379	38032	12	86	m+	3088.6	5	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M43	319859	39837	32	83	m+	3118.2	6	
M44	324542	42165	6	112	d	3150.6	5	
M45	326079	43456	7	85	m+	3160.8	5	
M46	330378	47646	12	169	m+	3191.8	5	
M47	332771	50029	20	143	m-	3208.7	5	
M48	337533	54777	7	171	m+	3242.5	5	
M49	338237	55476	35	305	D	3247.5	5	
M50	332724	50068	23	130	m+	3332.1	5	
M51	330389	48352	11	269	m+	3373.1	7	
M52	332505	50464	8	147	d	3388.0	5	
M53	337650	55633	7	102	m+	3424.8	5	
M54	338003	55985	46	209	d	3427.2	5	
M55	342754	60718	25	265	d	3460.5	5	
M56	344814	62775	13	143	m+	3475.2	5	
M57	344965	62912	13	117	m-	3476.2	5	
M58	347763	64626	9	99	m+	3500.2	4	
M59	343035	59789	28	194	d	3535.8	5	
M60	338361	55205	33	168	d	3568.7	5	
M61	332964	49810	5	92	m+	3606.9	5	
M62	316371	38498	15	222	m+	5241.9	5	
M63	320149	39749	20	159	m+	5262.1	5	
M64	320360	39821	16	129	m+	5263.3	6	
M65	320341	39903	22	176	d	5277.7	5	
M66	320192	39854	18	124	m-	5278.3	5	
M67	319969	39780	26	109	m+	5279.5	5	
M68	317433	38936	34	103	m-	5292.3	5	
M69	314351	37921	5	41	m-	5308.0	5	
M70	314170	37861	7	67	d	5308.9	5	
M71	313180	37532	15	47	m-	5314.0	5	
M72	312205	37205	12	83	m+	5319.1	5	
M73	311251	37536	11	43	m-	5325.2	5	
M74	311330	37547	27	114	m+	5325.5	5	
M75	311457	37578	20	87	m-	5326.2	5	
M76	314202	38495	13	69	d	5340.9	6	
M77	314622	38633	5	41	m-	5343.1	5	
M78	317655	39638	14	171	d	5359.3	5	
M79	319360	40205	15	119	m+	5368.5	6	
M80	320795	40763	6	102	m+	5376.6	5	
M81	320008	39987	66	146	m+	5386.5	5	
M82	319757	39908	98	301	m+	5388.1	5	
M83	315738	38582	44	269	m+	5408.5	5	
M84	314368	38128	12	84	d	5415.4	5	
M85	311919	37321	9	61	m+	5428.0	5	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M86	311670	37238	24	94	m+	5429.2	5	
M87	314321	38633	6	60	m-	5449.8	5	
M88	315742	39102	22	234	m+	5457.3	6	
M89	320008	40076	58	109	m+	5495.3	5	
M90	319679	39969	78	172	m+	5497.1	5	
M91	315744	38681	94	266	m+	5517.2	5	
M92	313312	37877	6	77	m+	5529.7	5	
M93	311490	37272	9	86	m+	5539.0	5	
M94	320477	40765	5	95	d	5601.8	5	
M95	315729	39186	37	350	m+	5627.0	5	
M96	311313	37733	53	184	m+	5650.0	5	
M98	311093	37809	19	46	m-	5654.2	4	
M99	311202	37648	36	65	d	5655.1	4	
M100	311329	37382	22	59	m+	5656.6	5	
M101	311601	36873	36	59	m+	5659.5	5	
M104	311881	37305	24	72	d	5667.9	5	
M105	311833	37449	28	80	d	5668.5	5	
M106	311811	37525	6	36	m+	5669.0	5	
M107	311795	37579	12	54	m+	5669.2	5	
M109	313320	37642	26	63	m+	5700.7	5	SS14
M111	313847	37616	9	65	m-	5710.4	6	
M112	313775	37837	24	108	d	5711.5	6	
M113	314092	38471	7	57	m+	5721.9	6	
M114	314564	38584	11	72	d	5734.0	5	SS69?
M116	316435	39158	11	52	d	5773.1	5	
M117	318354	39646	10	49	m-	5814.7	5	
M118	319788	40039	54	221	m-	5847.4	6	
M119	319856	39833	103	177	m+	5848.3	5	
M120	320378	39834	10	82	m+	5854.6	5	
M121	320335	39954	7	93	m+	5855.2	5	
M122	320824	40158	10	103	m-	5868.7	6	
M123	320804	40763	7	129	m+	5877.0	6	
M124	323402	41948	5	97	m-	5892.5	4	
M125	323714	42107	10	139	m+	5894.1	5	
M126	324005	42356	6	91	d	5896.1	6	
M127	324405	42293	9	113	m+	5971.6	6	
M128	324209	42125	19	123	d	5973.0	5	
M129	324089	42022	19	150	m-	5973.8	6	
M130	323521	41658	6	74	m-	5977.2	6	
M131	322578	41226	6	97	m-	5982.4	6	
M132	322059	40986	6	83	m-	5985.3	5	
M133	325702	43919	14	132	m+	6025.5	5	
M134	325408	42744	6	102	m+	6081.0	5	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M135	324794	42219	16	125	m+	6085.1	6	
M136	324408	41897	9	89	m+	6087.7	5	
M137	322642	40918	10	119	m+	6098.9	5	
M138	320455	40806	7	95	m+	6112.3	5	
M139	326305	44559	20	226	d	6149.8	5	
M140	329405	46342	6	154	d	6171.0	5	
M141	324647	41951	12	141	m+	6204.3	5	
M142	324478	41805	10	154	d	6205.5	5	
M143	323958	41407	15	187	m+	6209.8	6	
M144	322758	40838	12	128	d	6216.4	5	
M145	322151	40568	9	112	m+	6219.6	5	
M146	322052	40523	6	90	m+	6220.2	6	
M147	320686	41006	12	134	m+	6231.0	6	
M148	321385	41328	7	131	m-	6235.0	5	
M149	322230	41702	6	106	m+	6239.7	6	
M150	325302	43794	9	117	m+	6259.3	6	
M151	325451	43925	11	112	m+	6260.3	5	
M152	327650	44991	10	125	m+	6299.4	5	
M153	327383	44718	9	50	m+	6301.3	6	
M154	324899	42532	12	148	m+	6319.1	5	
M155	324684	42353	11	97	m+	6320.3	5	
M156	324493	42191	11	103	m+	6321.6	5	
M157	324288	42013	19	104	m+	6322.9	5	
M158	324184	41921	12	173	m+	6323.6	5	
M159	322626	41089	11	116	m-	6333.3	5	
M160	321158	40432	15	153	d	6341.3	5	
M161	321339	40184	6	116	m+	6351.3	6	
M162	321223	40434	17	136	d	6352.8	5	
M163	321415	41251	9	139	m+	6363.2	6	
M164	321550	40944	6	117	m+	6364.9	5	
M166	322174	40704	6	143	d	6374.0	6	
M167	322499	41226	5	107	m+	6387.6	5	
M168	322992	41278	5	91	m-	6396.9	6	
M169	322949	41373	10	98	m-	6397.4	5	
M170	322820	41649	5	101	m+	6399.1	6	
M171	322773	41751	7	119	m+	6399.6	6	
M172	332453	50408	25	78	m+	6607.5	6	
M173	332847	49941	25	60	m-	6663.3	6	
M174	333766	51996	7	53	m+	6727.2	5	
M175	333279	51628	11	47	m+	6767.2	5	
M176	332296	50645	31	91	m+	6774.2	6	
M177	331172	49526	15	66	di	6782.2	5	
M178	332662	50182	12	66	m+	6831.4	5	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M179	333692	50729	5	48	di	6905.8	5	
M182	337895	56189	52	243	di	7120.6	6	
M183	338289	56592	10	93	m+	7123.4	5	
M184	342615	60896	35	141	di	7153.7	5	SS52
M185	342992	59988	27	205	di	7170.0	6	
M186	342057	59057	8	77	m+	7176.6	6	
M187	338307	55326	40	141	di	7203.0	6	
M188	337671	55592	7	65	m+	7233.0	5	
M189	338032	55943	60	187	di	7235.9	5	
M190	341905	59800	6	61	di	7263.0	6	
M191	342681	60822	32	145	di	7273.3	6	
M192	337948	56093	49	161	di	7306.9	5	
M193	337497	54863	10	124	di	7337.6	5	
M194	338183	55555	50	187	di	7342.6	5	
M195	342902	60253	32	153	di	7375.7	5	
M196	342897	60344	43	153	di	7391.4	5	
M197	340852	58297	9	33	m+	7405.9	6	
M198	338517	55973	6	72	m+	7422.4	5	
M199	338181	55641	55	148	di	7424.8	5	
M200	337462	54926	10	94	m-	7429.8	6	
M201	337357	54822	8	35	m+	7430.7	5	
M202	342707	60773	29	122	di	7549.8	5	
M203	342873	60948	6	30	m+	7551.2	5	
M204	343000	61085	8	41	m+	7552.0	6	
M205	344042	62144	10	81	m+	7559.5	6	
M206	344685	62791	16	88	m+	7564.1	5	
M207	348011	66098	20	69	m+	7587.5	6	
M208	345794	63037	7	84	m+	7623.7	5	
M209	345065	62311	8	85	di	7629.0	5	
M210	342625	60850	33	127	di	7644.7	5	
M211	347973	66212	20	94	di	7682.6	5	
M212	345564	62943	7	111	m-	7723.2	6	
M213	345154	62542	7	72	m+	7726.0	6	
M214	342033	59056	10	92	m+	7744.7	5	
M215	342972	60002	30	136	di	7751.2	6	
M216	345263	62286	12	129	m+	7767.4	5	
M217	345788	62808	21	144	di	7771.1	6	
M218	347745	64859	70	91	di	7814.4	6	
M219	345267	62412	17	119	m+	7831.6	6	
M220	342972	60129	52	148	di	7848.0	5	
M221	341893	59509	17	96	di	7865.2	5	
M222	342829	60439	27	159	di	7871.8	6	
M223	342995	60604	7	51	m+	7873.0	6	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M224	347842	65824	6	34	m+	7941.8	6	
M225	349436	66343	5	41	m+	7959.6	5	SS19
M226	348790	65563	7	74	di	7965.2	5	
M227	348432	65923	7	75	m+	7967.8	5	
M228	348187	66181	9	134	di	7969.5	6	
M229	349314	67849	12	114	di	7982.2	5	
M230	350414	70415	18	67	m+	7997.0	5	
M231	351439	74122	5	44	m+	8018.8	6	SS47
M232	352284	78999	17	174	di	8061.4	5	
M233	352291	77642	6	43	m-	8068.2	5	
M234	351879	73059	8	64	m+	8093.4	6	
M235	350907	69964	14	97	di	8111.8	5	
M236	349920	67692	8	40	m+	8125.4	5	
M237	349836	67469	9	155	m+	8126.6	6	
M238	350353	70511	8	61	di	8158.0	5	
M239	350446	70726	5	50	m+	8159.2	5	
M240	350712	71356	27	91	m-	8163.5	5	
M241	351587	78781	4	34	m+	8204.3	5	
M242	352197	78973	14	227	di	8211.9	5	
M243	350821	70026	4	58	m+	8260.9	5	
M244	349839	67723	5	37	m+	8274.4	6	SS100
M245	349814	67668	17	65	m+	8274.8	6	SS100
M246	349716	67435	7	64	di	8276.1	6	
M247	349606	67190	5	37	m-	8277.5	5	
M248	349681	69173	5	51	m-	8299.1	6	
M249	350275	70574	15	99	m+	8307.7	6	
M250	351074	73081	14	46	m+	8322.5	5	SS46
M251	351322	74481	4	50	m+	8330.4	4	
M252	352503	79014	24	206	di	8361.0	6	
M253	351039	69782	42	106	m+	8412.5	5	
M254	350001	67379	8	157	m+	8426.8	6	
M255	349248	66645	5	59	m-	8438.5	5	
M256	350577	69771	5	43	m-	8455.7	5	
M257	350717	70111	41	100	m+	8457.7	5	
M258	352388	79031	18	177	di	8524.5	5	
M259	352159	74015	9	80	m-	8550.7	6	
M260	350965	69885	9	77	m-	8575.8	7	
M261	350319	68392	9	87	di	8585.0	6	
M262	350626	70182	23	93	m+	8619.6	6	
M263	351530	72950	4	40	di	8642.7	5	
M264	351565	73140	14	39	m+	8643.7	5	
M265	351956	75404	6	39	m+	8656.9	5	
M266	352393	79497	6	39	m+	8686.6	5	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M267	352036	76489	3	30	m-	8716.0	5	SS61
M268	351988	76487	4	38	m+	8716.6	5	SS61
M269	314888	38959	6	21	m+	1254.3	6	
M270	311254	37761	45	119	m+	1234.8	5	
M271	313796	38603	7	65	m+	1248.3	5	
M272	317905	39956	6	52	m+	1270.6	5	
M273	319656	39965	54	146	m+	1284.0	5	
M274	315719	38716	92	256	m+	1304.0	5	
M275	313065	37853	7	52	m+	1317.7	5	
M276	311816	37444	41	58	m-	1324.3	5	
M277	311166	37616	15	58	m-	1330.9	5	
M278	311302	37686	14	63	di	1332.8	5	
M279	312033	37918	64	89	di	1336.7	5	
M280	319743	39911	87	227	m+	1380.9	5	
M281	315728	38621	66	229	m+	1401.2	5	
M282	315090	38412	5	30	m+	1404.5	5	
M283	313615	37929	6	29	m+	1412.2	5	
M284	311185	37505	23	73	m+	1426.7	5	
M285	311320	37586	33	138	m+	1428.5	5	
M286	311534	37655	17	69	m+	1429.7	5	
M287	316322	39225	5	54	m+	1455.5	6	
M288	319339	40215	13	68	m+	1472.0	5	
M289	319863	39837	75	93	m+	1476.3	5	
M290	314378	38079	16	63	di	1504.3	5	
M291	311970	37287	34	54	m+	1516.9	5	
M292	311281	37460	16	70	m+	1525.1	5	
M293	311724	37612	21	112	m+	1527.5	5	
M294	313378	38163	24	44	m+	1536.5	5	
M295	314567	38548	6	62	di	1542.7	5	
M296	319497	40172	16	106	di	1569.5	6	
M297	319906	40307	8	48	di	1571.8	6	
M298	319951	39783	18	60	m+	1575.2	5	
M299	316636	38717	10	41	m-	1592.2	5	
M300	314352	37970	15	70	di	1603.8	5	
M301	313316	37626	6	31	m+	1609.2	6	
M302	313191	37587	26	90	di	1609.7	5	
M303	312134	37235	12	36	m+	1615.3	5	
M304	311868	37144	10	57	m+	1616.7	5	
M305	311657	37079	12	65	di	1617.8	5	
M306	311497	37016	7	31	m+	1619.8	5	
M307	311201	37304	76	54	m+	1622.4	5	
M308	314501	38427	15	44	di	1641.3	5	
M309	317455	38885	4	24	m+	1684.3	5	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M310	314855	38029	6	33	m+	1697.5	5	
M311	314385	37877	21	51	di	1699.8	5	
M312	313919	37728	8	32	m-	1702.3	5	
M313	312241	37172	7	48	m+	1710.9	5	
M314	312057	37112	20	58	di	1712.0	5	
M315	311685	36984	10	54	m+	1713.8	6	
M316	342990	125603	32	83	di	5951.3	5	
M317	343518	124030	7	63	m+	5959.8	5	
M318	344225	121396	15	70	di	5973.7	6	
M319	345322	115537	31	89	m+	6003.8	5	
M320	343196	126014	16	65	m+	6071.4	5	
M321	343000	126326	14	86	m+	6204.3	5	
M322	343980	121363	14	52	m+	6231.7	6	
M323	344480	118675	34	85	di	6245.6	5	
M324	340155	57528	11	106	m-	6278.4	6	
M325	341675	58781	7	67	di	6327.7	5	
M326	342841	60408	25	178	di	6367.3	6	
M327	342965	60995	8	48	m+	6375.1	5	
M328	342998	59864	27	215	di	6386.9	5	
M331	344029	62010	6	74	m+	6422.1	6	
M332	345073	62360	6	62	m+	6438.4	5	
M333	345263	62889	20	181	di	6448.2	6	
M334	345353	63475	5	75	m+	6459.4	5	
M335	346021	63511	6	73	m+	6466.8	5	
M336	345977	64241	5	58	m+	6478.9	5	
M337	346615	64324	8	121	di	6484.0	5	
M338	347776	64544	11	72	m-	6505.4	7	
M339	348009	65704	3	37	m+	6521.2	5	
M340	350732	71327	12	79	di	6628.3	5	
M341	351468	73104	22	67	di	6665.8	5	
M342	344833	118955	4	64	m+	6755.2	5	
M343	344099	122791	8	70	di	6774.4	5	
M344	342909	126239	9	75	m+	6792.4	5	
M345	343305	126008	6	50	m-	6798.2	6	
M346	343989	120782	6	57	di	6898.6	5	
M347	342524	125832	15	114	m+	6924.6	5	
M348	344373	123205	10	130	di	6945.7	6	
M349	344721	121662	7	58	di	6953.8	6	
M350	344281	118669	16	188	di	7023.3	5	
M351	343889	120784	10	60	m+	7034.0	5	
M352	342442	125760	13	91	m+	7059.6	5	
M353	344360	119046	8	114	di	7206.3	5	
M354	346103	112205	9	56	di	7311.6	5	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M355	347357	105453	39	55	m+	7345.8	5	
M356	345933	110369	9	58	m-	7395.7	5	
M357	345428	113085	16	175	m-	7409.7	6	
M358	347318	107270	6	48	m+	7467.0	5	
M359	347494	106329	13	57	m+	7471.9	6	
M360	347084	103684	32	50	m-	7485.2	5	
M361	346761	105359	6	37	m-	7492.8	5	
M362	346333	107655	20	60	m-	7504.5	5	
M363	345270	113385	8	51	di	7533.8	6	
M364	350700	87601	19	57	m-	7553.8	6	
M365	350788	87121	12	56	m+	7556.1	5	
M366	351210	84875	60	64	m+	7567.6	5	
M367	351941	80958	17	58	di	7587.5	5	
M368	350610	84829	11	68	di	7629.7	6	
M369	350502	85387	6	57	di	7632.5	6	
M370	350362	86146	6	85	m-	7636.5	5	
M371	350734	87932	5	49	di	7673.5	5	
M372	350824	87467	4	48	m+	7675.8	5	
M373	351159	85705	7	39	m+	7684.8	6	
M374	350954	83483	6	32	m+	7748.4	6	
M375	350316	86908	6	47	di	7765.9	6	
M376	350144	87834	3	25	m-	7770.6	5	
M377	350120	87965	5	38	m+	7771.3	6	
M378	350061	88813	236	88	m+	7775.3	9	
M379	349589	90771	19	49	m+	7785.6	5	
M380	349574	90844	24	42	m+	7785.9	5	
M381	349452	91487	9	44	m+	7789.3	5	
M382	349435	91572	18	45	m+	7789.6	5	
M383	350582	89247	5	49	m+	7808.2	5	
M384	352281	79013	18	168	di	7860.2	5	
M385	351065	83380	5	26	m+	7888.5	5	
M386	350962	83939	7	32	m+	7891.4	5	
M387	350387	87007	16	65	m+	7906.9	5	
M388	350049	88806	1226	49	m+	7916.2	6	
M389	349921	89347	13	40	m-	7918.8	6	
M390	350432	90503	9	37	m+	7926.2	6	SS3027
M391	350570	89776	3	30	m+	7929.9	5	
M392	350633	89481	14	39	m+	7931.4	5	
M393	350640	89439	4	25	m+	7931.6	5	
M394	351523	84708	6	39	m+	7955.8	5	
M395	352370	79030	18	164	di	7984.5	5	
M396	352472	79009	26	185	di	7992.5	5	
M397	352437	79398	4	40	m+	7994.5	6	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M398	351083	87541	21	152	m-	8035.9	5	
M399	350888	88836	4	51	m+	8042.3	7	
M400	350719	89492	8	37	m+	8045.8	6	
M401	350534	90465	17	60	di	8050.7	5	
M402	349968	90855	8	42	m-	8056.4	5	
M403	350216	89551	46	81	di	8063.2	6	SS3074
M404	350409	88497	8	33	m+	8068.5	6	M043?
M405	350584	87564	4	37	m+	8073.4	5	
M406	350889	85883	5	46	di	8081.8	6	
M407	351027	85174	4	41	m+	8085.5	6	
M408	351142	84592	4	44	di	8088.5	6	
M409	351264	83952	5	55	di	8091.7	5	SS3073
M410	351442	80383	4	45	m+	8131.3	6	
M411	350957	82741	7	47	m+	8188.8	5	
M412	350341	86128	20	82	m-	8261.8	5	
M413	352393	132163	12	90	di	8277.3	6	
M414	352497	133516	4	43	m+	8284.1	5	
M415	352841	138113	8	44	m+	8307.1	6	
M416	352958	139724	17	48	m+	8315.2	6	
M417	353259	145776	8	51	di	8345.4	6	
M418	352627	147733	8	48	m+	8355.3	6	
M424	352527	148075	22	59	m+	8371.9	6	
M425	352611	147922	15	94	m+	8372.8	6	
M426	352716	147729	5	37	m+	8373.9	6	
M427	353352	145841	9	34	m+	8384.7	5	SS2038?
M428	352678	138588	6	40	m+	8423.7	5	
M429	352845	140949	9	99	m+	8435.6	5	
M430	352924	141935	35	40	m+	8440.6	5	
M431	352923	146188	4	32	m+	8462.0	6	
M432	352837	146430	8	51	di	8463.3	6	
M433	352703	146868	4	31	m+	8465.7	6	
M439	352659	148040	79	71	m=	8485.8	5	
M440	352836	147722	8	50	di	8487.7	6	
M441	353264	141143	7	48	di	8521.3	6	
M442	353092	138794	7	50	di	8533.1	5	SS2068
M443	352751	140940	11	72	m+	8548.2	6	
M444	352966	143807	13	130	m-	8562.6	5	
M445	353028	144512	25	180	m+	8566.1	5	
M446	353089	145388	20	52	di	8570.4	5	
M447	352271	147691	5	46	m+	8582.8	6	
M448	352963	147689	5	50	m+	8599.5	5	
M449	353598	144360	21	149	m+	8616.8	6	
M450	352705	141665	27	163	m-	8669.6	6	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M451	352806	142931	10	66	di	8676.0	5	
M452	352962	145077	4	27	m+	8686.7	5	
M453	352118	147764	10	56	m+	8701.0	5	
M454	352085	147831	12	44	di	8701.5	5	
M455	351955	148065	11	56	m-	8702.6	5	
M460	353076	147699	10	30	m+	8718.3	5	
M461	353774	145487	7	43	di	8729.8	5	
M462	353772	145230	3	25	m-	8731.1	5	
M463	353588	142835	15	64	di	8743.2	6	
M464	353262	138527	5	41	m+	8764.8	6	
M465	352828	139285	5	34	m+	8772.5	6	
M466	352949	141064	4	33	m+	8781.5	5	
M467	352984	141434	11	101	m-	8783.3	6	
M468	353089	142931	12	26	m+	8790.9	5	
M469	353184	144120	7	79	m-	8796.8	5	
M470	352881	146648	28	140	di	8809.8	6	
M471	352800	146918	16	65	di	8811.2	6	
M472	352696	147254	5	35	m+	8813.2	5	
M473	352524	147635	4	39	m-	8815.2	5	
M474	352478	147727	12	50	m+	8815.8	5	
M475	352343	147986	6	36	m+	8817.1	6	
M476	352058	148488	5	34	m+	8820.0	5	
M480	353156	147710	6	34	m+	8834.9	5	
M481	353274	147329	7	41	m+	8836.8	5	
M482	353752	143899	4	50	m-	8854.6	6	
M483	353720	143408	5	50	m+	8857.0	6	
M484	353693	142957	5	42	m+	8859.3	6	
M485	353503	140439	3	38	m+	8872.1	5	
M486	352470	139806	16	72	di	8893.0	6	
M487	352528	140614	15	62	m-	8897.0	6	
M488	352674	142551	6	53	m+	8906.8	5	
M489	352291	147228	9	87	m-	8930.7	6	
M490	352282	147231	17	104	m-	8936.7	5	
M491	351834	148085	25	74	m-	8941.5	6	
M497	352083	147965	13	44	m-	8959.8	5	
M498	351880	147866	18	43	m+	8960.9	5	
M499	352470	147634	5	37	m+	8967.0	6	
M500	352650	147736	13	88	di	8968.2	6	
M501	347874	116801	10	45	m+	9628.5	5	
M502	351850	129150	8	42	m+	9631.1	5	
M503	349049	120442	7	44	di	9647.6	5	
M504	351957	129473	107	157	di	9649.9	6	
M505	349238	121033	8	53	m+	9650.7	6	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M506	352328	130622	7	47	m+	9700.8	5	
M507	352460	131748	23	64	di	9706.5	4	
M508	346733	109453	8	92	m+	26.8	6	
M509	347073	107602	9	70	di	36.4	6	
M510	347116	114230	6	58	m+	162.2	5	
M511	347534	116376	4	37	m+	173.1	5	
M512	349080	121197	8	101	m-	198.2	5	
M513	349279	121815	4	39	di	201.5	5	
M514	350246	124807	3	40	m+	217.1	5	
M515	350771	126440	8	59	m-	225.6	6	
M516	351520	128746	10	43	m+	237.7	6	
M517	352678	137271	10	43	m+	280.6	5	
M518	353244	136853	4	33	m+	301.9	5	
M519	353227	136617	5	38	m+	303.2	6	
M520	353058	134223	5	30	m-	315.2	5	
M521	352888	131857	12	52	m-	327.2	5	
M522	352853	131540	5	37	m+	328.8	6	
M523	352368	129460	6	41	m+	339.6	5	
M524	351830	127774	8	60	m-	348.4	6	SS2033?
M525	351795	127638	19	49	m-	349.2	6	
M526	351760	127531	14	78	m+	349.7	5	
M527	351747	129787	9	63	m+	363.8	5	
M528	352218	132359	11	74	di	376.8	5	
M529	352235	132552	4	58	m-	377.8	5	
M530	352355	134297	3	35	m+	386.5	5	
M531	352563	137016	13	69	di	400.0	5	
M532	352606	137639	7	94	di	403.1	6	
M533	352678	138587	6	45	m+	407.8	5	
M534	351338	129485	23	56	m+	486.3	5	
M535	351952	132721	7	44	m+	502.7	5	
M536	352218	136400	5	46	m+	521.0	6	
M537	352971	137553	8	35	m+	540.0	5	
M538	352485	137075	12	52	m+	549.5	5	
M539	352334	136102	15	49	m+	567.9	5	
M540	352992	135071	4	32	m+	583.3	5	
M541	353010	134077	25	58	m+	602.9	5	
M544	352438	132140	14	59	di	648.1	2	
M545	352400	132141	9	34	m+	648.2	5	
M546	352177	132156	6	56	m+	649.4	5	
M547	352748	131118	6	53	di	664.2	6	
M548	351394	129913	4	32	m+	690.3	6	
M549	352146	129154	5	48	m+	700.3	5	
M550	350921	129033	9	45	m+	707.2	6	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M551	351121	128983	9	46	m+	708.5	6	
M552	351048	128467	11	69	m+	727.5	6	
M553	349245	122931	5	65	m-	756.7	6	
M554	348937	121983	4	62	m+	761.8	6	
M555	348553	120778	6	51	m+	768.1	6	
M556	348490	120602	16	51	di	769.2	4	
M557	346938	115386	7	50	m+	856.1	6	
M558	346628	113661	5	36	m+	864.7	5	
M559	346992	114074	12	49	m+	890.5	5	SS2063
M560	347010	114165	22	74	di	890.9	6	
M561	347384	116177	8	74	di	901.2	5	
M562	349717	123481	10	46	m+	939.3	4	
M563	350511	125955	10	51	m+	952.4	5	
M564	350678	126456	6	44	m-	955.0	5	
M565	350874	127064	5	57	di	958.2	5	
M566	351602	127730	6	39	m+	971.6	5	
M567	350655	124766	6	42	m+	987.4	5	
M568	349185	120175	8	49	m-	1011.7	5	
M569	349050	119755	57	110	m+	1013.9	6	
M570	348522	118096	5	39	m+	1022.6	5	
M571	348398	117709	207	86	m-	1024.7	6	
M572	347511	114113	9	59	di	1043.2	6	
M573	347174	111218	9	84	m-	1077.2	6	
M574	347447	112746	5	59	di	1085.0	5	
M575	347506	113072	22	80	di	1086.8	5	
M576	347883	115150	7	63	di	1097.3	5	
M577	348753	118229	4	51	m+	1113.2	5	
M578	349161	119497	4	59	m+	1119.9	5	
M579	349321	119991	5	56	m-	1122.5	5	
M580	349574	120795	16	81	m-	1126.5	5	
M581	349606	120898	5	63	di	1127.1	5	
M582	350857	124778	8	63	m+	1147.3	5	
M583	351289	126124	6	52	m-	1154.5	5	
M584	351686	127348	17	77	m+	1160.9	5	
M585	351712	127431	8	82	m+	1161.3	6	
M586	351743	127525	16	73	m+	1161.8	6	
M587	351775	127625	23	64	di	1162.1	6	
M588	350554	126411	11	131	di	1176.3	6	
M589	350362	125797	4	34	m+	1179.5	5	
M590	349534	123224	7	67	m+	1193.1	5	
M591	347217	115882	7	57	m+	1231.7	5	
M592	346901	114078	24	54	m+	1240.9	5	SS2063
M593	346719	113709	13	63	m-	1267.6	6	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M594	349924	124763	5	45	m+	1324.8	5	
M595	350012	125060	5	67	m+	1326.2	5	
M596	350276	125848	12	69	m+	1330.5	5	
M597	350343	126066	29	85	di	1331.6	5	
M598	350836	125005	5	59	m+	1360.6	5	
M599	349501	120892	5	35	m-	1382.5	5	
M600	349353	120429	12	68	di	1384.8	6	
M601	349282	120171	5	54	m+	1386.3	5	
M602	349228	120009	5	47	m+	1387.1	5	
M603	349153	119781	16	94	di	1388.2	5	
M604	348468	117669	118	80	m-	1399.4	6	
M605	347903	115738	10	71	di	1409.3	6	
M606	347785	115111	5	44	m+	1412.7	5	
M607	347247	112172	10	68	m+	1427.6	6	
M608	346937	110504	19	66	m+	1436.2	5	
M609	346056	110702	43	81	m-	1459.8	6	
M610	346193	109970	9	111	m+	1463.8	6	
M611	346462	108515	18	135	m+	1471.0	5	
M612	347031	105507	8	45	m+	1486.2	5	
M613	347242	104379	16	50	m+	1491.7	5	
M614	348804	95974	6	61	di	1534.8	5	
M617	352635	147731	10	66	m+	1551.5	6	
M618	352871	147233	22	76	m+	1554.2	5	
M619	353260	145949	18	56	m+	1560.9	5	
M620	353367	144452	19	158	m+	1568.5	6	
M621	353224	142533	9	52	m+	1578.3	5	
M622	353191	142111	7	39	m+	1580.5	5	
M623	353001	139712	24	118	di	1592.4	5	
M624	352458	138825	6	62	m+	1604.7	6	
M625	352482	139175	5	95	di	1606.4	5	
M626	352661	141635	39	155	m-	1618.8	5	
M627	352666	141720	8	63	m-	1619.2	5	
M628	352914	145084	14	57	m+	1636.0	5	
M629	352629	146322	10	52	m+	1642.5	5	
M630	352374	147112	12	96	di	1646.7	5	
M631	352292	147355	51	83	di	1648.0	5	
M632	352125	147607	7	40	m+	1649.5	5	
M633	352038	147827	7	55	m-	1650.6	6	
M638	352572	148082	24	73	di	1663.3	5	
M639	352634	147979	7	75	m+	1663.9	5	
M640	352960	147267	11	38	m+	1667.8	6	SS2049
M641	353459	144262	6	72	m+	1683.1	6	
M642	353319	142554	19	50	m+	1698.9	6	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M643	353237	141478	22	185	m+	1704.3	6	
M644	353097	139711	11	89	di	1713.1	5	
M645	352577	139221	8	65	m+	1727.0	5	
M646	352860	143028	5	64	m+	1746.1	6	
M647	352780	146179	7	70	m-	1762.0	6	
M648	352176	147778	13	151	di	1770.6	5	
M649	352066	147975	12	70	di	1771.8	5	
M655	353262	146603	11	50	di	1793.0	5	
M656	353572	144604	36	103	m-	1803.1	5	
M657	353419	142625	8	53	m+	1813.2	6	
M658	352805	140916	30	147	di	1850.8	6	
M659	352851	141653	17	145	m-	1854.5	6	
M660	352891	142121	40	296	di	1856.8	6	
M661	352967	143076	8	38	m+	1861.6	5	
M662	352970	143239	10	84	m-	1862.4	5	
M663	353068	144523	27	226	m+	1868.7	5	
M664	352822	146383	6	66	di	1878.4	5	
M665	352678	146803	5	81	di	1880.7	6	
M666	352184	147971	15	78	di	1887.0	5	
M673	353020	147691	7	40	m+	1903.0	5	
M674	353652	144333	15	157	m+	1919.2	5	
M675	352824	139914	9	59	di	1961.0	5	
M677	352771	146860	5	45	m+	1996.2	6	
M678	352706	147077	13	52	m+	1997.3	6	
M679	352688	147134	23	74	di	1997.6	6	
M680	352484	147634	7	65	m+	2000.2	5	
M681	352423	147741	8	66	m+	2000.5	6	
M682	352359	147854	8	55	di	2000.8	5	
M688	353060	147802	12	61	di	2018.1	5	
M689	353117	147700	38	68	m+	2018.7	5	
M690	353581	146260	14	53	m+	2026.2	6	
M691	353820	145272	12	70	di	2031.2	5	
M692	353642	142934	6	62	m+	2043.0	5	
M693	352914	139717	22	94	m-	2076.3	6	
M694	352834	146996	8	49	m+	2113.2	5	
M695	352550	147732	11	56	m+	2117.2	6	
M698	348267	101091	11	45	m+	2344.5	6	
M699	349694	93444	5	44	m+	2383.5	5	SS3020
M700	349963	88295	5	32	m+	2406.4	6	
M701	349512	90662	4	29	m+	2418.5	6	
M702	349155	92562	7	69	di	2428.2	5	
M703	349003	93381	17	93	di	2432.3	5	
M704	348711	94953	6	60	di	2440.2	6	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M705	348443	96389	5	35	m+	2447.6	5	
M706	347533	101245	29	42	m+	2472.0	5	
M707	347239	102808	8	36	m-	2479.8	5	
M708	347226	102883	23	70	m+	2480.1	5	
M709	347084	103654	42	75	di	2484.1	5	
M710	348989	97837	3	43	m+	2524.6	5	
M711	349092	97243	7	43	m+	2527.8	5	
M712	350062	88388	5	32	m+	2566.3	5	
M713	349590	90824	11	102	di	2578.6	5	
M714	349449	91582	9	40	m+	2582.5	6	
M715	349407	91804	6	53	di	2583.5	5	
M716	349377	91961	6	38	m+	2584.5	5	
M717	349143	93209	4	39	m+	2590.6	6	
M718	349109	93406	14	65	m+	2591.6	5	
M719	349003	93955	9	43	m+	2594.5	5	
M720	348717	95541	6	37	m+	2602.5	5	
M721	348651	95875	7	58	m+	2604.3	5	
M722	348151	98528	10	79	di	2617.8	5	
M723	347160	103778	6	63	di	2644.1	5	
M724	348929	98749	3	36	m+	2681.5	5	
M725	349163	97531	9	67	m-	2687.8	5	
M726	349249	97042	23	71	m+	2690.2	5	
M727	349986	93063	5	51	m-	2710.5	5	
M728	350738	89072	18	87	di	2730.6	6	
M729	350080	88811	36	71	m+	2740.1	6	
M730	349872	89875	5	55	m-	2745.5	5	SS3044
M731	349478	91950	5	31	m+	2756.1	6	
M732	349004	94507	14	59	di	2769.2	5	
M733	348886	95150	12	41	m-	2772.3	5	
M734	348317	98183	6	70	di	2787.7	5	
M735	348634	100831	14	63	m+	2844.5	5	
M736	350568	90482	14	59	di	2897.2	5	
M737	349732	92760	10	84	di	2919.1	5	
M738	349478	94069	5	43	m+	2925.8	5	
M739	346771	110691	6	70	di	3011.4	5	
M740	346696	111085	6	54	m-	3013.4	5	
M741	346668	111227	4	54	m+	3014.2	5	
M742	345764	115868	3	80	di	3033.8	6	
M743	343354	125989	4	47	m+	3084.5	5	
M744	343320	126092	6	68	m+	3084.9	5	
M745	342958	126319	13	94	di	3090.8	6	
M746	344382	121690	5	38	m-	3115.3	6	
M747	345062	119006	5	41	m-	3180.8	5	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M748	344953	119593	4	72	m+	3183.8	5	
M749	344918	119798	9	124	m+	3184.7	5	
M750	344856	120140	6	74	m+	3186.5	5	
M751	344837	120249	7	85	m+	3187.1	5	
M752	351630	127313	48	89	m+	3224.3	5	
M753	351678	127464	21	93	m-	3225.0	6	
M754	351707	127555	9	86	m-	3225.5	6	
M755	352542	130167	8	55	m+	3239.2	5	
M756	352644	130489	16	40	m+	3240.8	5	
M757	352821	131875	16	53	m+	3247.7	5	
M758	353053	135006	7	66	di	3263.3	5	
M759	353218	137283	11	104	di	3274.7	5	
M760	352638	135977	7	50	m+	3298.3	6	
M761	352603	135555	31	92	m-	3300.5	6	
M762	352426	133020	4	35	m-	3313.2	5	
M763	352082	130309	4	42	m+	3327.2	6	
M764	351682	129053	13	84	m+	3333.7	5	
M765	351105	127282	6	32	m+	3343.0	5	
M766	350883	126601	6	55	di	3346.7	5	
M767	350835	126438	6	56	m-	3347.6	6	
M768	351220	126342	31	87	m+	3350.8	5	
M769	351734	127974	5	83	di	3359.4	5	
M770	351821	128242	5	53	m+	3360.8	5	
M771	351929	128568	48	115	di	3362.4	5	
M772	352203	129432	7	62	m+	3367.0	5	
M773	352652	130846	5	78	di	3374.3	5	
M774	352815	133112	7	77	di	3385.5	5	
M775	352932	134710	4	60	di	3393.5	5	
M776	353121	137210	8	48	m+	3406.0	5	
M777	352714	137976	9	59	m+	3418.6	5	
M778	352272	132379	3	39	m-	3446.8	5	
M779	351997	130371	11	66	m+	3457.0	5	
M780	351883	129989	10	49	m+	3459.0	5	
M781	351786	128469	9	77	m+	3480.6	5	
M782	351841	128636	12	52	m+	3481.5	5	
M783	352070	129362	29	177	di	3485.3	6	
M784	352654	132317	5	54	di	3500.2	5	
M785	352723	133218	23	157	m+	3504.7	5	
M786	352368	134990	8	42	m+	3556.8	5	
M787	352365	134912	12	42	m+	3557.3	6	
M788	352284	133883	17	89	m+	3562.4	6	
M789	352273	133759	6	41	m+	3563.1	5	
M790	352186	132436	6	42	m+	3569.7	5	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M791	352153	132006	5	55	m+	3571.9	6	
M792	351778	129958	5	76	m+	3582.5	5	
M793	350731	126776	10	98	di	3599.3	5	
M794	350632	126456	5	64	m-	3601.0	6	
M795	350579	126248	6	55	m+	3602.0	5	
M796	350902	126000	11	55	m+	3609.5	5	SS2051
M797	351710	128594	9	50	m+	3623.0	6	
M798	351747	128696	8	90	m+	3623.6	5	
M799	351987	129437	40	201	di	3627.5	5	
M800	352261	130294	7	46	m+	3631.9	5	
M801	352624	133184	15	168	m+	3646.3	6	
M802	352932	137323	11	70	di	3667.0	5	
M803	352964	137761	14	65	m+	3669.3	5	
M804	352968	137826	7	61	m+	3669.5	5	
M805	352355	136123	8	66	di	3689.5	5	
M806	352327	135738	4	38	m+	3691.4	5	
M807	352286	135195	14	65	m+	3694.2	6	
M808	352077	132361	4	43	m+	3708.5	5	
M809	352055	132111	12	50	m+	3709.7	6	
M810	351293	128842	4	42	m+	3726.7	5	
M811	351135	127037	9	61	m+	3740.7	5	
M812	351817	129231	9	65	m+	3752.1	5	
M813	352218	130473	18	86	m-	3758.5	5	
M814	352275	130658	7	76	di	3759.5	6	
M815	352438	131746	7	85	m+	3765.0	5	
M816	352438	131882	7	47	m+	3765.6	6	
M817	352456	132156	8	68	di	3767.0	5	
M818	352459	132212	4	34	m+	3767.3	5	
M819	352677	135316	5	62	di	3782.7	5	
M820	352694	135530	14	73	di	3783.8	5	
M821	352696	135573	14	70	m-	3784.0	5	
M822	352747	136232	6	78	m+	3787.3	5	
M823	352775	136552	7	66	m+	3788.9	5	
M824	352817	137158	14	52	m+	3791.9	5	
M825	352820	137193	18	56	di	3792.1	5	
M826	352459	138824	7	59	m+	3805.2	5	
M827	352359	137429	19	53	m+	3812.2	5	
M828	352167	134838	8	68	di	3825.2	6	
M829	352082	133787	23	88	m+	3830.5	6	
M830	351132	128669	10	78	m+	3856.9	5	
M831	350869	127828	6	69	m-	3861.3	5	
M832	351567	127868	9	49	m+	3867.7	5	
M833	351434	127478	5	43	m-	3869.7	6	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M834	351206	126769	4	73	m+	3873.6	6	
M835	350678	125168	6	74	m+	3882.1	6	
M836	350462	124473	4	71	di	3885.7	6	
M837	349808	122449	4	49	m-	3896.4	5	
M838	349352	121035	32	63	m+	3903.9	5	
M839	349238	120672	64	86	m+	3905.8	5	
M840	349205	120579	5	68	di	3906.3	5	
M841	349167	120460	33	77	di	3906.9	5	
M842	349148	120401	10	57	m-	3907.3	5	
M843	348561	120057	5	55	m+	3927.3	5	SS2052?
M844	349840	124031	13	169	m+	3948.0	6	
M845	349881	124163	6	115	m-	3948.8	6	
M846	350167	125060	6	73	m+	3953.4	5	
M847	350313	125516	4	48	m+	3955.8	5	
M848	351224	126349	25	80	m+	3963.8	5	
M849	350677	124687	5	54	m+	3972.6	5	
M850	350113	122907	4	37	m+	3982.1	5	
M851	349229	120167	12	68	m+	3996.5	6	
M852	349130	119871	11	87	di	3998.1	5	
M853	349101	119773	89	100	m+	3998.6	6	
M854	348428	117694	566	150	m+	4009.5	6	
M855	350876	88711	4	46	m-	4068.3	4	
M856	350827	88702	4	53	m+	4068.5	6	
M857	349486	88971	24	171	m-	4077.7	6	
M858	349881	89046	39	91	di	4079.8	5	
M859	350335	89136	5	32	m-	4082.2	5	
M860	350218	89601	10	40	m+	4092.8	5	
M861	350006	91075	3	36	m+	4124.4	5	
M863	349987	93075	5	53	di	4170.1	6	
M865	349091	93396	45	93	di	4180.8	5	
M866	348850	93865	11	46	m+	4186.2	6	SS3055
M867	349726	94031	9	44	m+	4190.8	5	
M868	349680	94511	16	76	di	4197.8	5	
M872	348606	100844	13	98	di	4341.2	5	
M873	347520	102131	9	146	m-	4371.3	5	
M875	346901	106021	6	75	di	4454.8	5	
M876	346487	106459	13	121	di	4460.6	6	
M877	347346	106615	11	126	m+	4465.1	6	
M878	347369	107107	8	127	m+	4471.6	5	
M879	347092	107056	6	106	di	4473.0	5	
M881	347072	107565	6	97	di	4484.6	5	
M882	347085	108056	5	97	m+	4492.2	6	
M883	346497	108458	3	63	m+	4502.8	6	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M884	346834	108520	13	159	m+	4504.5	6	
M885	347021	109053	9	75	m+	4512.5	5	
M886	346299	110420	7	47	di	4545.8	5	
M887	346891	110533	29	93	m-	4548.7	7	
M888	346058	113138	16	83	m+	4580.2	5	
M889	346607	110224	12	41	m+	4595.2	5	
M890	346746	109491	15	168	di	4598.7	5	
M891	347346	106249	8	78	m-	4615.2	5	
M892	347591	102205	20	62	m-	4646.2	5	
M893	346503	108063	12	80	di	4675.8	5	
M894	346047	110485	7	60	di	4688.2	6	
M895	346010	110695	10	58	m+	4689.2	6	
M896	345204	115023	35	107	di	4711.2	5	
M897	347019	109059	9	43	m+	4750.2	5	
M898	347487	106572	11	90	m+	4762.7	5	
M899	347907	104340	16	64	m+	4773.9	6	
M900	347562	104483	43	67	m-	4798.5	5	
M901	347384	105465	15	67	m-	4803.3	5	
M902	347084	107118	7	103	di	4811.7	6	
M903	346817	108543	16	145	di	4819.0	5	
M904	345989	110384	11	58	m+	4880.6	6	
M905	346548	107384	39	50	m+	4895.7	5	
M906	346897	107601	8	98	di	4956.3	6	
M907	346832	107930	10	75	di	4957.8	5	
M908	345780	113537	4	50	di	4986.5	6	
M909	345777	113539	5	66	di	4992.5	5	
M910	346829	109617	7	58	m+	5033.3	6	SS3080
M911	346848	109520	3	38	m+	5033.8	6	
M912	346967	108877	10	69	di	5037.0	5	
M913	347147	107923	6	37	m+	5041.8	5	
M914	347354	106824	8	117	di	5047.5	6	
M915	347400	106574	7	86	m-	5048.7	6	
M916	347635	105325	4	98	di	5055.1	6	
M917	347757	104638	6	59	m-	5058.5	6	
M918	347002	105956	9	41	m+	5102.0	5	
M919	346838	106829	3	30	m+	5106.5	5	
M920	346484	108720	21	74	m-	5116.2	5	
M921	345972	111478	10	59	di	5130.2	5	
M922	346587	106622	4	42	m+	5196.5	5	
M923	346845	105244	7	39	m-	5203.5	6	
M924	346953	104633	6	42	m+	5206.6	5	
M925	347285	104926	8	36	m+	5248.7	5	
M926	346255	110471	12	41	m-	5277.0	5	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M927	347266	106917	7	43	m+	5318.1	6	
M928	343031	126360	11	94	di	5423.4	5	
M929	342558	125882	13	113	m+	5427.5	5	
M930	345984	110385	20	54	m+	5507.9	5	
M931	345784	113551	5	49	m+	5518.2	5	
M932	342655	126002	11	124	di	5586.9	5	
M933	345222	115027	28	60	m+	5643.6	6	
M934	342497	125826	18	104	m+	5709.6	5	
M935	347016	115552	5	51	m-	5805.9	5	
M936	348079	119169	5	62	m+	5824.7	5	
M937	347172	115819	6	62	m+	5848.8	5	
M938	346756	112986	21	80	di	5877.4	6	
M939	346928	114010	46	107	m+	5882.5	5	SS2063
M940	347072	114726	29	75	m+	5886.2	5	
M941	347311	116033	8	72	di	5892.8	5	
M942	348168	117482	11	66	m+	5917.6	6	
M943	347971	116827	455	92	m-	5921.1	5	
M944	347176	112992	16	62	di	5940.6	5	
M945	347352	113625	7	61	di	5974.6	5	
M946	347938	116532	14	95	di	5989.4	5	
M947	348023	116788	293	71	m-	5990.7	6	
M948	348372	119079	3	40	m+	6006.9	5	SS2053
M949	347392	115963	3	54	di	6023.3	5	
M950	347075	114227	5	49	m+	6032.1	6	
M951	346965	113618	22	64	m-	6035.3	5	
M952	346565	111444	6	78	di	6046.3	5	
M953	346689	111089	5	53	m-	6050.1	5	
M954	346813	111755	11	89	di	6053.5	6	
M955	346913	112301	3	63	m+	6056.2	5	
M956	347057	113108	5	62	m-	6060.4	6	
M957	348527	118979	7	141	m+	6090.5	5	
M958	347780	116929	7	68	m+	6105.8	6	
M959	347722	116767	9	73	m-	6106.6	5	
M960	347336	115141	19	82	di	6115.0	5	
M961	347171	114158	8	94	di	6120.0	6	
M962	346878	112596	49	113	di	6127.8	5	
M963	346686	111550	3	58	m+	6133.3	6	
M964	346899	110526	50	105	di	6142.1	6	
M965	347189	112163	26	72	m-	6150.5	5	
M966	347902	116078	4	59	m+	6170.3	5	SS2047
M967	348424	117688	545	137	m+	6178.6	5	
M968	348837	118968	14	197	di	6185.5	5	
M969	349098	119772	89	105	m+	6189.7	5	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M970	349126	119866	9	81	di	6190.2	6	
M971	349219	120165	15	85	m+	6191.8	6	
M972	349545	120794	11	78	m+	6202.8	5	
M973	349367	120236	8	88	m+	6205.6	5	
M974	349061	119309	4	79	m+	6210.6	6	
M975	348928	118889	11	150	m+	6212.8	4	
M976	347969	115743	4	110	di	6229.3	6	
M977	347729	114465	4	58	m-	6235.7	5	
M978	347126	111219	20	85	m+	6252.3	5	
M979	348211	119283	7	57	m-	6275.3	5	
M980	348305	119556	4	49	m-	6276.7	5	
M981	349104	122058	8	86	m-	6289.6	5	
M982	349339	122762	8	99	m+	6293.4	5	
M983	350126	125231	6	77	m+	6306.2	6	
M984	350330	125866	7	86	di	6309.5	5	
M985	350820	127411	8	80	m+	6317.5	5	
M986	350905	125701	13	60	m+	6335.5	6	
M987	349911	122618	9	116	m+	6351.7	5	
M988	348997	119766	91	139	di	6366.7	5	
M989	348589	120788	5	54	m+	6383.7	5	
M990	349346	123125	6	71	m+	6395.9	5	
M991	349536	120797	12	64	m+	6415.3	5	
M992	350687	124426	40	132	di	6434.2	5	
M993	351622	127321	46	63	m+	6449.4	6	
M994	351673	127466	24	44	m-	6450.2	5	
M995	350728	126438	10	51	m-	6462.6	4	
M996	350547	125864	9	87	m+	6465.8	6	
M997	350480	125663	6	56	m+	6466.7	5	
M998	349069	120349	7	38	m+	6516.2	5	
M999	349100	120450	31	110	cd	6516.6	5	
M1000	349173	120672	21	74	m-	6517.8	6	
M1001	350546	124947	7	56	m+	6540.1	5	
M1002	350887	126008	7	47	m+	6545.6	5	SS2051
M1003	350525	126449	8	60	m+	6556.1	5	
M1004	350337	125865	7	57	m-	6559.2	5	
M1005	349521	123315	7	93	m-	6572.6	5	
M1006	349342	122767	11	82	m+	6575.5	5	
M1007	349115	122042	11	112	m-	6579.3	5	
M1008	348310	119560	4	41	m+	6592.5	5	
M1009	348218	119266	11	80	di	6594.0	5	
M1010	348539	119324	18	144	di	6615.3	6	
M1011	349592	122607	13	158	m-	6632.4	5	
M1012	350824	126441	8	55	m-	6652.4	5	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M1013	350871	126588	5	46	m+	6653.1	6	
M1014	351090	127283	4	43	m+	6656.7	6	
M1015	348211	119283	7	58	m-	6675.2	5	
M1016	350460	124978	19	130	di	6697.9	5	
M1017	350917	126429	5	57	m+	6705.5	5	
M1018	351076	126909	7	48	m+	6708.0	5	
M1019	350810	127663	6	46	m+	6714.2	5	
M1020	350242	125861	3	32	m-	6723.5	6	
M1021	351860	131342	3	33	m+	6747.5	6	
M1022	351995	130371	7	51	m+	6753.5	6	
M1023	352265	131625	9	31	m+	6760.8	6	
M1024	352442	131884	6	36	m+	6775.7	6	
M1025	352485	130131	5	80	di	6785.4	5	
M1026	353511	145030	5	29	m+	6830.3	5	
M1027	353500	144861	5	18	m+	6831.2	6	
M1028	352300	147361	23	79	di	6850.2	6	
M1033	351586	127280	20	74	m-	6893.5	5	
M1034	351199	126379	11	78	m-	6911.9	6	
M1035	350990	126442	6	40	di	6913.2	6	
M1036	351250	125840	5	30	m+	6926.0	5	
M1038	349574	122232	7	77	m+	6999.4	5	
M1039	349060	119313	7	56	di	7059.4	6	
M1040	348571	119467	4	52	m+	7062.0	5	
M1041	348304	119549	7	72	di	7063.4	5	
M1042	347928	116565	10	86	m-	7120.6	5	
M1043	347409	116200	4	76	di	7130.8	6	
M1044	347054	114744	8	89	di	7162.9	5	
M1045	347130	114247	6	58	m+	7171.3	6	
M1047	347690	113145	11	89	m-	7194.0	6	
M1049	346932	112284	10	52	m-	7212.1	5	
M1050	347143	111232	37	97	di	7234.2	6	
M1051	347133	110717	5	40	m+	7240.0	5	
M1052	347050	107593	57	63	m-	7265.3	5	
M1053	347104	104574	6	50	m+	7287.8	5	SS3042
M1054	349004	96070	27	106	di	7294.7	5	
M1055	349871	91451	8	47	m+	7318.4	5	
M1056	349980	90865	8	48	m+	7321.3	5	
M1057	350809	87462	3	45	m+	7329.6	6	
M1058	310486	36870	39	44	m-	3709.0	3	
M1059	310737	36955	79	75	di	3716.0	3	
M1060	310809	36986	75	51	m+	3717.8	3	
M1061	310508	37391	8	32	m+	3801.3	3	
M1062	310466	36869	47	57	di	3809.5	3	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M1063	310834	36926	45	46	di	3820.0	3	
M1064	311110	37095	6	47	m+	3828.4	3	
M1065	310545	37289	32	41	m+	3942.5	3	
M1066	310764	36814	105	92	m+	3956.3	3	
M1067	310907	36868	41	34	m+	3959.5	3	
M1068	310938	36880	147	41	m+	3960.1	3	
M1069	310731	36729	61	64	m-	4013.7	3	SS9
M1070	310549	37195	41	43	m+	4062.1	3	
M1071	310807	36707	117	132	di	4074.1	3	
M1072	310569	37144	117	77	m+	4122.2	3	
M1073	310503	37109	60	85	m+	4123.4	3	
M1074	310734	36619	31	34	m+	4131.5	3	
M1075	310981	36741	45	63	m-	4136.6	3	
M1076	310646	37122	131	113	di	4182.5	3	
M1077	310758	36562	47	73	di	4193.2	3	
M1078	310989	36695	66	69	m+	4197.9	3	
M1079	311162	36794	32	78	di	4201.4	3	SS12
M1080	310758	37130	21	67	m-	4240.1	3	
M1081	310951	36619	19	35	m+	4256.1	3	
M1082	311030	36663	43	48	m+	4257.7	3	
M1083	311364	36834	56	91	m-	4264.8	3	
M1084	311188	37315	15	47	m+	4292.0	3	
M1085	310770	37076	25	48	m-	4300.0	3	
M1086	310780	36475	28	68	m-	4312.0	3	
M1087	311384	36796	100	132	di	4324.4	3	
M1088	340665	126966	11	30	m+	5111.2	3	
M1089	340667	127212	12	42	di	5114.2	2	
M1090	352126	147606	19	37	m+	5254.3	4	
M1091	350375	147595	19	16	m+	5262.9	2	
M1092	350368	147226	12	11	m+	5265.6	1	
M1093	350471	147130	15	17	m-	5266.0	2	
M1094	352635	147130	15	60	di	5277.1	5	
M1095	352429	147650	12	26	m-	5282.7	4	
M1096	351262	147634	12	88	di	5288.5	5	
M1097	350631	147650	11	40	m-	5291.5	5	
M1098	350390	147208	13	11	m-	5295.6	2	
M1099	352085	147158	13	60	m+	5304.3	5	
M1100	352901	147695	10	38	m-	5311.4	4	
M1101	350344	147274	14	12	m+	5326.3	1	
M1102	351103	147211	19	88	m+	5330.3	6	
M1103	352249	147214	270	62	m+	5336.2	5	
M1104	352691	147208	10	43	m+	5338.4	5	
M1105	352847	147214	31	70	m-	5339.3	6	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M1106	352113	147732	12	24	m+	5347.3	5	
M1107	350897	147736	18	33	m+	5353.3	4	
M1108	350287	147568	13	23	m+	5358.1	2	
M1109	350303	147434	231	105	di	5358.8	2	
M1110	351111	147254	57	70	m-	5363.3	5	
M1111	352742	147778	7	48	m+	5376.2	4	
M1112	352115	147794	26	61	m+	5379.3	5	
M1113	352025	147792	6	21	m+	5379.6	5	
M1114	350188	147640	4	18	m+	5390.3	1	
M1115	350225	147444	1157	65	di	5390.6	1	
M1116	350990	147308	19	76	di	5394.7	5	
M1117	352372	147827	13	32	m+	5410.0	5	
M1118	351986	147835	70	67	m+	5411.9	4	
M1119	350793	147838	9	35	m-	5417.8	5	
M1120	350413	148193	10	21	m+	5421.7	1	
M1121	350411	147427	14	51	m-	5425.6	2	
M1122	350409	147371	10	36	m-	5425.8	1	
M1124	350334	147440	63	127	di	5432.9	2	
M1125	350222	147438	83	62	di	5443.5	1	
M1126	351383	148113	67	105	m+	5456.4	5	
M1127	351862	147875	59	117	m+	5469.3	5	
M1128	351855	147884	88	136	m+	5478.6	4	
M1129	350814	147892	15	41	m-	5483.6	5	
M1130	350246	147448	262	67	di	5489.7	1	
M1131	352295	147353	17	66	m-	5500.3	7	
M1132	352590	147915	39	91	m+	5506.0	5	
M1133	351772	147937	56	139	di	5510.0	4	
M1134	350245	147451	1031	32	di	5519.8	1	
M1135	350360	147409	28	48	m+	5520.5	2	
M1136	350381	147606	8	21	m+	5547.8	2	
M1137	350350	147463	76	47	m+	5551.6	2	
M1138	352071	147984	25	23	di	5570.6	3	
M1139	351603	147993	349	240	di	5572.9	4	
M1140	352797	147508	4	37	m	5594.9	6	
M1141	352643	148022	21	55	m-	5597.7	5	
M1142	351548	148041	508	228	m-	5603.1	5	
M1143	351272	148036	23	51	m+	5604.4	5	
M1144	350865	148029	23	55	m+	5606.6	4	
M1145	352577	148081	19	43	m-	5627.0	6	
M1146	352504	148083	40	96	di	5627.5	5	
M1147	351796	148092	52	161	cd	5631.0	4	
M1148	351596	148089	13	41	m+	5631.9	4	
M1149	351188	148083	85	63	m-	5633.9	5	

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M1150	350820	148087	12	31	m-	5635.8	3	
M1151	350589	148085	36	32	m	5636.8	3	
M1152	350353	148099	42	23	m	5637.9	2	
M1153	351271	147650	17	55	m-	5646.2	6	
M1154	332347	50544	18	77	m+	6084.2	6	
M1155	332436	50476	10	154	m-	6128.2	5	
M1156	331072	49112	6	54	di	6137.8	5	
M1157	332912	49847	23	65	m+	6187.3	5	
M1158	338345	55268	40	129	di	6229.8	6	
M1159	342107	58979	11	97	m+	6256.2	5	
M1160	342955	60109	24	93	di	6262.6	6	SS33
M1161	338275	55442	49	198	di	6295.8	5	
M1162	333937	51120	5	39	m+	6326.5	5	
M1163	341657	127289	14	46	m-	6861.3	4	
M1164	341250	127444	28	3	m+	6881.4	5	
M1165	340742	127410	89	22	di	6883.9	1	
M1166	341310	126930	22	17	di	6890.8	1	
M1167	342791	126139	5	54	m+	6899.5	4	
M1168	340918	126899	10	43	m-	6920.9	4	
M1169	340766	126833	5	39	m-	6951.3	4	
M1170	342717	126063	9	96	m+	6962.5	5	
M1171	342461	126707	8	44	di	6969.0	5	
M1172	341634	127171	55	39	m+	6973.6	4	
M1173	340721	127256	11	45	m+	6978.2	3	
M1174	340654	126791	32	42	m+	6982.1	2	
M1175	341349	126784	12	71	di	6985.5	4	
M1176	343014	126327	14	88	m+	6997.6	5	
M1177	342501	126621	5	53	di	7000.5	4	
M1178	342355	126704	15	87	m+	7001.3	4	
M1179	341462	127216	76	211	m+	7006.4	4	
M1180	341495	126636	12	43	m-	7018.6	3	SS3004
M1181	342607	126022	16	81	di	7025.5	4	
M1182	342978	126309	18	83	m+	7028.6	4	
M1183	341388	127182	71	118	m+	7037.4	4	
M1184	341451	126604	4	54	m+	7048.7	5	SS3004?
M1185	342561	125985	12	85	di	7055.2	6	
M1186	342939	126277	18	71	m+	7059.8	4	
M1187	341548	127010	39	192	m+	7067.4	4	
M1188	341577	126484	12	96	m+	7078.8	4	
M1189	342522	125954	5	54	m-	7084.3	5	
M1190	342859	126237	11	79	di	7087.8	4	
M1191	340926	126594	6	23	m+	7103.3	2	SS3005, SS3006?

Magnetic Anomalies; BITS Primary and Alternate Routes								
Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M1192	341032	126601	9	70	m+	7103.8	5	
M1193	341614	126394	7	89	m+	7107.0	4	
M1194	342521	125890	23	134	di	7112.5	4	
M1195	340896	126547	6	44	di	7131.5	2	SS3006, SS3005?
M1196	342493	125855	21	159	di	7140.5	4	
M1197	342461	125833	20	141	di	7168.4	4	
M1198	341042	126638	10	77	di	7176.5	5	
M1199	341361	126774	4	23	m+	7181.9	4	
M1200	342460	126716	18	64	di	7200.5	4	
M1201	342633	126022	11	86	m+	7209.9	5	
M1202	342465	61076	41	282	di	15.0	0	
M1204	342566	60997	36	254	di	28.2	6	
M1206	343018	59820	39	175	di	40.2	5	
M1208	343094	59719	32	258	di	53.2	6	
M1209	342974	59486	6	44	m+	65.2	6	
M1210	343091	59596	35	221	di	66.0	5	
M1213	342456	61144	36	184	di	79.5	5	
M1214	337770	56481	48	134	m+	92.3	5	
M1215	337540	56249	19	120	m-	94.0	5	
M1216	337577	56173	13	109	m-	103.5	5	
M1217	337805	56399	52	184	di	105.1	6	
M1219	337884	56295	55	184	di	119.3	5	
M1220	337746	56161	12	115	m-	120.3	5	
M1221	337510	55930	8	127	m+	121.9	5	
M1222	338388	55153	47	225	di	132.0	5	
M1223	338456	55059	40	151	di	144.7	6	
M1224	338474	54967	71	127	di	156.7	5	
M1226	310261	37414	35	56	m+	4591.6	3	
M1227	310280	37358	22	46	m+	4592.6	3	
M1228	310501	36900	20	43	m+	4600.4	3	
M1229	310875	37196	17	47	m+	4627.8	3	
M1230	310848	37243	26	83	di	4628.8	3	
M1232	310247	37411	31	36	di	4641.3	3	
M1233	310286	37251	101	36	m+	4644.0	3	
M1234	310607	36725	27	57	di	4653.3	3	
M1506	312137	37238	10	42	m+	436.5	4	
M1507	311872	37156	11	56	m+	437.8	4	
M1508	311589	36873	40	89	m+	1613.0	6	
M1535	313378	38175	6	77	di	2188.2	5	
M1567	314372	38061	11	110	m-	2766.7	5	
M1608	312257	37131	5	36	m+	5129.9	5	
M1682	314386	37894	16	82	di	958.0	6	

Magnetic Anomalies; BITS Primary and Alternate Routes

Anomaly ID[1]	Easting [2]	Northing[2]	Amplitude	Duration	Type[3]	Event	Altitude	Sonar Association[4]
	feet	feet	gammas	feet			meters	
M1694	313911	37707	7	53	di	1151.7	5	
M1818	311628	37080	6	72	m+	4405.1	1	
M1819	311415	37026	16	87	m+	4408.9	1	
M1820	311266	36978	7	52	m+	4411.6	1	
M1821	311224	36965	24	92	di	4412.4	1	
M1822	311018	36894	35	100	m-	4416.1	3	
M1823	310761	36810	82	157	m+	4420.7	3	
M1830	312905	37538	22	95	di	6357.8	5	
M1831	313111	37607	6	47	m+	6358.9	5	
M1832	313189	37635	9	99	di	6359.3	5	SS15
M1834	313770	37828	18	117	m-	6362.4	5	

NOTES:

1. Anomaly ID numbers are non-sequential.
2. Coordinates are referenced to RI State Plane, Zone 3800, NAD83, in feet.
3. Anomaly Types: m+=positive monopole, m-=negative monopole, di=dipole, cd=complex dipole
4. ? symbolizes the sonar target is nearby, but not close enough to make a definitive correlation.

APPENDIX 5

EQUIPMENT OPERATIONS AND PROCEDURES

Applanix POS MV Differential Global Positioning System
Applanix POSPAC Mobile Mapping Suite
HYPACK Navigation Software
Reson SeaBat 7101 Focused 455 kHz Multibeam Echosounder
Innerspace Model 448, 200 kHz Single Beam Depth Sounder
Sea-Bird Electronics SBE19*plus* SEACAT Profiler
Klein 3000 Dual 100/500 kHz Side Scan Sonar System
LinkQuest TrackLink 1500 USBL Acoustic Tracking System
Applied Acoustics 200J, 0.5-8 kHz Boomer Seismic Reflection System
EdgeTech 3200XS 2-16 kHz Chirp Subbottom Profiler
Geometrics G882 Cesium Marine Magnetometer
OSI Model BH1500 Vibratory Corer
GS2500 Cable Toner and Detection System

EQUIPMENT OPERATIONS AND PROCEDURES

Applanix POS MV Differential Global Positioning System

The Applanix POS (**P**osition and **O**rientation **S**ystem) MV provides reliable, high-speed and high-precision positioning that utilizes the latest developments in aided inertial technology. The system components include a POS computer system (PCS), inertial measurement unit (IMU), primary and secondary GPS antennae, and all power, antenna, and interconnecting data cables. The system not only provides the highest precision DGPS positioning, but also includes motion and compass measurements normally separate from other manufactured GPS systems. The POS MV delivers a full six degree-of-freedom position and orientation solution to provide the following param: position (latitude, longitude, elevation), velocity (north, east, vertical), attitude (roll, pitch, true heading), heave (real-time, delayed), acceleration vectors, and angular rate vectors. The POS MV was engineered specifically for areas of problematic GPS/DGPS reception and demanding motion compensation applications, using inertial measurements during GPS dropouts or degraded differential correctors to maintain accurate navigation solutions.

For this project, the POS MV was interfaced to a Trimble ProBeacon receiver that acquires differential correctors from U.S. Coast Guard reference stations. The ProBeacon is interfaced to the POS MV receiver via RS232 connection. In this system configuration, the manufacturer states a horizontal position accuracy of ±1 m; however, navigation checks performed each day typically show positioning repeatability of 0.3-0.5 m. The POS MV system is interfaced to the HYPACK navigation software for trackline control and data logging.

Applanix POS Pac Mobile Mapping Suite

Vertical positioning of the survey vessel and depth sounder transducers was accomplished using a combination of the POS MV and POSPac Mobile Mapping System (MMS). The POSPac MMS is the next generation software for direct georeferencing of survey sensors using GNSS and inertial technology, specifically integrated with the POS MV for marine mapping applications. POSPac is a powerful post-survey software package that provides maximum accuracy and efficiency for georeferencing the multibeam echosounder data. The suite incorporates the Applanix SmartBase™ module that automatically selects, downloads, and imports the best available network of continuously operating reference stations (CORS) surrounding the project area.

The raw POS MV position measurements are adjusted for the differential corrections from the network reference stations and simultaneously processed along with the inertial measurement unit (IMU) data using Applanix IN-Fusion™ technology to solve for GNSS ambiguities (i.e. outages, atmospheric delays) and final vessel position and orientation. Position accuracies can approach those achieved using an RTK (real-time kinematic) system, thus eliminating the cost and time associated with establishing a local GPS reference station for the project. In this manner, elevations for the vessel and transducers are obtained in order to reference the water depths to the MLLW datum.

HYPACK Navigation Software

Survey vessel trackline control and position fixing were obtained by utilizing an OSI computer-based data-logging package running HYPACK navigation software. The computer is interfaced with the DGPS onboard the survey vessel. Vessel position data were updated at 100-millisecond intervals and input to the HYPACK navigation system which processes the geodetic position data into State Plane coordinates used to guide the survey vessel accurately along preselected tracklines. The incoming data are logged on disk and processed in real time allowing the vessel position to be displayed on a video monitor and compared to each preplotted trackline as the survey progresses. Digitized shoreline, NOAA charts, and the locations of existing structures, buoys, and control points can also be displayed on the monitor in relation to the vessel position. The OSI computer logging system, combined with the HYPACK software, thus provide an accurate visual representation of survey vessel location in real time, combined with highly efficient data logging capability and post-survey data processing and plotting routines.

Prior to and during the reconnaissance field work, trackline files were generated for use with the navigation software which included the lines to be surveyed each day. Review and interpretation of previous days' investigations allowed new planned line files to be developed for surveying areas of interest.

Reson SeaBat 7101 Focused 455 kHz Multibeam Echosounder

Precision swath water depth measurements are obtained by using a SeaBat 7101 digital multibeam echosounder capable of recording water depths of over 1,000 ft. The SeaBat 7101 system operates at a frequency of 240 kHz and measures up to 40 swaths per second with 511 individual soundings in each swath. This swath configuration provides complete bottom coverage over a 150° wide by 1.5° long geometrically correct cross section. Real time roll stabilization combined with the equidistant sounding density maximizes usable swath width. Depending on site conditions, the system can be operated at speeds upwards of 10 knots while still maintaining 100% coverage of the bottom. Digital data can be output through any of its RS-232 serial ports and displayed on a high-resolution color monitor. The SeaBat 7101 incorporates tide and draft corrections plus a calibration capability for local water mass sound speed.

Innerspace Model 448 200kHz Single Beam Depth Sounder

Precision single beam water depth measurements were obtained by employing an Innerspace Model 448 digital depth sounder with a 200 kilohertz, 3° beam width transducer. The Model 448 recorder provides precise, high-resolution depth records using a solid-state thermal printer as well as digital data output which allows integration with the OSI computer-based HYPACK navigation system. The Model 448 also incorporates both tide and draft corrections plus a calibration capability for local water mass sound speed.

Sound speed calibrations are accomplished by performing "bar checks". The bar check procedure consists of lowering an acoustic target, typically a 20 pound lead disk, on a measured sounding line, to the specified project depth. The speed of sound control is adjusted such that the reflection from the disk is printed on the recorder precisely at this known depth. The acoustic target is then raised to successively shallower depths and calibration readings at these depths are recorded. Variations which exist in the indicated depth at these calibration points are incorporated in the sounding data processing to produce maximum accuracy in the resulting depth measurements. Bar checks were performed at the beginning of each day to check the surface water mass sound speed in comparison with the CTD profiler.

Bar checks are used for calibration when surveying in shallow water areas of generally less than 80 to 100 ft. For depth sounder calibration in the deeper water a Sea-Bird SBE19 CTD Profiler is utilized to measure the temperature, salinity, and density of the entire water column from which sound velocity can be calculated and input to the 448 recorder and Reson multibeam echosounder. Both checks were performed during this field investigation for quality control and comparison.

Sea-Bird Electronics SBE19*plus* SEACAT Profiler

Water column velocity measurements were logged a minimum of three times daily using Sea-Bird Electronics 19*plus* SEACAT Profiler. The SBE 19*plus* is the next generation personal CTD, bringing numerous improvements in accuracy, resolution, reliability and ease-of-use. The 19*plus* samples at 4 Hz, has a 0.005 accuracy and has 8 Mbytes of memory. Data are recorded in non-volatile FLASH memory and can be transferred and processed on a

PC. The 19*plus* has a fast sampling and pump controlled TC-ducted flow configuration, significantly reducing salinity spiking caused by ship heave.

The sound velocity profiles collected using the Sea-Bird are important for adjusting the multibeam and single beam depth soundings for velocity changes in the water column to attain the highest level depth accuracy possible. Sound velocity is also input to the TrackLink USBL system for ensuring accurate time to distance conversions.

Klein 3000 Dual 100/500 kHz Side Scan Sonar System

Side scan sonar images of the bottom were collected using a Klein 3000 dual frequency, high-resolution sonar system operating at frequencies of 100 and 500 kilohertz. The system consists of a topside computer, color monitor, keyboard, mouse, an EPC1086 dual-channel thermal graphic recorder, tow cable, and sonar towfish. All system components are interfaced via a local network hub and cable connections. The system contains an integrated navigational plotter which accepts standard NMEA 0183 input from a GPS system. This allows vessel position to be displayed on the monitor and speed information to be used for controlling sonar ping rate. Sonar sweep can also be plotted in the navigation window for monitoring bottom coverage in the survey area.

The hardware listed above is interfaced to the Klein SonarPro data acquisition and playback software package which runs on the topside computer. All sonar images are stored digitally and can be enhanced real-time or post-survey by numerous mathematical filters available in the program software. Imagery is displayed in a waterfall window in either normal or ground range (water column removed) formats. Other software functions that are available during data acquisition include; changing range scale and delay, display color, automatic or manual TVG (time variable gain), speed over bottom, multiple enlargement zoom, target length, height, and area measurements, logging and saving of target images, and annotation frequency and content. The power of this system is its real-time processing capability for determining precise dimensions of targets and areas on the bottom.

As with many other marine geophysical instruments, the side scan sonar derives its information from reflected acoustic energy. A set of transducers mounted in a compact towfish generate the short duration acoustic pulses required for extremely high resolution. The pulses are emitted in a thin, fan-shaped pattern that spreads downward to either side of the fish in a plane perpendicular to its path. As the fish progresses along the trackline this acoustic beam sequentially scans the bottom from a point directly beneath the fish outward to each side of the survey trackline.

Acoustic energy reflected from any bottom discontinuities is received by the set of transducers in the towfish, amplified and transmitted to the survey vessel via the tow cable where it is further amplified, processed, and converted to a graphic record by the side scan recorder. The sequence of reflections from the series of pulses is displayed on a video monitor and/or dual-channel graphic recorder on which paper is incrementally advanced prior to printing each acoustic pulse. The resulting output is essentially analogous to a high angle oblique "photograph" providing detailed representation of bottom features and characteristics. This system allows display of positive relief (features extending above the bottom) and negative relief (such as depressions) in either light or dark opposing contrast modes on the video monitor. Examination of the images thus allows a determination of significant features and objects present on the bottom within the survey area.

LinkQuest TrackLink 1500 USBL Acoustic Tracking System

The side scan sonar towfish position was tracked in real time utilizing LinkQuest's TrackLink 1500 acoustic tracking system for underwater positioning of towed sensors. The TrackLink 1500 systems are USBL (ultra short baseline) acoustic tracking systems with fully integrated high-speed acoustic communication ability using Broadband Acoustic Spread Spectrum technology. The TrackLink Navigator Windows software integrates the TrackLink USBL transceiver with the ship's DGPS, gyrocompass, and motion sensor using serial communication. The software displays the positions of the ship and up to 8 targets in various plots and textual displays. It also interfaces to other computers for acoustic communication data and sends position data to other computers. The TrackLink software interfaces smoothly with HYPACK navigation software. TrackLink positions were recorded and offsets were calculated in real time with HYPACK and output to the digital side scan sonar data, providing for accurate and continuous position information on the side scan towfish.

Applied Acoustics 200J, 0.5-8 kHz "Boomer" Seismic Reflection System

Subsurface exploration was accomplished utilizing an Applied Acoustics 200 joule "boomer" seismic reflection system comprised of an AA200 boomer plate, CSP 300 power supply, 10-element hydrophone array (eel), Octopus 760 Shallow Seismic Processor with filter and time-varied-gain system, and an EPC 1086 thermal paper recorder. The Octopus 760 processor is a universal amplifier and filter which includes TVG (time varied gain) with bottom tracking, automatic gain control, and a swell filter. Digital seismic files were saved on the 760 (24 kHz sampling frequency) using a standard seismic data format (SEG Y) and printed in real time on the EPC 1086 recorder.

The "boomer" employs a sound source that utilizes electrical energy discharged from a capacitor bank to rapidly move a metal plate in the transducer bed. The short-duration motion of the metal plate creates a broadband (500–8,000 Hz) pressure wave capable of penetrating hundreds of ft of marine sediments under suitable site conditions. In New England, these low-frequency systems are used for any depth range to penetrate coarse glacial till commonly overlying bedrock. Higher frequency seismic systems have greater difficulty resolving the top of rock with a coarse till overburden.

Operationally, a seismic source (boomer) is used to create an intense, short duration acoustic pulse or signal in the water column. This signal propagates downward to the bottom where it is partially reflected at the sediment-water interface, while the rest of the signal continues into the subbottom. As the downward propagating signal encounters successive interfaces between layers of different material, similar partial reflections occur. The characteristics of the materials which cause acoustic signals to behave in such a manner are defined primarily by the cross-product of the bulk density and the compressional wave velocity of each material, a quantity known as the acoustic impedance. As a first approximation, the percentage of an acoustic signal which is reflected from an interface is directly proportional to the change in acoustic impedance across that interface.

The return signal consists of a continuous sequence of reflected energy that has a series of "peaks" correlative in intensity with the magnitude of change in acoustic impedance of the materials on either side of the interface. These return signals received by the transducer array are subsequently converted to electrical voltages which indicate the intensity of the return and hence how strongly the return is printed on the graphic recorder. Ambient noise is filtered out and the signal is then amplified with overall gain and/or TVG and displayed trace-by-trace iteratively on the recorder to yield a continuous display somewhat analogous to a geologic cross section.

The subbottom profiling system is installed aboard the survey vessel along with other scientific instrumentation, all of which is operated simultaneously along the desired survey lines. Both the energy source and the hydrophone array are deployed in an appropriate configuration to minimize the recording of background noise generated by the survey vessel. For this investigation, the seismic source and hydrophone array were deployed astern of the vessel and electronic filter settings were adjusted to an approximate bandwidth of 800-4,000 Hz. This towing configuration and filter setting provided a quiet environment even in moderately rough sea conditions.

EdgeTech 3200XS 2-16 kHz "Chirp" Subbottom Profiler

High-resolution subbottom profiling was accomplished utilizing an EdgeTech 3200 XStar Full Spectrum "Chirp" subbottom profiler system operating with frequencies of 2-16 kHz. The subbottom profiler consists of three components: the deck or topside unit (computer processor, amplifier, monitor, keyboard, and trackball), an underwater cable, and a Model 216 towed vehicle housing the transducers. Data are displayed on a color monitor and EPC 1086 thermal printer while saved in a JSF proprietary digital format on the XS topside computer.

The 3200 XS Chirp sonar is a versatile subbottom profiler that generates cross-sectional images and collects normal incidence reflection data over many frequency ranges. The system transmits and receives an FM pulse signal generated via a streamlined towed vehicle (subsurface transducer array). The outgoing FM pulse is linearly swept over a full spectrum range of 2-16 kHz for a period of approximately 20 milliseconds. The acoustic return received at the hydrophone array is cross-correlated with the outgoing FM pulse and sent to the deck unit for display and archiving, generating a high-resolution image of the subbottom stratigraphy. Because the FM pulse is generated by a converter with a wide dynamic range and a transmitter with linear components, the energy, amplitude, and phase characteristics of the acoustic pulse can be precisely controlled and enhanced.

The "chirp" subbottom profiler is designed for acquiring high-resolution subsurface data from the upper portions of the stratigraphic column (20-50 ft depending on site conditions). The higher end frequencies allow good resolution of subbottom layering while the lower end acoustic frequencies provide significant penetration. This particular system is capable of providing excellent acoustic imagery of the nearsurface in a wide variety of marine environments.

During data acquisition, all records were annotated with relevant supporting information, field observations, line number, run number, navigation event marks and numbers for later interpretation and correlation with vessel position data.

Geometrics G882 Cesium Marine Magnetometer

Total magnetic field intensity measurements were acquired along the survey tracklines using a Geometrics G882 cesium magnetometer that has an instrument sensitivity of 0.1 gamma. The G882 magnetometer system includes the sensor head with a coil and optical component tube, a sensor electronics package which houses the AC signal generator and mini-counter that converts the Larmor signal into a magnetic anomaly value in gammas, and a RS-232 data cable for transmitting digital measurements to a data logging system. The cesium-based method of magnetic detection allows a center or nose tow configuration off the survey vessel, simultaneously with other remote sensing equipment, while maintaining high quality, quiet magnetic data with ambient fluctuations of less than 1 gamma. The G882 also features an altimeter which outputs sensor height above the seafloor along with the magnetic intensity readings at a 10-hertz sampling rate. Data were recorded on the OSI data-logging computer by the HYPACK software.

The G882 magnetometer acquires information on the ambient magnetic field strength by measuring the variation in cesium electron energy level states. The presence of only one electron in the atom's outermost electron shell (known as an alkali metal) makes cesium ideal for optical pumping and magnetometry.

In operation, a beam of infrared light is passed through a cesium vapor chamber producing a Larmor frequency output in the form of a continuous sine wave. This radio frequency field is generated by an H1 coil wound around a tube containing the optical components (lamp oscillator, optical filters and lenses, split-circular polarizer, and infrared photo detector). The Larmor frequency is directly proportional to the ambient magnetic intensity, and is exactly 3.49872 times the ambient magnetic field measured in gammas or nano-Teslas. Changes in the ambient magnetic field cause different degrees of atomic excitation in the cesium vapor which in turn allows variable amounts of infrared light to pass, resulting in fluctuations in the Larmor frequency.

Although the earth's magnetic field does change with both time and distance, over short periods and distances the earth's field can be viewed as relatively constant. The presence of magnetic material and/or magnetic minerals, however, can add to or subtract from the earth's magnetic field creating a magnetic anomaly. Rapid changes in total magnetic field intensity, which are not associated with normal background fluctuations, mark the locations of these anomalies.

Determination of the location of an object producing a magnetic anomaly depends on whether or not the magnetometer sensor passed directly over the object and if the anomaly is an apparent monopole or dipole. A magnetic dipole can be thought of simply as a common bar magnet having a positive and negative end or pole. A monopole arises when the magnetometer senses only one end of a dipole as it passes over the object. This situation occurs mainly when the distance between opposite poles of a dipole is much greater than the distance between the magnetometer and the sensed pole, or when a dipole is oriented nearly perpendicular to the ambient field thus shielding one pole from detection. For dipolar anomalies, the location of the object is at the point of maximum gradient between the two poles. In the case of a monopole, the object associated with the anomaly is located below the maximum or minimum magnetic value.

OSI Model 1500 Vibratory Corer

An OSI Model 1500 vibratory corer was used to obtain continuous core samples of unconsolidated sediments within the survey area. The vibratory core rig used for this study utilized a standard 3.5 to 4-inch diameter steel core barrel, a clear plastic Lexan liner, a cutter head or shoe, a core catcher, and a pneumatically driven vibratory head attached to the upper end of the core barrel. The vibratory core unit requires an air compressor to power the piston inside the head of the corer, which is the driving force of the system. A large stable platform is necessary to lay down the vibracore rig when not in use and provide support for the handling gear and hydraulic winches required to operate the rig.

Once securely on station, the entire coring rig is lowered over the side or stern of the coring vessel via the crane, winch, and connecting cable. The rig is lowered down through the water column to the bottom. Once in contact with the bottom the vibratory head is activated and the winch cable is slackened. The pneumatically powered vibratory head drives the core barrel into the underlying sediments while inducing only minor deformation in the sedimentary structures. The pneumatic head achieves its vibratory motion by means of a reciprocating air driven piston, powered by means of a flexible hose connected to a large-capacity air compressor located onboard the coring vessel.

Following penetration of the core barrel to the desired depth, the entire rig is lifted back onboard the vessel. Once on deck, the liner containing the core is removed, cut into manageable sections, the ends capped and sealed, and the core sections are marked for orientation, identification, and post-survey analysis. Only the accessible part of the core (top and bottom open ends) is examined to provide a brief sediment description onsite. The cores are stored vertically to prevent mixing of the stratigraphic layers in the sample and offloaded at the dock to a secure storage facility. Specific handling procedures for cores destined for chemical and/or biological analyses are followed carefully.

GS2500 Cable Toner and Detection System

A GS2500 cable detection system was used to assist in positioning existing submarine utility cables in the survey area. This OSI proprietary system consists of an electrode generator onshore and a tone detector unit with sensor and connecting cable on the survey vessel.

The tone generator is connected directly to the submarine cable onshore, requiring access to the cable itself through the owner. The generator functions by energizing the cable with a low-frequency sine wave signal with variable settings up to 500 milliamps at 500 volts and at frequencies ranging from 5-50 Hz. The applied current has specific electrical characteristics to increase the sensitivity of detection over longer distances.

Offshore, the tone sensor is mounted on any type of tow vehicle (ROV or other deep tow platform) and towed just above the seafloor for maximum resolution of the tone signal. Digital thumbwheel switches and rotary dial switches on the front panel of the control unit allow the settings to be fine tuned to the signal generated. Digital displays show the values in effect and a precision analog meter reveals the level of the signal tone being received. The digital tone values are also exported out of the control unit and into HYPACK where they are recorded for post-survey processing and review.

APPENDIX 6

DATA PROCESSING AND ANALYSIS SUMMARY

Navigation and Hydrographic Data

Subbottom Profile Data

Core Information

Side Scan Sonar Imagery

Magnetometer Data

DATA PROCESSING AND ANALYSIS SUMMARY

Navigation and Hydrographic Data

During the field investigation, vessel navigation files were continuously processed and entered into AutoCAD drawings to verify survey coverage and assist with the onsite review of geophysical data. Vessel tracklines with event labels were incorporated into the final presentations in AutoCAD.

Upon completion of the field work, the multibeam data were processed using CARIS HIPS&SIPS Ver. 7.1 batch processor. Hypack HYSWEEP HSX and raw data were converted to CARIS format and systematic corrections were applied, including but not limited to sound speed profiles, heave, vessel offset/alignment, tide and draft. Depths were filtered based on project specific criteria and edited using the CARIS Swath Editor to eliminate noise, multipath returns, and fliers. The editing process is performed with care to eliminate points attributed to objects in the water column (fish, floating debris, etc.) while preserving small features important to the project (boulders and other potential obstructions). Depth data were reviewed in subsets in the CARIS Map window and combined for additional data review of the entire survey coverage area.

A total of 2.5 billion raw data points were processed. After editing and filtering, approximately 900 million points were used to generate surface models that placed the depth data into cell bins of a sufficient size to preserve the features of interest. Shaded rendering maps were generated using a 5 by 5-ft grid cell within the software program Global Mapper, Version 13. The processed x, y, z data for the survey areas were then contoured at an appropriate interval and presented in a plan view panel of the final drawing. The color, sun-illuminated relief maps provide detailed visualization of the bottom topography, often revealing features difficult to see in the contours. Cross-sections of the depth data along the route centerline were generated in HYPACK 2011 TIN MODEL and combined with the subbottom data in the profile panel of the route alignment sheets. Final presentations of the depth data were developed in AutoCAD.

Subbottom Profile Data

Once back in the office, digital seismic profiles were corrected for sound velocity, filtered, and enhanced to obtain maximum resolution for interpretation. For the route centerline profile, the high-frequency "chirp" profile was the focus of subsurface information. EdgeTech Discover Subbottom Processing software was used to review and interpret these data for acoustic reflectors in the upper 10-20 ft of the stratigraphic column. Each digital chirp image was properly scaled, amplified by overall gain and TVG (time variable gain) adjustments, and smoothed using a swell filter. The final processed digital image was exported out of Discover for import to AutoCAD.

Reflectors of interest were mapped on a gridded depth profile overlaying the chirp digital image in AutoCAD as part of the final route alignment drawing sheets. In some places along the route where the “chirp” system did not achieve penetration, the “boomer” profile was reviewed for supplemental subbottom information.

The low frequency “boomer” profiles were processed using the seismic analysis software REFLEXW (Sendmeier Software Version 6.0.5). The program is a powerful 32 bit software package which runs in the Windows XP environment and allows the user full control over signal processing functions such as filtering, stacking, multiple suppression, a variety of gain adjustments, and many file manipulation options. Once all static corrections, filtering, and gain adjustments have been completed, acoustic reflectors of interest to the project can be picked manually by the user or automatically by the program in a cross-sectional format on the monitor. Adjustable threshold, amplitude scale, and gate window allow the automatic assignment of reflector picks to a selected phase. Separate pick codes, colors, and layer names allow the user to organize and export multiple reflector picks in a variety of file formats.

Since the vertical axis of the seismic records is signal travel time and not material thickness, a conversion from time to thickness or reflector depth was performed. A constant propagation velocity of 5,000 ft per second (1,524 m per second) was used during depth and thickness computations as an average representative velocity of the saturated marine sediments in the site. Multiple layer modeling of the seismic traces allows different velocities to be assumed for each layer, if necessary. The program performs the time to distance/depth conversions using the input velocities and produces a corrected geologic cross section. Digital files can be exported containing the bottom and subbottom reflector depths in a number of formats for use with other modeling and mapping programs.

In general, the digital seismic processing steps performed using the REFLEXW program are as follows:

1) File conversion and geometry/navigation checks
   SEGY formatted reflection shot point files were imported into ReflexW. All survey geometry param contained in the file headers, as well as coordinates and event marks were checked.

2) Band Pass Filtering
   A 1-D bandpass filter (800-4,000 Hz) was applied to all traces to increase the signal/noise ratio improving the interpretability of reflected arrivals. This helped minimize interference recorded from the second subbottom system.
3) Deconvolution
   A spiking-deconvolution using the recursion-algorithm of Levinson (Wiener-Filter method) was applied to concentrate the signal wavelet in the time domain creating a highly broadband and smooth spectrum.
4) Envelope Calculation
   A complex trace-analysis was carried out using the Hilbert-Transformation to calculate the envelope or instantaneous amplitude. This instantaneous attribute gave an overview of the energy distribution of the traces and facilitated the determination of signal arrivals.
5) Swell Filtering
   A lowpass filter in the distance dimension was applied to eliminate fluctuations in the x-direction smaller than a chosen wavelength. This step was used for smoothing the data to remove the effect of sea conditions.
6) Static corrections
   A muting curve above the seafloor was defined to set all data points in the water column to zero amplitude. This was done to clear out all reflections produced in the water column improving visualization and interpretability of the profiles. A time cut was applied to reduce trace length to the desired depth of interest.
7) Gain Adjustment
   AGC (automatic gain control) or manual gain curve applications are used, along with a TVG (time variable gain) curve, to adjust the gain settings over the depth of interest to optimize the visual display
8) Trace Editing & Interpolation
   Processing features in this function include combining multiple profiles into one file, trimming overlap from combined profiles, flipping profiles end to end so all are viewed from the same direction, and more.

Individual reflector and seismic facies characteristics were examined in an attempt to determine the possible material types represented on the profiles. Correlation with the geotechnical data (vibratory cores) then allowed lithological identities (clay, sand, bedrock, etc.) to be assigned to the shallow portion of the subbottom profiles.

Core Information

Geotechnical ground truthing of the seismic reflection data was accomplished through use of the OSI vibratory core system which retrieved nearly undisturbed samples of the upper 10 ft of sediment. The samples were also collected for engineering purposes for grain size analysis and other mechanical property analyses. Field core logs were compiled by AECOM for each station to document the onsite conditions including position, water depth, penetration rate, and recovery. All final core logging, photography, lab analyses, and reporting were handled by AECOM, who transmitted all the results to OSI for correlation with the subbottom profiles.

Correlation of the core samples with specific seismic reflectors on the profiles allows the identification of the sediment horizons generating the acoustic interfaces. Those interfaces or reflectors can then be traced between geotechnical sampling stations to provide extrapolation of sediment units laterally below the survey area. Core locations are shown on the final drawing in both plan and profile panels with sediment descriptions where appropriate. A summary of the core data has been included in an appendix at the end of this report.

Side Scan Sonar Images

During interpretation of the side scan sonar records, areas on the seabed exhibiting different acoustical properties were identified. The variation in acoustical characteristics on the bottom represents changes in surficial sediments and/or the presence of benthic communities and foreign material. Areas of large natural seabed features were identified by the increased topographic relief and morphologic variations observed on the records. The sonar data, in conjunction with vibratory core logs, were used to develop a surficial sediment type map for the survey corridor.

Side scan sonar mosaics were created using SonarWiz Version 5.04 (Chesapeake Technologies, Inc.) to show the acoustical variations on the seafloor that could then be interpreted and translated into surficial sediment type maps. The different levels of sonar reflectivity were generally correlated to changes in sediment types (i.e. low reflectivity often represents silt and clay, whereas strong reflectivity may represent coarse sand, gravel, boulders). Areas of different surficial lithology (deemed “types” for this project) and morphology were plotted on the plan view drawings.

Imagery was also reviewed for individual targets with the intent of identifying any object 1-2 ft in size or larger. This served two purposes: it provided information on potential obstructions to the cable installation and data to support the marine archaeological assessment of the route. Given the finer sediments (clay, silt, sand) that exist over much of the route, and the likelihood of many objects being at least partially buried in the seabed, targets were chosen with a high degree of sensitivity. Each target is interpreted and measured individually. A detailed spreadsheet summarizes specific information for each target such as position, number, size, and relief and all the targets are plotted in the plan view panel of the final drawing.

Magnetometer Data

The objective of the magnetometer survey was to locate any ferrous objects lying on or below the seafloor which (1) could represent potential archaeological sites of historic significance and/or (2) may impede the cable installation. Digital records of the magnetic data were reviewed and interpreted using HYPACK to determine the presence of ferrous material in the designated project areas. Anomalous readings above the regional geologic background gradient were identified. A coordinate and descriptive list of the anomalies as well as a map of anomalies relative to sonar contacts were provided to the project archaeologist in support of the cultural resource assessment.

For discrete anomalies, determination of the location of an object producing a magnetic anomaly depends on whether or not the magnetometer sensor passed directly over the object and if the anomaly is an apparent monopole or dipole. A magnetic dipole can be thought of simply as a common bar magnet having a positive and negative end or pole. A monopole arises when the magnetometer senses only one end of a dipole as it passes over the object. This situation occurs mainly when the distance between opposite poles of a dipole is much greater than the distance between the magnetometer and the sensed pole, or when a dipole is oriented nearly perpendicular to the ambient field thus shielding one pole from detection. For dipolar anomalies, the location of the object is at the point of maximum gradient between the two poles. In the case of a monopole, the object associated with the anomaly is located below the maximum or minimum magnetic value.

The magnetic intensity data were also contoured to reveal gradients of the earth's total magnetic field in the site and assist the project archaeologist with review of the data. An xyz ASCII file of the magnetic intensity measurements was exported out of HYPACK and imported to Geometrics MagPick Version 3.2 software for data manipulation. MagPick provides numerous mathematical functions that allow the development of a processed magnetic data set to meet project requirements. Processing and analysis techniques may vary for different types of surveys and intended use of the data (ie. pipeline search, obstruction identification, magnetic gradient mapping). A final data set is exported out of MagPick and imported to QuickSurf for contouring and surface rendering. The magnetic contours and color shaded relief generated are then imported to AutoCAD drawings for final presentation.

APPENDIX 7

QUALITY ASSURANCE/QUALITY CONTROL

OSI QA/QC OVERVIEW

FIELD CALIBRATIONS REPORTS

- Applanix POS MV
- Multibeam Patch Test
- Multibeam Performance Test
- TrackLink USBL

DATA PROCESSING QC REPORTS

OSI QA/QC OVERVIEW

Ocean Surveys, Inc. (OSI) is an environmental / scientific data acquisition firm that provides hydrographic, oceanographic, geophysical, and geotechnical survey services in support of the design and/or construction of freshwater and marine projects. As such, OSI acts as the field data acquisition arm of engineers and owners undertaking marine/freshwater work domestically and overseas. To ensure that OSI provides exceptional services to our clients, the company has a strong commitment to Quality Assurance (QA) and Quality Control (QC) practices in order to maintain a high level of data acquisition and processing excellence. These procedures are in place to establish and maintain consistently high standards of accuracy, reliability, efficiency and overall quality in all aspects of marine surveying.

Details of the Quality Assurance and Quality Control procedures are outlined in the OSI document entitled, “Quality Assurance Approach to Marine Surveying” (July 2009 update). A brief summary is included here to demonstrate and document the commitment of OSI to the highest standard of excellence in the industry.

Quality procedures provide the framework for development and implementation of an effective QA/QC program within OSI. The program is applied to all activities within the company, with employees striving to produce error-free work in all tasks and at all levels. Specific quality management that is incorporated into these procedures is focused on technical activities, including the field studies (data acquisition), laboratory analysis, data validation, database management, data analysis and interpretation, graphics development, and report preparation.

The basic QA routine for each marine survey project shall include (but may not be limited to) the following functional elements:

- Calibration and control of equipment
- Data acquisition / field operations
- Data processing and interpretation
- Document control, report and drawing preparation, product review
- Handling, shipping and storage
- Job specific instruction of OSI personnel
- Quality assurance audits

OSI personnel, under the direction of the project Program Manager, are ultimately responsible for the acquisition and presentation of high quality data and data products. Persons assigned quality assurance functions shall have sufficient authority and organizational freedom to assure total compliance with established quality practices. OSI management will regularly review the status and adequacy of internal QA practices as they are applied to specific projects and will effect modifications as required.

Project managers are responsible for applying the required and appropriate QA procedures to each project. A project manager works with management and technical staff to identify the quality requirements of a specific project. Project manager responsibilities include: (1) ensuring that technical staff are adequately trained and properly applying QA procedures, (2) conducting QA reviews to check for errors or other quality problems, and (3) developing and applying methods to correct errors or quality problems.

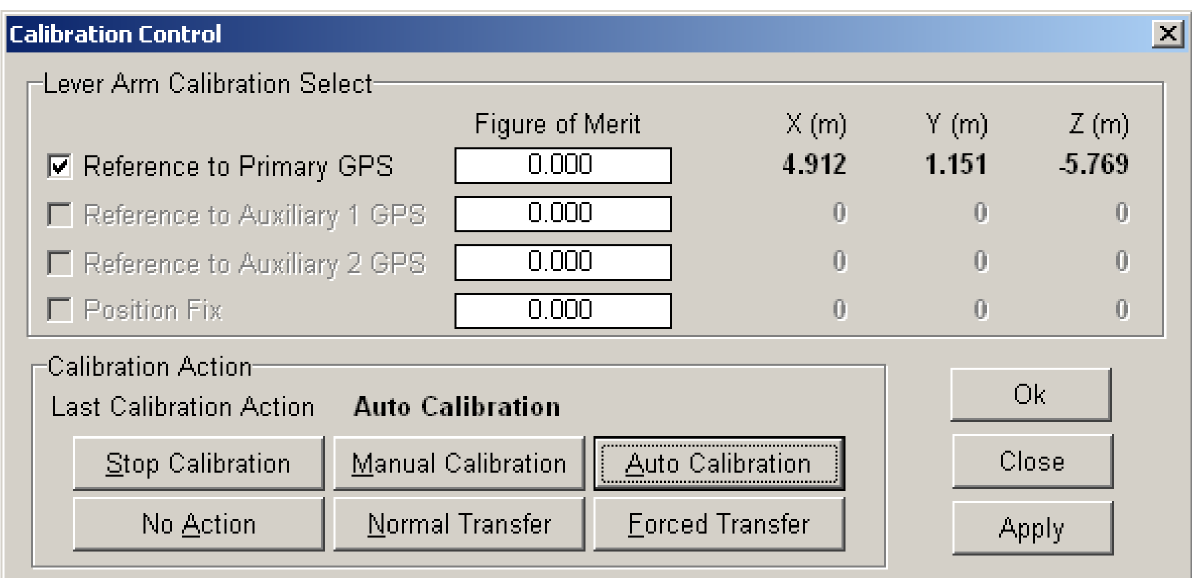
POS MV DIFFERENTIAL GPS CALIBRATION

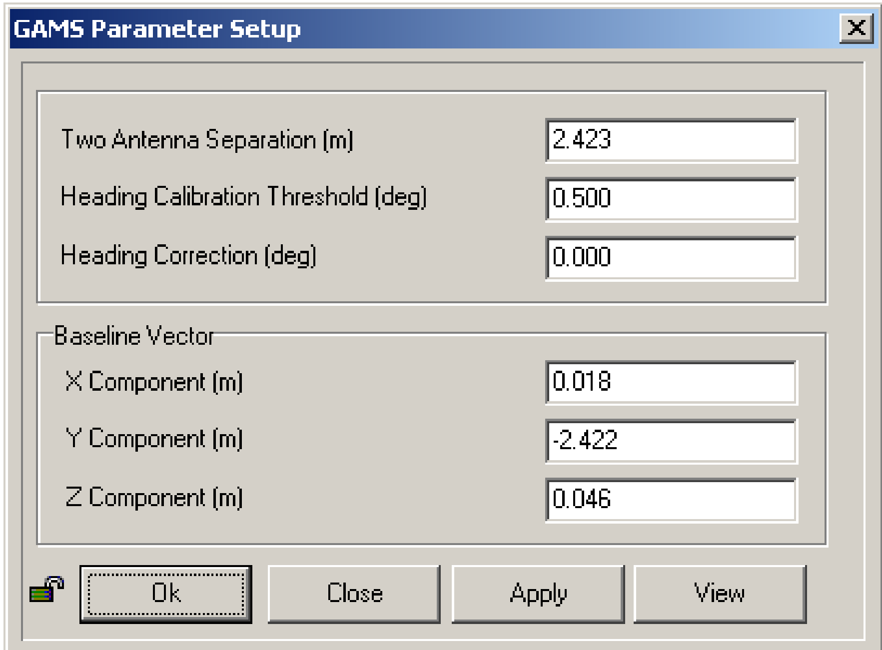
Calibration of the POS MV system involves vessel maneuvers in an unrestricted area using high quality GPS positioning. The GPS Azimuth Measurement Subsystem (GAMS) routine used by the POS MV requires five or more satellites with a Positional Dilution of Precision (PDOP) of less than three. This translates to performing the calibration procedure when there is good satellite geometry.

Once the GPS antennas, inertial measurement unit (IMU), topside control unit, and system computer have been securely installed aboard the vessel, calibration may commence under suitable satellite conditions. A series of broad “S-turns” or “figure-8” turns lasting approximately one minute should be executed after starting either the automatic or manual calibration mode. The system will sequence through the following phases of the calibration, noted in the status line: ready offline, cal in progress, cal completed, and online.

Upon successful calibration, the system reports and outputs the following survey information: geographic position (latitude, longitude), heading, attitude (pitch and roll), vertical displacement (heave), velocity, acceleration, angular rate of turn, performance metrics, and fault detection.

The following image captures of the POS MV setup illustrate the parameters outlined above and the accuracies achieved after calibration (MV-POS view).

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Two Antenna Separation (m) 2.423
Heading Calibration Threshold (deg) 0.500
Heading Correction (deg) 0.000
Baseline Vector
X Component (m) 0.018
Y Component (m) -2.422
Z Component (m) 0.046
Ok
Close
Apply
View


MV-POSView
File Settings Logging View Tools Diagnostics Help
10.69.10.36
Status
POS Mode Nav: Full
IMU Status OK
Nav Status RTCM DGPS
GAMS Online
Accuracy
Attitude
Heading
Position
Velocity
Heave
Attitude
Accuracy (deg)
Roll (deg) -3.547 0.023
Pitch (deg) 4.314 0.023
Heading (deg) 263.389 0.014
Speed (knots) 15.837 Track (deg) 263.357
Position
Accuracy (m)
Latitude 40°31'55.3660" N 0.548
Longitude 73°53'47.0486" W 0.515
Altitude (m) -30.931 1.253
Velocity
Accuracy (m/s)
North (m/s) -0.943 0.052
East (m/s) -8.093 0.050
Down (m/s) 0.003 0.041
Dynamics
Angular Rate (deg/s) Accel. (m/s²)
Longitudinal -6.775 -0.530
Transverse 1.352 -0.251
Vertical 0.440 -1.339
Events
Time Count
Event 1
Event 2
PPS 20:41:53.000000 UTC 36946
20:41:53 UTC 20:41:53 UTC Connected

MULTIBEAM ECHOSOUNDER "PATCH TEST"

A "patch test" is a calibration procedure for the multibeam system designed to accurately measure the angular mounting components (roll, pitch, and yaw) and positioning latency for the equipment configuration onboard the survey vessel.

The following general components are necessary to perform a patch test:

- Differential global positioning system (geographic positions)
- Multibeam echosounder (water depths)
- Motion sensor (heave, pitch, and roll)
- Gyro compass (heading)
- Barcheck or CTD profiler (sound velocity calibration)
- Data collection and processing software (HYPACK / HYSWEEP)

The general procedure for calibrating the multibeam system, once all the above equipment has been installed and secured for survey operations, is to run a series of tracklines over different bottom terrain (sloping and flat) in opposing directions and at varying survey speeds. Prior to running the calibration lines, a CTD profiler is used to acquire a sound speed profile, which corrects soundings for variations in sound speed within the water column. Lines are typically run in the following manner:

1. Positioning latency is determined by collecting data twice along the same trackline located over a prominent bathymetric feature, once at a slow speed and once at maximum survey speed.
2. Pitch offset angle is determined by collecting data along the same trackline positioned over a prominent bathymetric feature, in opposite directions at an average survey speed.
3. Roll offset angle is determined by collecting data along the same trackline positioned over a flat bottom, in opposite directions and at an average survey speed.
4. Yaw offset angle is determined by collecting data along two parallel lines offset to provide overlapping coverage over a prominent feature. Each line is run in the same direction and at an average survey speed.

Data from the calibration runs are processed to determine timing latency and angular biases for pitch, roll, and yaw. The angular and timing values, along with sound speed and water level correctors, are subsequently used during data processing to determine the final depth and position of each sounding. Water level correctors are obtained from a NOAA tide station to reference the soundings to the project vertical datum. Patch test results are provided below.

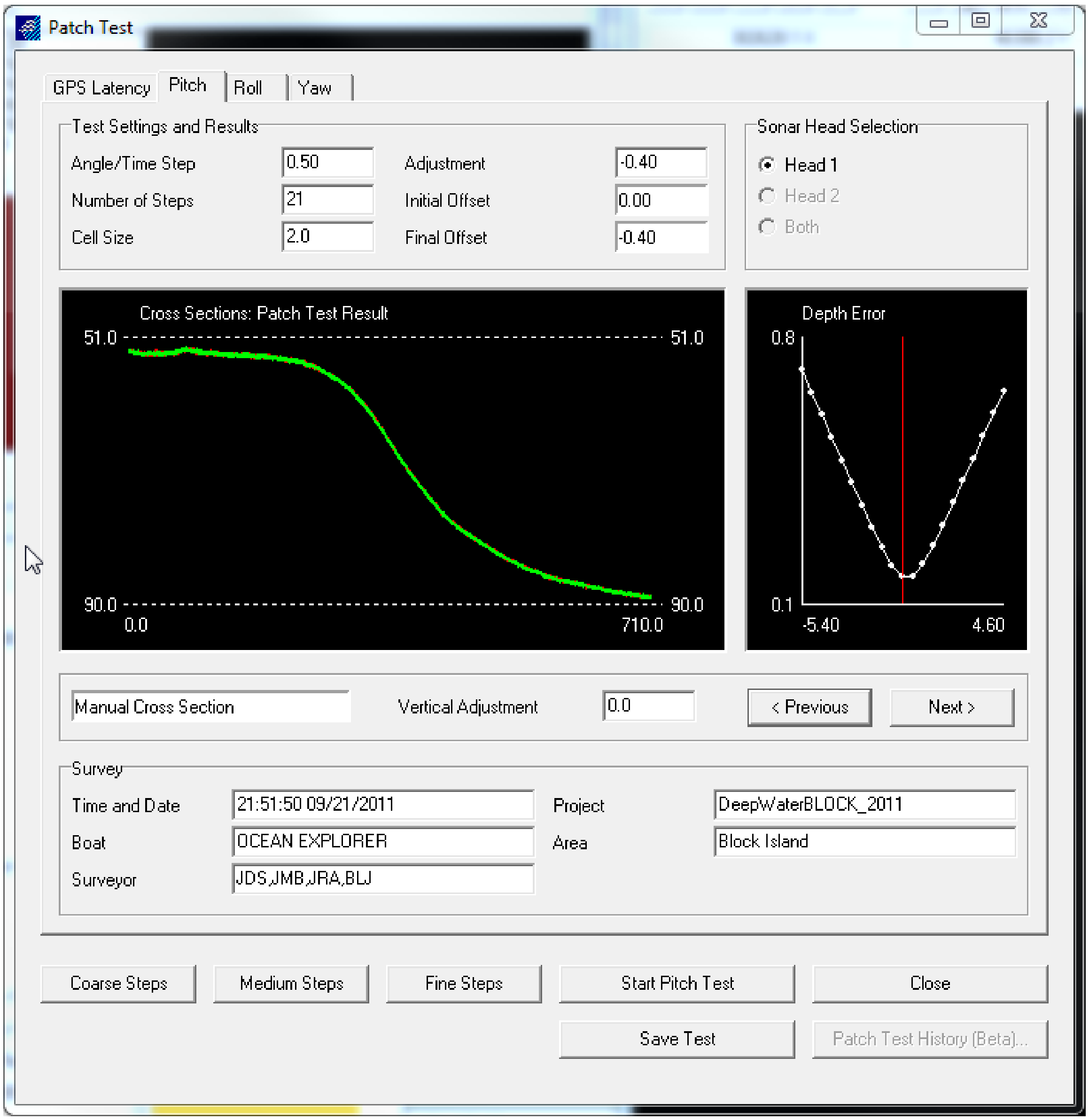
RESON 8101 MULTIBEAM PATCH TEST RESULTS

Final System Offsets

System Parameter	Offset
Timing Latency	0.00 seconds
Pitch	-0.40 degrees
Roll	-0.73 degrees
Yaw	0.16 degrees

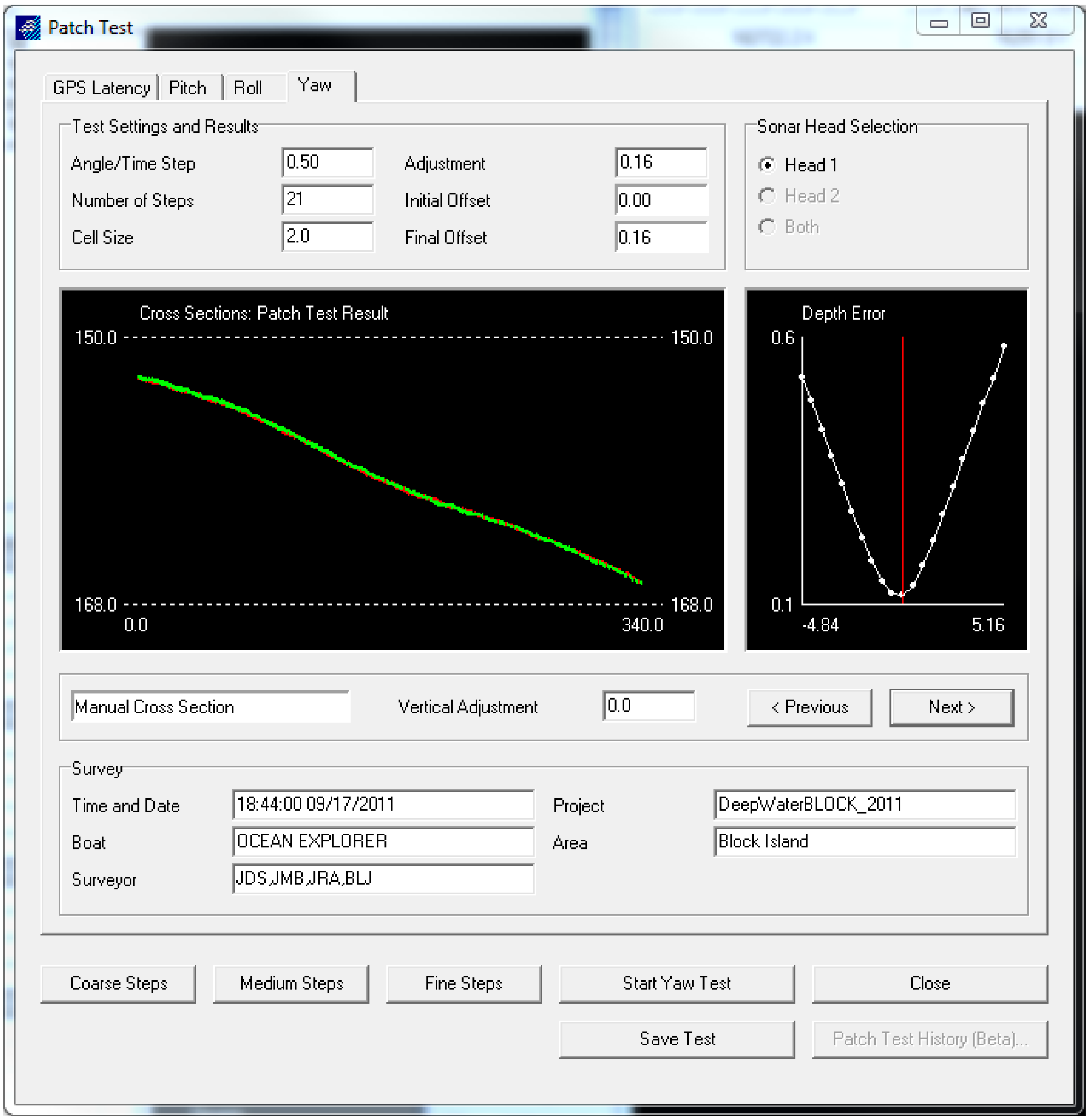
Timing Latency Value

Pitch Bias Value



Roll Bias Value

Yaw Bias Value



MULTIBEAM PERFORMANCE TEST & BAR CHECK

Upon determination of all physical, angular, and timing offsets, a “QA Performance Test” is carried out per specifications in the U.S. Army Corps of Engineers (ACOE) Hydrographic Surveying manual “EM 1110-2-1003”. Per the ACOE manual, “The performance test is used to evaluate the quality and confidence of multibeam data being collected. This test typically compares overlapping data sets from two different multibeam surveys, performed by either the same or different vessels”.

The test consists of two phases. First, a “performance surface” is created by means of executing a small survey run over a flat section of sea floor. Multiple runs are performed over the performance surface area to acquire approximately 400% coverage. Only data within 45 degrees of the echosounder’s nadir beam are cleaned and a 1 ft by 1 ft performance surface is created resulting in an accurate and dense XYZ data set. Next, two “multibeam check lines” are run over the performance surface. These data are input to the HYPACK MAX Beam Angle Test program, which compares multibeam check lines to the performance surface and estimates the depth accuracy of the multibeam system at different beam angle limits.

For this survey, the performance surface was established on 19 September 2011 and a set of performance test values was derived the same day. The ACOE test parameters of depth outliers, mean bias, and standard deviation were considered. The quality of the data tested were within the accuracy requirements specified in the ACOE manual. The table below presents the results of the QA performance test as well as the ACOE standards for these QA criteria.

Statistical Quantity Per Beam Angle Group	Beam Angle Test Results	ACOE Maximum Allowed
Maximum Depth Outlier	0.00 - 0.68 ft	1.0 ft
Mean Difference (Reference Surface – Check Line)	(-0.08) - (0.10) ft	0.1 ft
Depth Standard Deviation (1-•)	+/- 0.13 ft	------
Depth Accuracy At 95% Confidence	+/- 0.25 ft	+/- 0.5 ft – 1.0 ft

The depth measuring accuracy of the echosounder was confirmed by means of a “bar check”. The bar check procedure consists of lowering an acoustical target on a graduated sounding line to the deepest practical depth. The target is then raised to successively shallower depths and the displayed digital depths noted.

LINKQUEST USBL CALIBRATION PROCEDURE

General procedure for calibrating the TrackLink USBL system involves deployment of a beacon or transponder on the bottom in expected project water depths. The survey vessel then runs transects directly over the transponder, both toward and away from its location, to determine the heading offset value for the transceiver as installed on the vessel.

The following systems are required to complete this calibration:

- Navigation computer running HYPACK software
- Differential GPS
- Motion sensor
- Gyro compass
- TrackLink system components and computer
- CTD profiler

The TrackLink system consists of a topside computer, transceiver unit fix mounted to the survey vessel, and battery powered transponders which are attached just above towed sensors. The TrackLink system requires input from a motion sensor to monitor transceiver head motion for accurate determination of transponder positions away from the vessel.

The HYPACK navigation computer requires input from the differential GPS, motion sensor, gyro compass, (or all-in-one POS MV IMU) and TrackLink system. All systems must be correctly installed in the HYPACK setup file to include offsets and laybacks relative to the vessel origin point.

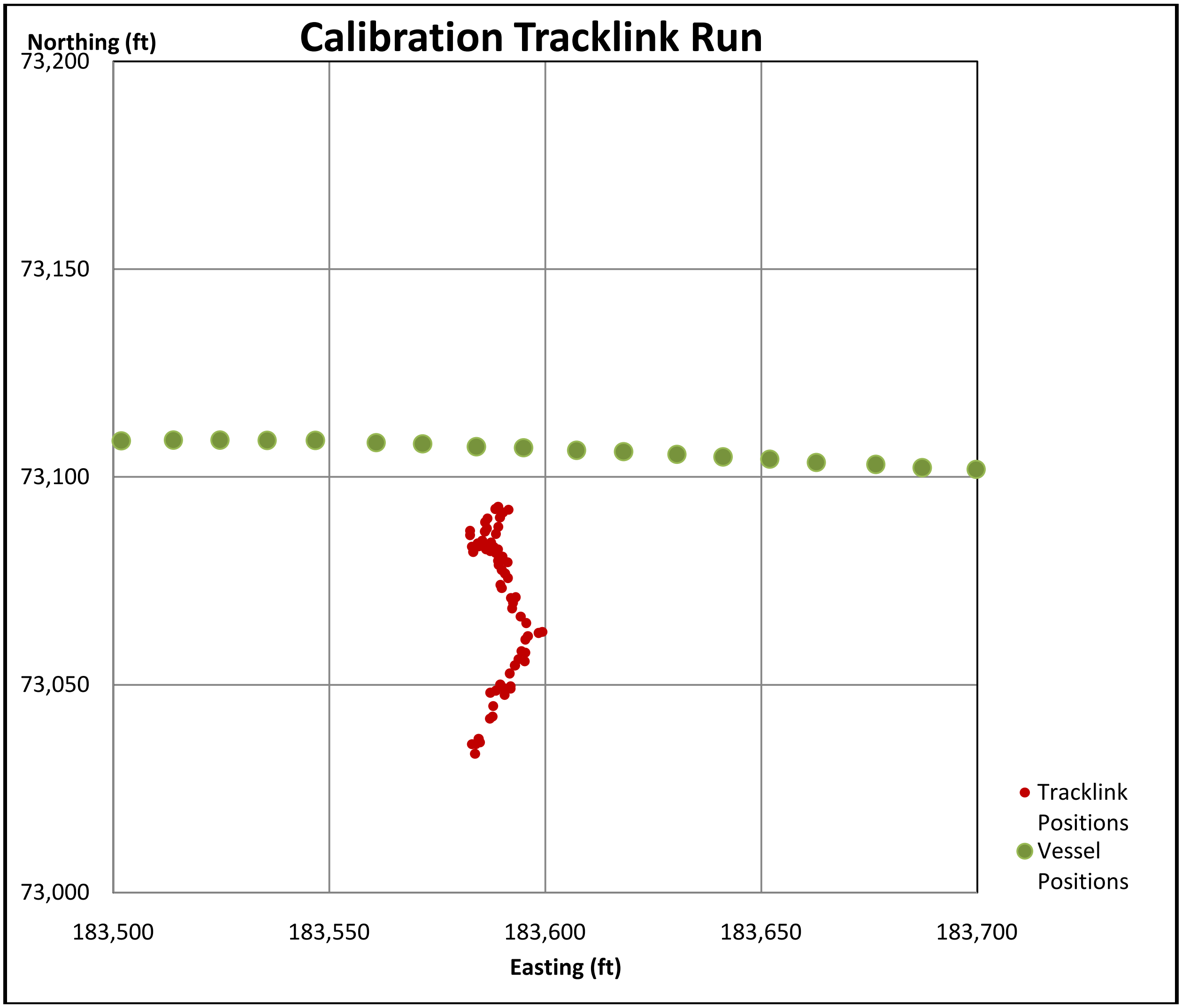
After collecting vessel and USBL positions over the transponder deployed on the bottom, the navigation files are edited to correlate the two system's positions by time. The angular variation between the actual transponder location and the recorded transponder positions is equivalent to the heading offset.

Once the average heading offset is calculated from analysis of the calibration runs, the average value is input to the TrackLink system and the same data collection procedure is repeated to verify the calculated offset.

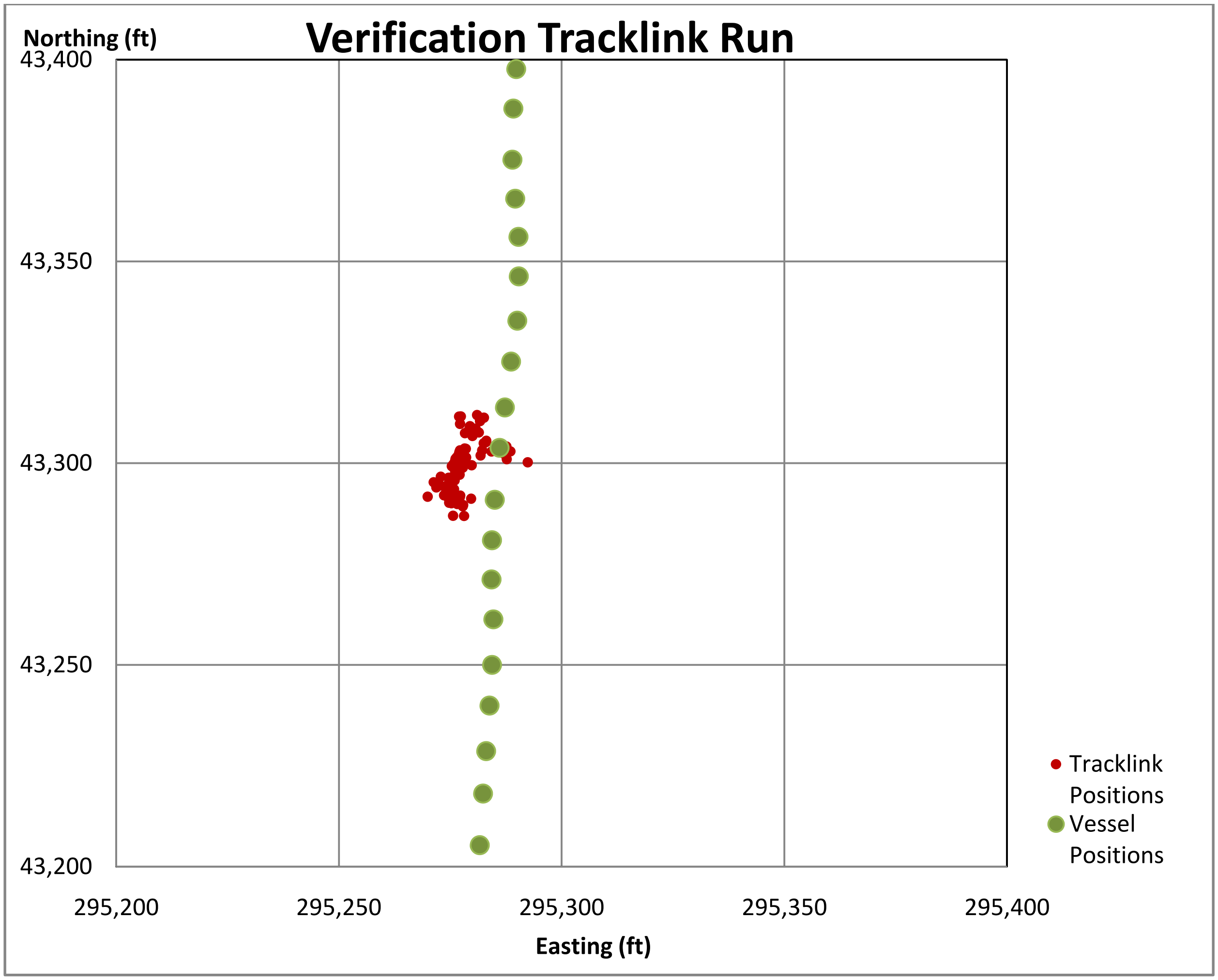
TRACKLINK USBL CALIBRATION RESULTS

Deepwater Wind BITS Project

CALIBRATION RUN (to determine the heading offset)



VERIFICATION RUN (to validate the heading offset)



Calibration Summary			
	Heading Offset (deg.)	Standard Deviation (feet)	95% Confidence --to 500 ft distance-- (feet)
Pre-Cal	0.0	8.1	15.9
Post-Cal	3.2	2.6	5.1

DATA PROCESSING QC REPORTS

During the processing stage of all data sets, continual quality checks were performed to ensure a high standard of accuracy is maintained. Comparative analyses were conducted to provide a measure of quality level, with statistical results generated whenever applicable. For the hydrographic data, the final processed multibeam depth values were compared at line intersections (where crossing/tie lines intersect primary lines). This provides a measure of the quality of final integrated hydrographic measurements, including the application of motion (heave, pitch, roll), speed of sound, and tide adjustments. These comparisons were accomplished using the CARIS QC Report Utility to generate statistical quality control information with respect to International Hydrographic Organization (IHO) "Special Order" and United States Army Corps of Engineers (USACE) survey specifications.

Four orders of survey are defined by IHO in publication S-44 5th Edition 2008. These are described in subsequent paragraphs.

Special Order

This is the most rigorous of the orders and its use is intended only for those areas where under-keel clearance is critical. Because under-keel clearance is critical a full sea floor search is required and the size of the features to be detected by this search is deliberately kept small. Since under keel clearance is critical it is considered unlikely that Special Order surveys will be conducted in waters deeper than 40 meters. Examples of areas that may warrant Special Order surveys are: berthing areas, harbors and critical areas of shipping channels.

Order 1a

This order is intended for those areas where the sea is sufficiently shallow to allow natural or man-made features on the seabed to be a concern to the type of surface shipping expected to transit the area but where the under-keel clearance is less critical than for Special Order above. Because man-made or natural features may exist that are of concern to surface shipping, a full sea floor search is required, however the size of the feature to be detected is larger than for Special Order. Under-keel clearance becomes less critical as depth increases so the size of the feature to be detected by the full sea floor search is increased in areas where the water depth is greater than 40 meters. Order 1a surveys may be limited to water shallower than 100 meters.

Order 1b

This order is intended for areas shallower than 100 meters where a general depiction of the seabed is considered adequate for the type of surface shipping expected to transit the area. A full sea floor search is not required which means some features may be missed although the maximum permissible line spacing will limit the size of the features that are likely to remain undetected. This order of survey is only recommended where under-keel clearance is not considered to be an issue. An example would be an area where the seabed characteristics are such that the likelihood of there being a man-made or natural feature on the sea floor that will endanger the type of surface vessel expected to navigate the area is low.

Order 2 (beyond the depth limits of this study)

This is the least stringent order and is intended for those areas where the depth of water is such that a general depiction of the seabed is considered adequate. A full sea floor search is not required. It is recommended that Order 2 surveys are limited to areas deeper than 100 meters as once the water depth exceeds 100 meters the existence of man-made or natural features that are large enough to impact on surface navigation and yet still remain undetected by an Order 2 survey is considered to be unlikely.

The following table outlines the IHO minimum standards for hydrographic surveys.

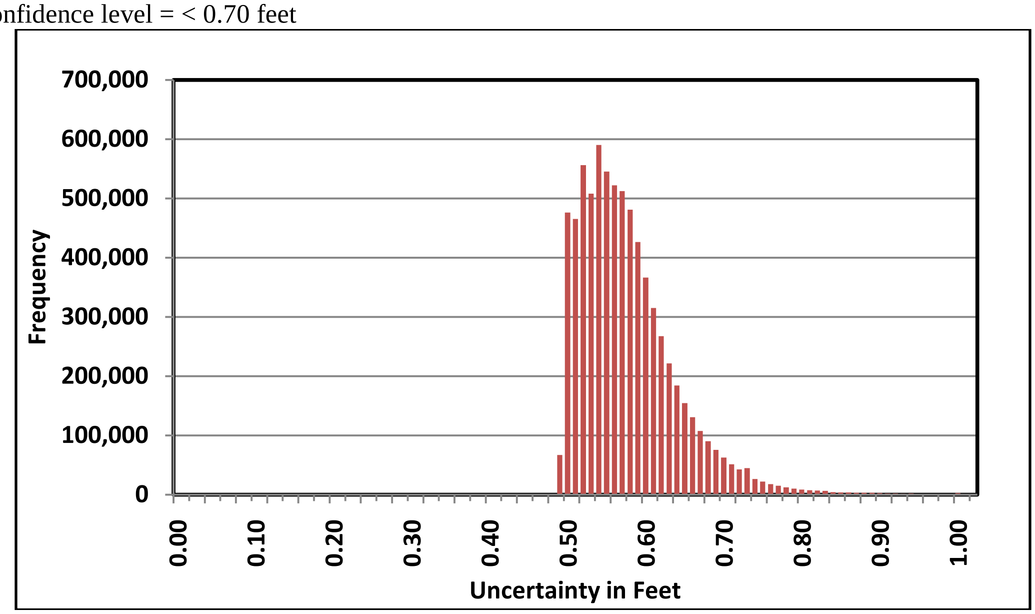
ORDER	**Special**	**1**	**2**
Examples of Typical Areas	Harbors, berthing areas, and associated critical channels with minimum underkeel clearances	Harbors, harbor approach channels, recommended tracks and some coastal areas with depths up to 100 m	Areas not described in Special Order and Order 1, or areas up to 200 m water depth
Horizontal Accuracy (95% Confidence Level)	2 m	5 m + 5% of depth	20 m + 5% of depth
Depth accuracy for Reduced Depths (95% Confidence Level) (1)	a = 0.25 m b = 0.0075	a = 0.5 m b = 0.013	a = 1.0 m b = 0.023
System Detection Capability	Cubic features > 1 m	Cubic features > 2 m in depths up to 40 m; 10% of depth beyond 40 m	Same as Order 1
Horizontal control	10 cm at 95% confidence level for geodetic satellite methods.	Same as Special	Same as Special
Tidal Observations	Error not to exceed Γ 5 cm at 95% confidence level	Error not to exceed Γ 10 cm at 95% confidence level	Same as Order 1

The following table lists the maximum values by depth for vertical uncertainty allowed for the four orders of survey. Order 2 is included to show the magnitude of variation for the next level of hydrographic survey (deeper water).

IHO S-44 Vertical Uncertainty Maximum Values by Depth				
Depth (feet)	Special Order (feet)	Order 1a (feet)	Order 1b (feet)	Order 2 (feet)
10	0.82	1.65	1.65	3.29
20	0.83	1.66	1.66	3.31
30	0.85	1.69	1.69	3.35
40	0.87	1.72	1.72	3.41
50	0.90	1.76	1.76	3.48
60	0.94	1.82	1.82	3.56
70	0.97	1.88	1.88	3.65
80	1.02	1.94	1.94	3.76
90	1.06	2.01	2.01	3.88
100	1.11	2.09	2.09	4.01
110	1.16	2.18	2.18	4.14
120	1.22	2.26	2.26	4.29
130	1.27	2.36	2.36	4.44
140	1.33	2.45	2.45	4.60
150	1.39	2.55	2.55	4.76

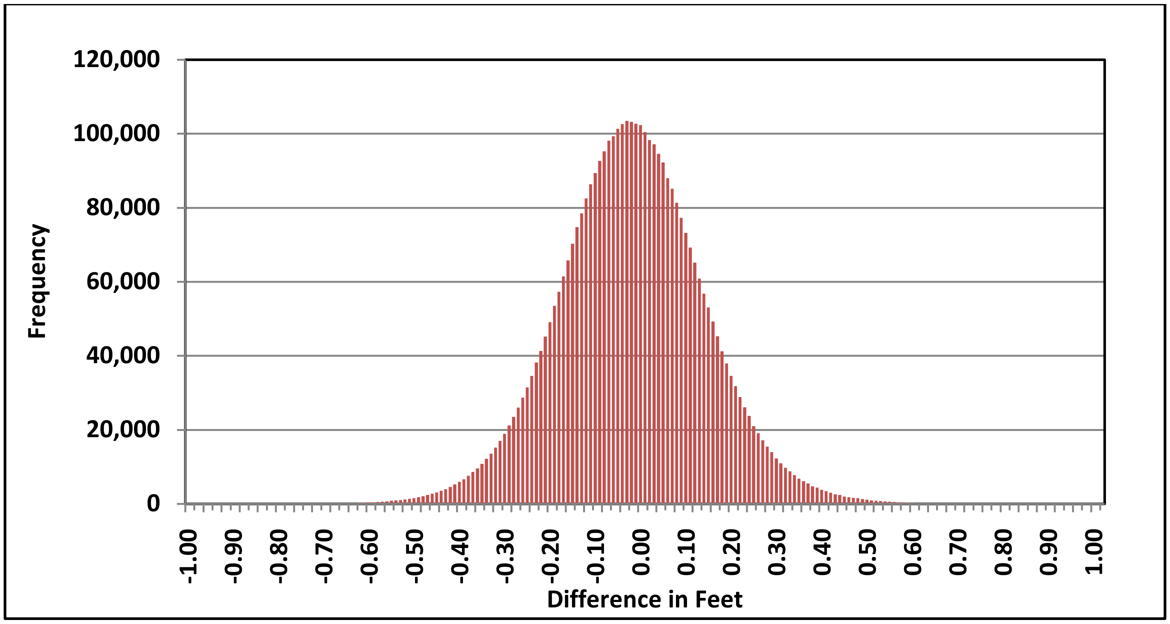
The graph below plots the vertical uncertainty values from the BITS survey for all multibeam lines conducted. The 95% confidence level of less than 0.70 ft is well below the limits for a Special Order survey at all depths.

BITS Multibeam Survey Depth Uncertainty
95% confidence level = < 0.70 feet



The following graph plots comparisons of all the multibeam overlapping depth bins throughout the areas surveyed. This includes where tielines cross main lines (route parallel) as well as overlapping beams on adjacent, parallel tracklines. The 95% confidence level depth values are +/- 0.32 ft.

BITS Crossing Line Comparison
95% confidence level = +/- 0.32 feet



Similar comparative procedures were performed on the geophysical data sets to verify accurate positioning of acoustic data on the seafloor, seismic data in the subsurface, and magnetic intensity measurements. Side scan sonar images recorded on adjacent tracklines were imported, checked for GPS latency and accuracy, and overlaid in a mosaic format to verify that surficial features (sand waves, rocks, objects) were being positioned in the same place. On subbottom profiles, depths to prominent reflectors mapped in the subsurface were compared at intersection points to ensure layer interfaces were plotted correctly in the horizontal and vertical planes. For the magnetic intensity measurements, after applying diurnal variation and leveling adjustments, magnetic field strength at intersection points were compared, as well as individual anomalies identified near crossing lines and on overlapping tracklines.

APPENDIX B

Benthic Resources Survey Report

Deepwater Wind
Block Island Wind Farm and Block Island Transmission System

Benthic Resources

April 2012

Deepwater Wind
Block Island Wind Farm and Block Island Transmission System

Benthic Resources

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April 2012

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Executive Summary

Deepwater Wind Block Island, LLC, proposes to construct the Block Island Wind Farm (BIWF), a 30 MW offshore wind project to be located approximately 3 mi (4.8 km) southeast of Block Island, Rhode Island. In connection with the BIWF, Deepwater Wind Block Island Transmission, LLC, proposes to construct the Block Island Transmission System (BITS), a new 34.5 kilovolt (kV) alternating current (AC) bidirectional submerged transmission line between Block Island and the Rhode Island mainland. Deepwater Wind Block Island, LLC and Deepwater Wind Block Island Transmission, LLC are collectively referred to as "Deepwater Wind" in this report. BIWF and BITS are collectively referred to as "the Project" in this report.

Deepwater Wind has conducted numerous Project-specific field surveys to support the environmental permitting for the BIWF and the BITS. The surveys relevant to the understanding of impacts to benthic resources, the topic of this report, consisted of detailed geophysical investigations that characterized the seafloor conditions, a sediment profile imagery (REMOTS®) survey that characterized the physical and biological features of the near-surface sediments, an eelgrass survey to document the distribution of this resource near the Project, and a video survey examining the hard substrate habitat present within the Project Area. Each of these surveys contributed to an understanding of the benthic ecology in and near the Project Area to enable a complete assessment of the potential impacts of installation and operation of the BIWF and the BITS. Results of several of the studies (geophysical, sediment profile imagery, and eelgrass) provided Deepwater Wind with important guidance in siting Project components to avoid impacts to sensitive habitats.

Both Rhode Island Sound and Block Island Sound are physically dynamic as is evidenced by predominantly sandy substrate conditions that frequently feature sand waves. The deeper portions of the Project Area are less dynamic with a higher proportion of silt in the sediment. Hard substrate is limited in distribution within the Project Area occurring primarily in the southwestern portion of the Area of Potential Effect (APE) beyond the proposed wind turbine generator (WTG) sites. These conditions define the types of benthic macroinvertebrates that are present. Benthic infauna in the Project Area is dominated by species adapted to this dynamic environment and is similar to benthic communities throughout both Rhode Island Sound and Block Island Sound, factors that enhance the ability of the benthic community to recover from disturbances. Hard substrate communities exhibited relatively low diversity; most of the hard substrate comprised scattered cobble and supported little erect or foliose macroalgae that could provide the secondary habitat commonly observed with hard substrate.

Direct impacts to benthic habitat from the Project are small. The only long-term benthic habitat losses will occur in the WTG footprints (a total of 0.35 acre [0.14 hectare]). Habitat conversion from soft to hard substrate (up to 1.93 acre [0.78 hectare]) will occur along the cable routes where protective covering is needed to accommodate existing cable crossings and areas where >4 ft (1.2 m) of burial cannot be achieved. The WTG foundations will provide artificial hard substrate that is likely to be colonized by benthic fouling organisms. Similarly, protective material placed over transmission cables is likely to be colonized.

Most benthic impacts will be temporary. Installation of the WTGs will require the use of vessels that will be kept stationary either by multi-point anchoring or by spuds inserted into the substrate. In either case, mooring will be of short duration and physical and biological recovery of the anchor

scars is expected. The Inter-Array, Export, and BITS Cables will be installed primarily by a jet plow towed by a dynamic positioning vessel. This method avoids the use of anchors and avoids open trenching. Although jet plowing will suspend some sediment, most will settle out of the water column quickly with little transport beyond the trench. Neither eelgrass nor hard substrate habitats will be affected by redeposition of suspended sediments. Impacts associated with alternative methods for cable installations at the landfalls will also be temporary and will not affect either eelgrass or hard substrate habitats.

No significant long-term operational impacts will occur. The cable design and deep burial will minimize magnetic field emissions to levels below those likely to be perceived by benthic organisms. Although maintenance operations will likely require anchored vessels, the substrate disturbance will be short-lived.

Deepwater Wind incorporated mitigation through avoidance and minimization throughout the Project design and siting process. Sensitive habitats were avoided. Construction methods that will cause the least habitat disturbance were selected. The number of WTGs was reduced from eight to five, reducing the Project footprint. No additional mitigation is therefore required.

1.0 Introduction

Deepwater Wind Block Island, LLC, a wholly-owned indirect subsidiary of Deepwater Holdings, LLC proposes to develop the Block Island Wind Farm (BIWF), a 30 megawatt (MG) offshore wind project approximately 3 miles (4.8 km) southeast of Block Island, Rhode Island comprising two major components – the wind farm and the transmission system to move electricity from Block Island to the Rhode Island mainland. The BIWF will consist of five, 6 MW wind turbine generators (WTGs), a submarine cable (approximately 2 mi [3.2 km]) interconnecting the WTGs ("Inter-Array Cable") and a 34.5-kV transmission cable connecting the northernmost WTG to an interconnection point on Block Island ("Export Cable") (submarine section is approximately 6.2 mi [10 km]). In connection with the Wind Farm, Deepwater Wind Block Island Transmission, LLC, also a wholly owned indirect subsidiary of Deepwater Wind Holdings, LLC, proposes to develop a new 34.5 kilovolt (kV) alternating current (AC) bidirectional submerged transmission line, the Block Island Transmission System (BITS), between Block Island and the Rhode Island mainland (approximately 21.8 mi [35.1 km] to 25.9 mi [41.7 km]) to interconnect with the existing Narragansett Electric (National Grid) system in Narragansett, Rhode Island. Deepwater Wind Block Island, LLC and Deepwater Wind Block Island Transmission, LLC are collectively referred to as "Deepwater Wind" in this report. BIWF and BITS are collectively referred to as "the Project" in this report.

This report describes the marine benthic resources in the Project Area and discusses the effects of the construction, operation and decommissioning of BIWF and BITS on these resources. For the purposes of this report, the two Deepwater Wind Holdings, LLC corporate entities associated with the development of the BIWF and BITS are collectively referred to as "Deepwater Wind." Likewise, the BIWF and BITS are collectively referred to as "the Project."

1.1 Project Location

This section describes the proposed location of each of the BIWF and BITS components. For the purpose of impact analysis, the Project Area refers to the footprint of the BIWF and BITS facilities within these locations. The Project Area encompasses the wind farm itself (WTGs and Inter-Array Cable), the Export Cable), the two Alternative BITS routes, and areas where direct impacts to benthic resources can occur. The Project Area also encompasses areas where indirect impacts (e.g., temporary effects during construction outside the footprint of the Project infrastructure) to the benthos can occur. These include the Areas of Potential Effect (APE) where construction activities may affect the substrate and associated benthos as well as resources in the vicinity of the BIWF and BITS Project. Figure 1 provides an overview of the Project Area and the APE of potential direct and indirect effect.

1.1.1 Block Island Wind Farm

The BIWF will be located approximately 3 miles (4.8 km) southeast of Block Island, and approximately 16 miles (25.7 km) south of the Rhode Island mainland. The WTGs, Inter-Array Cable, and a portion of the Export Cable are located within the Rhode Island Renewable Energy Zone established by the Coastal Resources Management Council (CRMC) through the Rhode Island Ocean Special Area Management Plan (RI Ocean SAMP). The WTGs will be located approximately 0.5 mi (0.8 km) apart. The Inter-Array cable will connect the five, 6 MW WTGs for a total length of 2 mi (3.2 km) (Figure 1).

The Export Cable will originate at the northernmost WTG and travel 6.2 mi (10 km) to Town Beach on Block Island. Deepwater Wind is considering two different options for landing the Export Cable on Block Island. These landing alternatives include either (1) conducting a long-distance horizontal directional drill (HDD) from the Town Beach parking lot to a temporary cofferdam located up to 1900 ft (579 m) from shore or (2) conducting a short-distance HDD to bring the cable to an excavated trench located at mean high water (MHW) from which a jet plow would be launched directly from the beach.

1.1.2 Block Island Transmission System

The BITS cable will traverse state and federal submerged lands through the Rhode Island Sound for a distance of approximately 21.8 mi (35.1 km) to make landfall at Narragansett Town Beach (BITS Alternative 1) or approximately 25.9 miles (41.7 km) to a landfall at the University of Rhode Island (URI) Bay Campus (BITS Alternative 2) in Narragansett, Rhode Island. The BITS alternative routes cross through federal waters for approximately 9.0 miles (14.5 km).

As with the BIWF Export Cable, Deepwater Wind is proposing either a long-distance HDD to a temporary cofferdam located up to 1900 ft (579 m) offshore of Block Island and up to 1600 ft (488 m) offshore from Narragansett Town Beach or a short-distance HDD with a jet plow launched directly from the beach at MHW.

For the BITS Alternative 2 landing at the URI Bay Campus, the use of short-distance HDD and a jet plow is not feasible, therefore Deepwater Wind is proposing a long-distance HDD from an existing cleared storage area to a temporary cofferdam located up to 1800 ft (549 m) from shore.

1.2 Submarine Components of the Project Facilities

1.2.1 BIWF

Wind Turbine Generators

Deepwater Wind proposes to install five, 6 MW WTGs. Each WTG would be attached to the seafloor using jacket foundations secured with four through-the-leg foundation piles. The jackets consist of hollow steel tubular members joined together in a lattice structure, which will sit on the seabed supporting the WTG tower. The diameter of each pile is expected to be between 42 in and 54 in (107 cm and 137 cm), with a maximum wall thickness of 1.5 in (3.8 cm). The foundation piles will be driven to a depth of up to 250 ft (76.2 m) into the seafloor. The foundation for each WTG will comprise several components that will cover the seafloor: four circular legs, four linear braces between the legs, four triangular mud mats, and cable sand/cement bag armoring that, in total will occupy about 0.07 acres (3016 ft^2) of seafloor. Thus, the five WTGs will directly cover 0.35 acre (0.14 hectare) of seafloor in the aggregate.

Inter-Array Cable

The WTGs will be interconnected via a 34.5 kV submarine cable system connecting the WTGs in a radial inter-turbine configuration (Inter-Array Cable). The Inter-Array cable system will comprise a single three-core 34.5 kV, 6 to 10-inch (15.2 to 25.4-cm) diameter submarine cable buried to a target depth of 6 ft (1.8 m) beneath the seafloor. The actual burial depth will depend on substrate encountered along the route and could vary from 4 to 8 ft (1.2 to 2.4 m). The Inter-Array Cable will require a trench width corridor 5 ft (1.5 m) wide and a plow skid width of 15 ft (4.6 m) during construction. At each of the foundation locations, the Inter-Array Cable will be pulled into J Tubes mounted on the foundations. A portion of the Inter-Array Cable close to the J Tubes will not be buried, but instead be covered with supplemental armoring.

Export Cable

A 34.5 kV submarine cable will connect the WTGs to a new substation on Block Island (Export Cable). As with the Inter-Array Cable, the Export Cable has a 6 to 10-inch (15.2 to 25.4-cm) diameter and will require a trench width corridor 5 ft (1.5 m) wide and a plow skid width of 15 ft (4.6 m) during construction. The Export Cable will be buried at a target depth of approximately 6 ft (1.8 m) although the actual burial depth could vary from 4 to 8 ft (1.2 to 2.4 m) beneath the seafloor depending on substrate conditions.

1.2.2 BITS

From the proposed HDD work area on Block Island, the BITS route will travel either 21.8 mi (35.1 km) to the landfall at Narragansett Town Beach (Alternative 1) or 25.9 mi (41.7 km) to the landfall at URI Bay Campus (Alternative 2) in Narragansett, Rhode Island. Connection to the terrestrial portion of the BITS will be either through a long distance HDDs to temporary offshore cofferdams proposed off of Block Island Town Beach, Narragansett Town Beach, and the URI Bay Campus or via a jet plow from the MHW lines on Block Island and Narragansett Town Beach (BITS Alterative 1 only). For BITS Alternative 2, jet plowing from shore is not feasible from the URI Bay Campus.

Like the Inter-Array and Export Cables, the BITS will also have a cable diameter of 6 to 10 inches (15.2 to 25.4 cm) and will require a submarine trench width corridor 5 ft (1.5 m) wide and a plow skid width of 15 ft (4.6 m) during construction. The cable will be buried to a target depth of 6 ft (1.8 m) beneath the seafloor. The actual burial depth will depend on substrate encountered along the route and could vary from 4 ft to 8 ft (1.2 m to 2.4 m).

1.3 Construction

The construction of the submarine components of the Project involves the following activities:

- Installation of offshore cofferdams in support of the long-distance HDDs and/or jet plow trench excavation up to the MHW line on Block Island and Narragansett Town Beach;
- Transmission system installation; and
- Offshore installation of the WTGs.

1.3.1 Cable Landfalls and Transmission System Installation

Upon the issuance of requisite permits and approvals and completion of route clearance and pre-lay grapnel activities, Deepwater Wind and its subcontractors will construct and install the submarine Export Cable, BITS, Block Island substation, and associated facilities necessary to interconnect with the Project to the existing National Grid transmission system. Submerged cable installation for the Inter-Array Cable, Export Cable, and BITS will utilize jet plowing to minimize seafloor disturbance. Connections to the terrestrial portion of the transmission cable systems will be will be accomplished via either a long-distance HDD to a temporary offshore cofferdam or a short-distance HDD with a jet plow launched directly from the beach at MHW.

Various methods are available for the installation of submarine cables depending on the type of subsurface material encountered. These methods employ different types of specialized equipment.

A dynamic positioning cable-laying ship will be used for this Project. Positioning of the lay vessel is achieved by thrusters on the vessel and thereby eliminates impacts to the seabed from anchors and cable sweep except on rare occasions (e.g., cable crossings, areas where 4-ft burial cannot be achieved and the cofferdam locations [where a jackup barge will be held in place with spuds]). Deepwater Wind expects to use jet plowing to install the cable in the seafloor.

Jet plowing is a process that can simultaneously trench, lay, and embed the cable with one device. This method is used where the sediments are sufficiently soft, without significant rocky material, and local environmental regulations permit the disturbed material to be naturally re-deposited into the trench. In this method, a rubber-tired or skid-mounted plow is pulled along the bottom behind the lay vessel. High pressure water from vessel-mounted pumps is injected into the sediments through nozzles situated along the plow causing the sediments to fluidize momentarily, creating a liquified trench. Deepwater Wind anticipates a temporary trench width of up to 5 ft (1.5 m). As the plow is pulled along the route behind the barge, the cable will be laid into the opened trench through the back of the plow. The trench will be backfilled by the water current and the natural settlement of the suspended material. Depth of burial is controlled by adjusting the angle of the plow relative to the bottom. The Export Cable and BITS Cable will be buried to a target depth of 6 ft (1.8 m) beneath the seafloor. The actual burial depth will depend on substrate conditions and could vary from 4 to 8 ft (1.2 to 2.4 m). If less than 4 ft (1.2 m) burial is achieved, Deepwater Wind may elect to install additional protection such as concrete matting or rock piles. Given the results of the detailed Project-specific geophysical investigations (OSI 2012a and b), Deepwater Wind expects that additional protection would be required at a maximum of 1 percent of the cable routes.

Depending on bottom conditions, the cable installation is expected to take 4 to 7 weeks to complete for all submarine cabling.

1.3.2 Foundation Fabrication and Transportation

Deepwater Wind will commission the fabrication of the foundations, including piles, jackets, and transition decks. The jackets and transition decks will be fabricated in the U.S. Gulf of Mexico region, most likely in Texas or Louisiana, and shipped to Rhode Island. The jackets and transition decks will be transported to the offshore installation site by a transportation barge, typically 400 ft by 120 ft (122 m by 37m) in size, towed by ocean going tugboats. Once on location, the transportation barge will be secured by inserting spuds into the substrate.

1.3.3 Offshore Installation of the Foundations and WTGs

Offshore installation of the foundations will be carried out by 500-ft (152.4-m) derrick barges moored to the seabed by an 8-point mooring system consisting of 10-ton anchors.

Prior to commencing installation activities, the seabed will be checked for debris and levelness within a 100-ft (30.5 m) radius of the jacket installation location and debris will be removed as necessary. Each jacket will be lifted from the material barge, placed onto the seafloor, set level, secured and made ready for piling. The piles will then be inserted into each corner of the jacket in two segments. First the lead sections of the piles will be inserted and welded into the jacket legs and then driven into the seafloor. The second part of the piles will be placed on the pile tip and welded into place. The foundation piles will then be driven into the seafloor to their final penetration depth as determined through final design or until refusal, whichever occurs first. Once the pile driving is complete, the top of the piles will be welded to the jacket legs using shear plates and cut to allow for horizontal placement of the transmission deck. Finally, the boat landing and

transition decks will be welded into place onto the jacket foundation. Jacket appurtenances such as boat landings, stairs, and J tubes will be installed at this time.
Duration of pile driving is anticipated as 4 days per jacket with a 24-hour work schedule. Each jacket will require 7 days to complete the installation. Once the foundation and piling are in place, the derrick barge will be moved to the next WTG site. Installation of all five foundations is expected to take approximately 5 weeks.

The WTGs will be installed upon completion of the jacket foundations and the pull-in of the Inter-Array Cable. The WTGs will be transported to the offshore installation site from the storage facility at Quonset Point by jack-up transportation barges. The transportation barges will set up at the installation site adjacent to the jack-up lift barges. The jack-up barge legs will be lowered to the seafloor to provide a level work surface and begin the WTG installation. Installation of each turbine will require two days to complete, assuming a 24-hour work window and no delays due to weather or other issues.

1.4 Decommissioning

After the expected 25-year lifespan of the Project has elapsed, decommissioning will follow the same relative sequence as construction but will occur in reverse using similar vessels as used during construction. The WTG components will be removed by a jack-up lift vessel or with the use of a derrick barge and lifted onto a material barge. The material barge will transport the components to a recycling yard where the components will be disassembled and prepared for re-use and/or recycling for scrap steel and other materials. The foundations will be removed using 500-ton derrick barges and lifted onto material barges. The piles will be cut by an internal abrasive water jet cutting tool at a pre-determined level below the seabed based on regulations and permit conditions. The submarine cables will be abandoned in place. Impacts associated with decommissioning will be comparable to those described for construction.

2.0 Existing Conditions

2.1 Substrate Conditions

Substrate conditions play a large role in defining benthic communities. Much of our understanding of the benthic resources in the Project Area is based on detailed surveys that focused primarily on describing the substrate (CoastalVision and CR Environmental 2010; CoastalVision and Germano 2010; LaFrance et al. 2010; OSI 2012a and 2012b). Substrate conditions described in these reports are summarized in Table 1 (OSI 2012a and b), Table 2 (CoastalVision and Germano 2010), and Table 3 (LaFrance et al. 2010). Additional information on the biota were obtained from a Project-specific video survey in areas suspected to have hard substrate conditions (Appendix A), a Project-specific eelgrass survey at Block Island (CoastalVision and CR. Environmental 2010), and data obtained from the RI Ocean SAMP program courtesy of Dr. John King (URI). The broad nature of the side scan sonar surveys conducted for the Project demonstrate the variable nature of the substrate, but also show that similar substrate conditions occur in different portions of the Project.

Results of the Project-specific geophysical surveys showed that there are three basic substrate conditions within the greater Project Area – silty sand, sand, and cobble or rocky substrate (OSI 2012a and 2012b). Smooth sandy sediments (Figure 2), with a proportion of silt, are widespread, particularly in the reach between Block Island and the mainland and into Narragansett Bay, and also in portions of the APE (Figure 1; adapted from OSI 2012a and 2012b). In more physically dynamic areas, such as portions of the APE, along the Export Cable and the mid-point of the BITS route, bottom currents create sand waves where coarser sediments (e.g., gravel) occur on the exposed side of the wave (Figure 3). Nearshore areas and portions of the Project Area southeast of Block Island show evidence of glacially-deposited material. Hard substrate including cobble and boulders is evident in these areas, but is typically limited to relatively small patches (a linear extent of up to about 100-200 ft [30 to 61 m]) or simply a scattering throughout the sand matrix (Figure 4). There was no evidence of large expanses of boulders and no evidence of exposed bedrock. In general, the substrates exhibited some gradient among these three basic types.

Substrate conditions observed in the geophysical surveys (Figures 5 and 6) are summarized in Table 1. Sediment grain size was estimated visually from side scan sonar images and inspection of vibracore samples. REMOTS® sampling (in which a camera is inserted vertically into the substrate to collect vertical images of the near surface conditions) during planning phases of the Project was conducted along the originally proposed export and Inter-Array cable areas (CoastalVision and Germano 2010). Sediment texture, as well as benthic community information, was interpreted from these images (Table 2). Granular substrate ranged from silt to gravel and was primarily classified as mobile sand or washed gravel. CoastalVision and Germano (2010) concluded that areas of Rhode Island Sound shallower than 100 ft (30 m) were dominated by dynamic deposits of sand and gravel while silt and sand dominated deeper areas. Geophysical surveys along the transmission route corridors and the APE confirmed these conclusions (OSI 2012a and b).

The proposed BITS route was modified to avoid the Point Judith Shoal as a result of observations made during the REMOTS® survey. Other portions of the route are reasonably well represented by the REMOTS® survey. In the open water between Point Judith Shoal and Block Island, CoastalVision and Germano (2010) classified the substrate as silt/clay and very fine sand, consistent with observations by OSI (2012 – BITS). North of the Point Judith Shoal to the proposed BITS Alternative 1 landing at the Narragansett Town Beach, CoastalVision and Germano (2010) classified the substrate as primarily silt/clay until it neared shore where fine sand to very fine sand predominated, again, consistent with the later findings during the geophysical survey for both the primary and alternative BITS routes. Characteristic sediment conditions observed along the BITS route are depicted in Figure 7 (from CoastalVision and Germano 2010).

Data from the RI Ocean SAMP from the area south of Block Island provides some insight into actual grain size distribution. In the RI Ocean SAMP program, sediments collected in the vicinity of the BIWF ranged from predominantly medium sand to predominantly medium-to-coarse sand, as shown in Figure 8 (from CoastalVision and Germano 2010). Other portions of the RI Ocean SAMP area reflected the variability expected in an area whose sediments were glacially deposited. Sediments in the RI Ocean SAMP area near Block Island included a mosaic of sediment textures where the proportion of silt, fine sand, medium sand, coarse sand, and very coarse sand varied over short distances. In addition, LaFrance et al. (2010) found that in some areas sediment sampling was impossible because of the presence of cobble and boulders.

In addition, eelgrass beds have been identified near the Block Island Export Cable and BITS landfall as well as in the vicinity of the BITS Alternative 2 landfall at the URI Bay Campus. Eelgrass beds in both locations are outside the BITS corridor. This resource is discussed in more detail in Section 2.2.3.

2.2 Biological Resources

Discussion of the habitat functions and the benthic resources expected to occur in association with each substrate type is provided in the following sections.

2.2.1 Soft Substrate

Benthic infauna in Block Island and Rhode Island Sounds has been examined intermittently over the last seventy years (Zajac 2009). Comparing results from studies several decades apart, Steimle (1982) concluded that the benthic community was relatively stable in Block Island Sound and this observation was reconfirmed by the Environmental Monitoring and Assessment Program (EMAP) program in the 1990s (Zajac 2009). Each of these studies found that the surface-swelling, tube mat-forming ampeliscid amphipods (*Ampelisca agassizi*) dominated in the finest sediments with the nut clam (*Nucula*) co-dominating in some cases. Other amphipod species (e.g., *Byblis serrata* and haustorids) and polychaetes (such as *Aricidea,* maldanids, nephtyids, and spionids) dominated in coarser sands. Bivalves such as *Mytilus edulis* (blue mussel) and *Arctica islandica* (ocean quahog) were also present. Steimle (1982) reported a rich fauna of 224 species throughout Block Island Sound.

Battelle (2003) sampled the benthos in the vicinity of proposed and active dredged material disposal sites in Rhode Island Sound about 10 miles (16 km) northeast of the Project Area off the mouth of Narragansett Bay. The disposal site area supported somewhat higher abundances (514 to 2549 individuals per 0.4 ft^2 [0.04 m^2] Young-modified van Veen grab) and species richness (44 to 75 species per grab) than earlier surveys, possibly related to the fact that Battelle used a finer mesh sieve (0.5 mm-mesh compared to the 1.0 mm-mesh used by other studies), although differences in sediment grain size may also be a factor. Benthic fauna at the western proposed disposal site was dominated by *Ampelisca* and *Nucula*, but abundances of a number of other amphipod, mollusk, and polychaete species were also relatively high. The authors concluded that benthic infaunal communities in Rhode Island Sound are similar over a scale of tens of kilometers.

Observations of infauna during the RI Ocean SAMP studies were similar to that previously reported (LaFrance et al. 2010). Sampling took place south of Block Island, including the area proposed for the BIWF; results for the RI Ocean SAMP Block Island survey area are summarized in Table 3 and Figure 9. The benthos was dominated by amphipods, particularly the surface oriented tube-dwelling ampeliscids. Species richness (number of taxa) and total abundance was variable and appeared to be related to such physical factors as sediment grain size, water depth, and exposure or bottom currents. Within individual stations, species richness ranged from 5 to 27 taxa and abundance ranged from 12 to 1541 individuals per grab (0.5 ft^2]0.05 m^2] Smith McIntyre grab). In the finer grained sediments (silty sand or fine to medium sand), one or two species usually comprised more than 70% of the total abundance, an indication of low species diversity, typically considered a trait of a habitat experiencing regular disturbance. The amphipods *Ampelisca* and *Byblis* dominated at most of these stations. Where sediments were coarser, there were usually more dominant species (four or five), suggesting higher species diversity and potentially more stability in the community. While amphipods were often among the dominants at these stations, in most cases burrowing polychaetes and occasionally mollusks were the most abundant species. Tube-dwelling amphipods such as *Ampelisca* form dense mats that can improve habitat stability by binding the surface sediments, although this also reduces access to the underlying sediment. Often other benthic fauna reside within the mats themselves.

The general consistency of the RI Ocean SAMP Block Island area samples with previous surveys in various areas of Block Island and Rhode Island Sounds indicates that the RI Ocean SAMP data are applicable to soft substrates in the BIWF and BITS Project Area as well. Given the broad similarities observed among the benthic surveys that have taken place historically in Block Island and Rhode Island Sounds, it is reasonable to assume that the recent data from the RI Ocean SAMP program can be used to describe the benthic community in various portions of the BIWF and BITS Project Areas (Table 4; Figures 5, 6, and 9).

Rhoads and Boyer (1982) hypothesized that recolonization of fine-grained sediments by infauna follows a predictable pattern after a major seafloor disturbance. They theorized that the pattern of recolonization was based on the appearance of species groups by functional types. Pioneering species (i.e., Stage I) are small, surface-dwelling species characterized by high abundances and reproductive rates. Stage I species may appear within days of the disturbance. They feed at or near the substrate surface and can change the substrate physically by constructing tubes. In the absence of further disturbance, species that reside deeper in the substrate appear. Stage II species burrow in the near-surface sediments and the mature Stage III species reside deep in the substrate oxygenating the deeper sediments and recycling nutrients with their burrowing activities. Stage II and III species tend to be larger in body size and lower in abundance and reproductive rate than Stage I species. In dynamic areas like much of the Project Area, it is likely that some physical disturbances only affect the substrate surface. As a result, there may be secondary succession where Stage I species occur simultaneously with Stage III species, as was observed in some portions of the Export Cable and BITS route (Table 4).

In order to support the alternative landfall design – a short HDD connecting to an excavated trench on the beach, with the jet plow landing directly on the beach, Deepwater Wind plans to conduct certain intertidal surveys; however, no such surveys have been conducted yet. In order to characterize and evaluate impacts on intertidal resources, Deepwater Wind plans to conduct qualitative and quantitative biological surveys at each potential landfall. Along a transect at each landfall, descriptive and photographic information will be recorded. Benthic sampling will be conducted to characterize infauna and shellfish resources. The surveys are planned for a period of spring tide to ensure that shallow subtidal resources can be readily evaluated. Results will be a provided as a supplement to this report.

2.2.2 Hard Substrate

Hard substrate (cobble and boulders) has been reported in several portions of the Project Area, specifically - near each of the landfalls and in the southwestern portion of the BIWF APE. During a reconnaissance survey near the Narragansett landfall, CoastalVision and CR Environmental (2010) reported a predominantly sand bottom with patches of cobble and boulders. In this area, the hard substrate supported northern coral, sponges, sea stars, and some kelp. The proposed BITS Alternative 1 route, reaching landfall at the Narragansett Town Beach, was refined to avoid crossing directly through these patches; a side scan sonar survey showed that while hard substrate exists at the southern edge of the 984-ft (300-m) corridor, the 200-ft (61-m)wide centerline corridor avoids rock (OSI 2010b). OSI (2010b) reported no hard substrate near shore at the BITS Alternative 2 lands at the URI Bay Campus.

CoastalVision and CR Environmental (2010) recommended moving the Block Island landfall north to avoid an area of cobble and boulders that supported dense patches of red and brown algae as well as to increase the distance from the eelgrass bed. Deepwater Wind realigned the route based on the recommendation to avoid these areas of concern as is evident in the results of the side scan sonar surveys for the Export Cable and BITS routes (OSI 2010a and 2010b).

A detailed side scan sonar survey revealed the presence of patches of cobble and boulders in the southwest portion of the APE (beyond the WTG and Inter-Array cable locations) and north of the Export Cable route (OSI 2010a). These areas were examined using video surveillance to characterize benthic resources (Appendix A to this report). Distribution of hard substrate, where it occurred, was highly variable (Table 5). Hard substrate rarely predominated, usually occurring as scattered features within a sand matrix. Encrusting and erect or foliose red algae were the predominant plant forms. Cobbles and boulders supported typical "fouling" organisms such as sponges, hydroids, the northern stony coral, the northern red anemone and tube-dwelling polychaetes. Barnacles, mussels, and blood stars were also associated with hard substrate.

2.2.3 Eelgrass

Eelgrass (*Zostera marina*) is the only species of seagrass documented in the Project Area. CoastalVision and CR Environmental (2010) documented the existence of an eelgrass bed in the southern margin of Old Harbor, Block Island, approximately 2,000 ft (610 m) southeast of the original Block Island landfall, consistent with RIGIS records (Figure 10). Deepwater Wind relocated the Block Island landfall to increase the distance from this eelgrass bed. No eelgrass has been reported in the vicinity of the proposed BITS Alternative 1 Narragansett Town Beach landfall, but there is a suspected bed in the vicinity of the BITS Alternative 2 landfall at the URI Bay Campus (Figure 11). At the point that the BITS Alternative 2 landfall site was determined, it was too late in the season to accurately delineate eelgrass beds per CRMC requirements (July 1-September 15; CRMC 2007); an appropriate survey will be undertaken in summer 2012 when biomass is at its peak. Results will be a provided in a supplemental report expected to be filed in September 2012.

Typically, eelgrass occurs in nearshore areas. Generally the maximum depth is controlled by light penetration, but is also affected by hydrodynamics, nutrients (controlling phytoplankton and macroalgae growth, thereby affecting water clarity), and substrate conditions, among other factors (Thayer et al. 1984). Eelgrass may occur in a wide range of substrates, including silt, sand, gravel, and cobble. The nature of the substrate, coupled with the local hydrodynamics, affects the pattern of growth. In fine-grained sediment under low to moderate energy conditions, eelgrass may form an extensive bed. In coarser substrates and higher energy environments, eelgrass is more likely to be patchy and sparse.

In New England, the primary growing season for eelgrass is about May through September or October. The plants reproduce both sexually and asexually (through adventitious root growth) during this period. Shoot growth is greatest during this period, although it may continue at low levels during the colder months. Leaves are shed throughout the growing season but most prominently in the fall. Overwintering plants exhibit greatly reduced aboveground material.

Eelgrass beds provide several important functions and values to the ecosystem, including sediment stabilization, sediment/toxicant retention, nutrient removal/transformation, production export, aquatic diversity/abundance, and wildlife diversity/abundance (Adamus et al. 1987). In addition, eelgrass beds have been documented as providing a nursery function for finfish (Thayer et al. 1984). In this role, it provides both refuge and forage for juvenile fish. Because of the valuable habitat functions that eelgrass beds provide, Deepwater Wind is committed to avoiding direct and indirect impacts to this resource.

3.0 Potential Impacts

Construction, operation, and decommissioning of the BIWF and BITS will introduce several types of impact-producing factors into the marine environment. The sources and types of effects are summarized for each Project component on Table 6 and are presented in expected chronological order.

3.1 Construction

Construction of the components of the BIWF and BITS will cause several types of impacts to benthic resources. Quantifiable direct impacts will be incurred in the footprints of the cables and the WTGs. Use of jack-up barges and anchored vessels for WTG installation, anchored vessels for cable crossings, and placement of concrete mats over active cables will cause additional direct impacts. Indirect impacts can arise as a result of suspension and redeposition of sediments or from anchor cables that sweep the substrate.

3.1.1 Cable Installation – Jet Plowing and HDD Installation

Soft Substrate Habitats

Installation of the Inter-Array, export, and BITS cables by jet plow will disturb a 5-foot (1.5 m) wide swath of the substrate to a depth of up to about 8 ft (2.4 m) along the length of each cable section. The areas directly affected by the trenching are shown in Table 7. In these areas, the sediment will be removed from the substrate and any infaunal organisms will be suspended into the water column. It is unlikely that many organisms affected this way will survive so there will be a temporary loss of benthic production. It is common, however, for scavengers (fish and epibenthic crustaceans) to be attracted to areas of disturbance so at least some of this benthic production will go directly into the food web. Dead organisms not consumed will eventually be broken down chemically and return to the ecosystem through the nutrient cycle.

In addition to the direct impact in the area trenched, the plow skids or wheels spanning the trench will likely crush surface-dwelling benthic organisms along the length of each cable route. As discussed in the following paragraph on re-deposition of suspended sediments, this effect will generally lie within the area experiencing 10 mm (0.4 inch) of sedimentation.

According to suspended sediment modeling conducted by RPS ASA (2012), most material that has been suspended by the jet plow will be redeposited in the immediate area (Table 7). RPS ASA (2012) predicted that along the Inter-Array cable route, deposition exceeding 1 mm (0.04 inch) would be confined to the area within 130 ft (40 m) on either side of the cable, including the trench (Figure 12a). Sediments along the Export Cable in the vicinity of MP 2.0-2.8 contain a higher proportion of silt-clay material so the maximum extent of deposition exceeding 0.04 inch (1 mm) is predicted to be up to 250 ft (75 m) on either side of the trench in this area (Figure 12b). At the Block Island cofferdam site, the 0.04-in (1-mm) deposition footprint would be limited to an area within 175 ft (50 m) on either side of the cofferdam (Figure 13a). Along both of the BITS Alternative cable routes, RPS ASA (2012) predicted that there would be a sedimentation footprint $\geq$ 0.04 in (1 mm) extending up to 330 ft (100 m) on either side of the cable (Figures 12 c and d). At the BITS Alternative 1 Narragansett Beach landfall, the sedimentation footprint $\geq$ 0.04 in ($\geq$1 mm) could extend up to 190 ft (58 m) from the cofferdam (Figure 13 b). At the BITS Alternative 2 URI Bay Campus landfall, the sedimentation footprint $\geq$0.04 in ($\geq$1 mm) could extend up to 130 ft (40 m) from the cofferdam (Figure 13c). Maurer et al. (1986) found that several species of marine benthic infauna (the clam *Mercenaria mercenaria*, the amphipod *Parahaustorius* longimerus, and the polychaetes *Scoloplos fragilis* and *Nereis succinea*) exhibited little to no mortality when buried under up to 3 in (8 cm) of various types of sediment (from predominantly silt-clay to pure sand). While these species do not dominate in the Project Area, this is suggestive that burial with 0.4 in (10 mm) will have little effect on the benthos near the trench.

Cable installation will be conducted using a dynamic positioning vessel so there will generally be no anchoring necessary. The BITS route crosses two existing cables and at these locations the BITS cable will be laid on the surface. In these areas, the lay vessel will have to anchor so that concrete matting can be installed between the cables and over the BITS cable. Anchoring would temporarily disturb about 168 ft^2 (16 m^2; Table 8) and the mats would cover 0.07 to 0.33 acre (0.03 to 0.13 hectare) of soft substrate, converting it to artificial hard substrate. Anchoring and placement of concrete mats are also expected to be required along up to 1 percent of the cable routes where burial of the cable would be less than 4 ft (1.2 m) because of subsurface conditions. This could affect up to 0.1 acre (0.04 hectare) along the Inter-Array Cable, 0.3 acre (0.12 hectare) along the Export Cable, and 1.00 to 1.21 acres (0.4 to 0.49 hectare) along the BITS route (depending on the alternative). Areas disturbed by anchoring are expected to recover quickly to predisturbance physical conditions and given the small areas affected, biological recovery would also be rapid. Fouling organisms such as those observed in the hardbottom video survey (Appendix A) are likely to colonize the concrete mats.

Connections to the terrestrial portion of the Export Cable and BITS Cable will be accomplished either through a long-distance HDD to a temporary offshore cofferdam or by a short-distance HDD with a jet plow launched directly from the beach at MHW. If the long-distance HDD method is used, a temporary cofferdam about 500 ft^2 (47 m^2) in size will be constructed and excavated to a depth of 10 ft (3.3 m) in an offshore location to contain sediments and drilling muds released during excavation and drilling. This activity will require use of a stationary jackup barge held in place with spuds inserted into the substrate affecting an area of up to 452 ft^2 (42 m^2) per cofferdam. Sediment removed will be deposited in an approved disposal area; benthic resources in the footprint of the cofferdam will therefore be removed from the ecosystem. In addition, excavation of the cofferdam will allow the resuspension of some sediment into the water column. It is expected that most of this material will settle rapidly resulting in deposition in the vicinity of each cofferdam area (Table 7). Upon completion of the cable installation, the cofferdam will be backfilled using material with similar properties to the surrounding substrate (e.g., grain size distribution) and the sheet piling will be removed. Once the disturbed area has stabilized physically, benthic recolonization will occur.

If the short-distance HDD and jet plow landfall method is used, sediment will be dispersed adjacent to the trench on the beach in the intertidal zone. Much of the sand will be placed back into the trench following construction. Organisms jet plowed out of the sediment will be exposed or buried. Exposed organisms would be subject to predation by scavengers (e.g., gulls, terns, raccoons). Buried organisms may be unable to survive. It is likely that the beach contour would return naturally to its pre-construction contour within several tidal cycles of the installation activity.

There is substantial evidence from both the REMOTS® and the geophysical surveys that the physical environment in the vicinity of the Project is dynamic. The presence of sand waves throughout much of the area is a strong indicator that bottom currents move surface sediments routinely. This action is enhanced during storm events. The benthic fauna predominant in the Project Area comprises species that are adapted to this type of physical condition (CRMC 2010) and are likely to be able to withstand small amounts of sedimentation. The areas where deposition associated with construction activities is ≥0.4 in (≥ 10 mm), and which include the footprint of the trenches and plow skids, represent the maximum benthic impacts.

Benthic impacts along the trenches are expected to be temporary in nature except where concrete matting is required. Once the trenches have been refilled, natural colonization will begin. Rhoads et al. (1978) found that organisms colonized azoic sediments in 10 to 29 days in Long Island Sound. Dredged material at the Western Long Island Sound disposal site was colonized in 1 to 2 weeks (Murray and Saffert 1999). Table 9 shows results of studies tracking the recovery of disturbed sediments to late-stage benthic communities. Recovery to a mature community took from several months to as long as 5 years depending on the nature of the disturbance and the baseline characteristics of the habitat. Recolonization generally occurs as a result of both larval settlement and migration of individuals from nearby areas. Given the narrowness of the impact areas (350 to 660 ft [100 to 200 m]) and the widespread distribution of dominant species in Block Island and Rhode Island Sounds, it is reasonable to suggest that either mechanism could occur here.

Hard Substrate Habitats

During initial consultations with state and federal agencies, there was a concern that sediments suspended during the installation of the cables would be transported into areas of hard substrate and potentially smother the fouling community. While there may be occasional cobble or boulders within the 984-ft (300-m) cable corridors that could be affected this way, no extensive areas of hard substrate have been identified near the cable routes. It is concluded, therefore, that hard substrate benthic communities will not be impacted by installation of the cables.

Eelgrass Habitats

Deepwater Wind's proposed landfall methodologies avoid the potential for direct impact to eelgrass habitat at the Block Island or BITS Alternative 2 URI Bay Campus landfalls. For the long-distance HDD landfall alternative, construction of an offshore cofferdam and performance of HDD operations off within the confines of this cofferdam will help to contain sediments released into the water column and prevent their transport into nearby eelgrass beds. The eelgrass bed nearest the Block Island landfall is more than 2000 ft (600 m) away from the proposed offshore cofferdam area or nearshore jet plow activity, well beyond the area where sediment transport modeling has indicated deposition of even 0.04 in (1 mm) is likely to occur. The boundaries of the eelgrass bed near the BITS Alternative 2 URI Bay Campus landfall has not yet been confirmed (surveys are planned for the summer of 2012). The temporary cofferdam is proposed to be located up to 1800ft (549 m) offshore; however, and modeling predicted that sediment deposition would likely be limited to an area within 130 ft (40 m) of the cofferdam. It is not likely, therefore, that sediment transported from the cofferdam excavation and backfilling activities would reach the eelgrass bed in sufficient amount to cause a discernible effect. For the short-distance HDD and jet plow landfall alternative, proposed on Block Island and at the Narragansett Town Beach, the avoidance of any in-water excavation will limit any sediment transport to that material suspended by the jet plow.

3.1.2 WTG and Foundation Installation

Soft Substrate Community

Benthic fauna in the footprint of the WTG foundations will be crushed during the installation. Pile driving will push any organisms in this footprint more deeply into the substrate, removing them from the ecosystem even as a contribution to the detrital or nutrient cycles. This will affect a 0.35 acre (0.14 hectare) area of the benthos in total.

In addition to the direct loss of benthos in the footprint of the foundations, use of a derrick barge will also crush the benthos where the eight anchors are inserted into the substrate. Under normal conditions, the derrick barge would anchor once per foundation, but Deepwater Wind has conservatively assumed that anchoring could occur up to three times per foundation, resulting in an estimated total anchor footprint of 0.09 acre (0.04 hectare; Table 8). Based on the depth of the water, it has been estimated that some anchor cables will be as long as 4500 ft (1370 m) and this calculation was used to estimate the dimensions of the APE. The weight of the anchor cable will cause it to drape through the water column and close to the anchors the cable may rest on the seafloor, potentially sweeping across the substrate in respond to bottom currents. Where cable sweep occurs in soft substrates the top few inches of the sediment may be disturbed. Tube-dwelling amphipods and polychaetes, solitary anemones, and other larger infauna are probably the most susceptible to harm from anchor cable sweep in soft sediments and are likely to be killed. While disturbed sediments may be released into the water column, the action of the cable sweep is not as forceful as during jet plowing so it is unlikely that resuspended sediments would be transported very far from the source. After construction is complete, the derrick barge will be removed from the area. The substrate disturbed by the anchors will be allowed to fill in naturally and ultimately will be recolonized by benthic fauna as was described for the cable routes.

Installation of the WTGs themselves will be supported by two jackup barges (the transportation barge and the installation barge) both held in place with spuds. The barges will remain in place at a separate location for each WTG and Deepwater Wind has assumed that each barge would be repositioned once at each WTG (a total of 10 anchor locations for each barge). The substrate will be directly impacted by the spuds for an estimated impact area of 0.76 acre (0.31 hectare; Table 8).

There is limited information available about recovery of soft substrate benthic communities from anchoring impacts and it focuses on the effects of small boat anchoring. One study noted that small anchors (44 pounds [20 kg]) could severely damage organisms such as clams leaving them more vulnerable to predation (Backhurst and Cole 2000). Backhurst and Cole (2000) also found that repeated anchoring in an area (which affected 20 % of their study area) caused localized impacts but did not change the overall characteristics of the infaunal community compared to undamaged areas although anchor scars were evident for as long as three months. Anchoring of the derrick barge will be considerably more severe than with a small anchor, but these impacts will occur in a small portion of the APE and only for a short-duration during the installation of the jacket foundations.

Hard Bottom Community

Substrate conditions were an important consideration during siting of the WTGs because of the effect of substrate on constructability. Hard bottom was avoided. Therefore, there will be no direct impacts to hard bottom benthos in the WTG footprint.

If anchoring of the derrick barge is required in the southwestern portion of the APE where some hard bottom habitat occurs, then it is likely that either the anchors themselves or the anchor cables will affect this resource. The main damage from anchoring in hard substrate areas will likely be attributable to the direct impact of the anchor on the substrate, an action that will crush attached epifauna and further imbed rocks and cobble into the sediment. Organisms likely to be affected include sponges, corals, anemones, and hydroids as well as some motile fauna such as crustaceans and sea stars. These effects will be limited in spatial extent therefore it will be unlikely to affect the general population. Anchor cables may sweep across hard substrate when the cable drags across the seafloor. Deepwater Wind is working to design an anchor configuration that will minimize impacts to these hard substrate areas.

3.2 Operation of the Wind Farm and Transmission Cables

Operation of the wind farm and associated cables will be relatively benign in terms of its ability to impact benthos. There are three potential sources of impacts: introduction of a physical structure that may be colonized by epifaunal organisms (adding some habitat and community diversity to the immediate Project Area), potential increase in vessel activity in the area thereby increasing the potential for anchoring impacts and accidental discharges, and potential release of electromagnetic fields (EMF) into the overlying substrate and water column.

After the steel foundations for the WTGs have been in place for an undefined period, it is likely that microbial organisms will settle on them creating a biofilm that makes the steel more attractive for settlement of macrofauna and algae. It is likely that the entire length of each leg as well as the linear braces will be colonized by similar organisms as those observed in the hard bottom video survey. Colonization of structures has been observed in European wind farm structures (Michel et al. 2007). In the likely event that this occurs, each WTG will therefore function as an artificial reef. The 20 legs in total (each with a 42-inch [107-cm] diameter) would provide a surface area on the order of 0.4 acre (0.2 hectare) that could be colonized. While colonization of the physical structure would not replace the soft substrate that is lost in-kind, it would restore some benthic production to the immediate area. The fouling community offers a different type of habitat function to the ecosystem for two reasons because the organisms that might grow on the structure are different than those that would live within the substrate. Thus, species that feed on benthic infauna may not be able to switch to consumption of fouling organisms. In addition, species that feed on infauna tend to occupy bottom waters; they are less likely to venture up into the water column and would, therefore, have limited access to the organisms growing on the structures. Pelagic species may graze on the fouling community, however.

Any routine maintenance of the WTGs will be conducted using anchored vessels. Anchoring will occur in the immediate vicinity of the WTGs. As described for construction, anchoring will disturb the substrate and associated benthic resources. It is likely that after the anchor is removed natural processes will allow the substrate to recover to its prior condition and benthic organisms will recolonize the disturbed area. Extensive maintenance (e.g., replacement of major components of a WTG) would require a stable work platform and may require the use of a jackup barge. Impacts to the seafloor would be similar to those described for construction and recovery of the benthic community would be expected.

Operating AC transmission cables emit EMF. Modeling of the Inter-Array, Export, and BITS cables indicated that, at the maximum predicted load and assuming no sheathing around the cable, the maximum magnetic field at the seafloor directly above the cable will be about 22.1 milligauss and will attenuate with distance both vertically and horizontally (Exponent 2012). Little is known about whether benthic invertebrates are affected by EMF and, if they are, what their responses would be (Normandeau et al. 2011) although the predicted level at the seafloor is less than half the theoretical detection level for organisms (e.g., fish and invertebrates) with magnetite-based sensory systems (Exponent 2012). Given that benthic infauna are typically most abundant in the uppermost 0.5 ft (0.15 m) and that Deepwater Wind plans to bury the transmission cables under 6 ft (1.8 m) of sediment, on average, most infauna would have minimal exposure to EMF from the Project’s cabling. It is unlikely therefore that EMF from the Inter-Array, Export, or BITS cables will discernibly alter the benthic community.

3.3 Decommissioning

Decommissioning will involve removal of portions of the Project components. The WTGs and foundations have a projected 25-year life span and at that point will be removed in their entirety. The transmission cables will be abandoned in place.

3.3.1 Removal of Cables

Disturbance of the seafloor during removal of cables will be minimal. At each foundation, the cable will be cut at the mud line (substrate surface) in the area where it enters the J-Tube. All cable below the mud line will be left in place. All cable above the mud line will be removed with the decommissioned foundation. This technique would minimize impacts to benthic resources.

3.3.2 Removal of WTGs and Foundations

Removal of the WTGs will be a disruptive activity in several ways. Positioning of the vessels to remove the above-substrate portions of the WTGs will have the same type of impacts described for installation. Removal of the piles below the substrate will disturb the sediments to a greater extent than installation, however. The use of an abrasive water jet cutting tool below the seafloor will liquefy and suspend sediments into the water column resulting in redeposition nearby. Once the holes created in the seafloor fill with sediments through natural processes, the disturbed area will be recolonized with native benthic species.

The sessile fouling community that is expected to have developed on the piles and support structures will be removed. This will results in a small reduction in the habitat diversity in the area, although it will actually represent a return to pre-project conditions.

4.0 Mitigation

Careful siting has enabled Deepwater Wind to avoid impacts to particularly sensitive benthic resources including hard substrate communities and eelgrass beds. The BIWF is located within the designated Rhode Island Renewable Energy Zone, thereby limiting impacts to an area that has been approved by the state as being suitable for such activities. The WTGs are planned for placement in an area of soft substrate to avoid impacts to sensitive hard substrate habitat. The BITS cable was routed into Narragansett Bay to avoid sensitive hard bottom habitat along the south shore. It was further realigned along the middle of the route to avoid hard substrate associated with the Point Judith shoal. The location of the Block Island landfall was moved north to ensure that the installation would not disturb the nearby eelgrass bed.

Deepwater Wind has selected construction techniques and turbine technologies that will avoid some potential impacts and minimize others. Specifically, the installation of the cables by jet plows will minimize the size of the trench and allow rapid return to pre-construction physical conditions. As shown in the sediment transport modeling (RPS ASA 2012), most of the sediment disturbed by the jet plow will be redeposited on or immediately adjacent to the trench within minutes of the disturbance. By using dynamic-positioning vessels for cable installation, Deepwater Wind has eliminated the majority of seafloor impacts from anchoring along these routes. At the landfalls, the use of either offshore cofferdams to contain the release of sediments into the water column, or the direct landing of the jet plow in an excavated trench on the beach will prevent deposition onto sensitive shallow water habitats such as eelgrass beds. Finally, several design factors will contribute to minimizing the strength of the EMF emitted by the cable including: use of a medium-voltage cable, the bundling of all conductors within one armored and sheathed cable, and the target depth of burial.

Deepwater Wind will require the use of an anchor barge to install the WTG foundations. Deepwater WInd is working on the design of the anchor configuration for this derrick barge with the goal of avoiding the need to anchor in the hard substrate found in the southwestern portion of the APE.

Deepwater Wind has minimized the direct impact to the sea floor by reducing the number of WTGs from 8 to 5 by using the highest capacity turbines available, reducing the footprint of the WTGs from 0.56 to 0.35 acre (0.23 to 0.14 hectare), the only portion of the project where benthic habitat will be eliminated. Although protective armoring may be required on up to 1.93 acres (0.78 hectare) along the Cable routes, these areas will be suitable for colonization by sessile benthic species characteristic of natural hard substrate communities. All other areas impacted during construction are expected to recover to their pre-project condition. Therefore, no compensatory mitigation is warranted.

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Figures

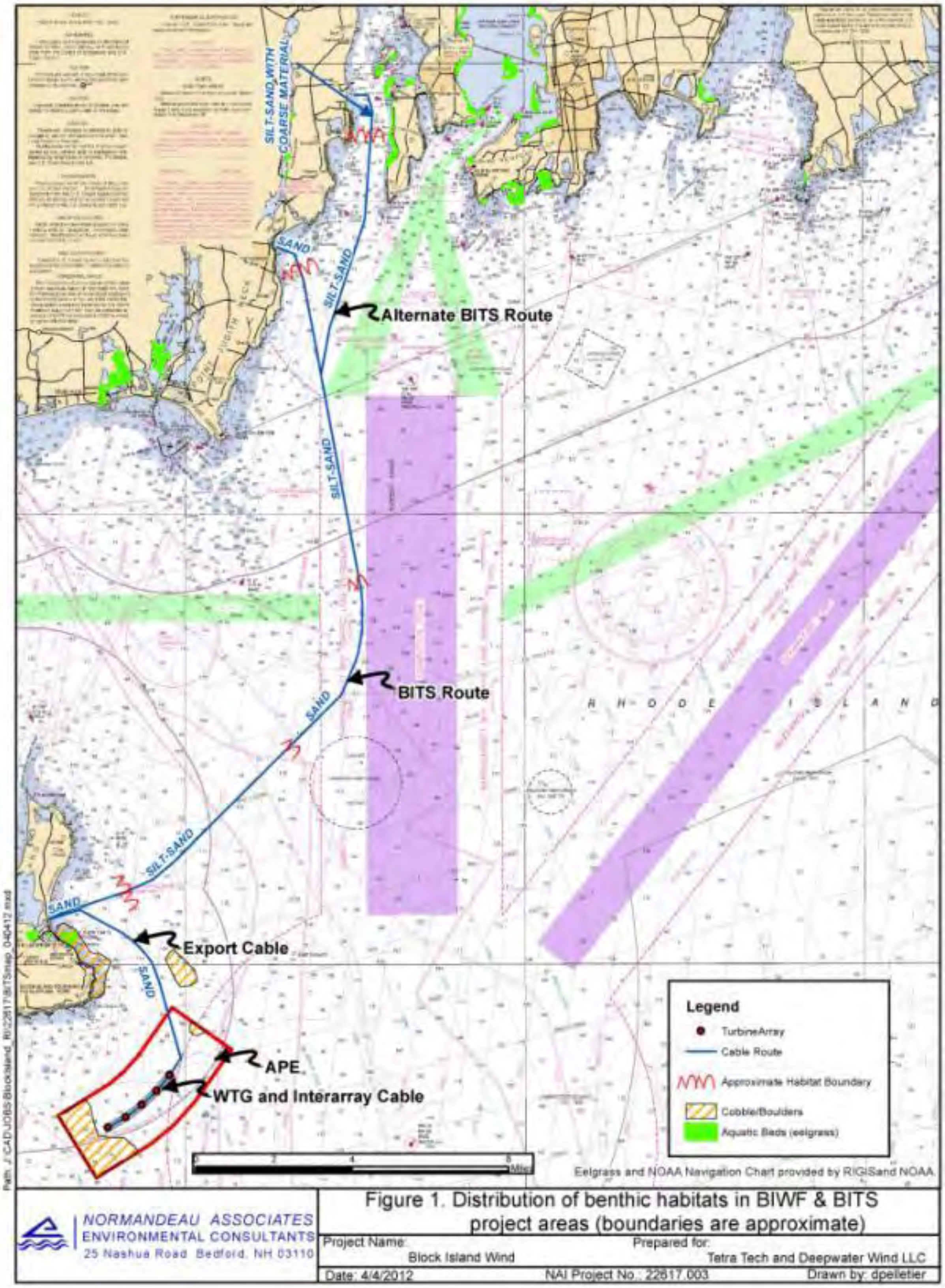


Figure 1. Location of Project components and distribution of benthic habitats.

Figure 2. Sand bottom on video transect in APE.

Figure 3. Sand wave with exposed gravel on video transect in the APE.

Figure 4. Cobble in sand matrix along video transects in APE.

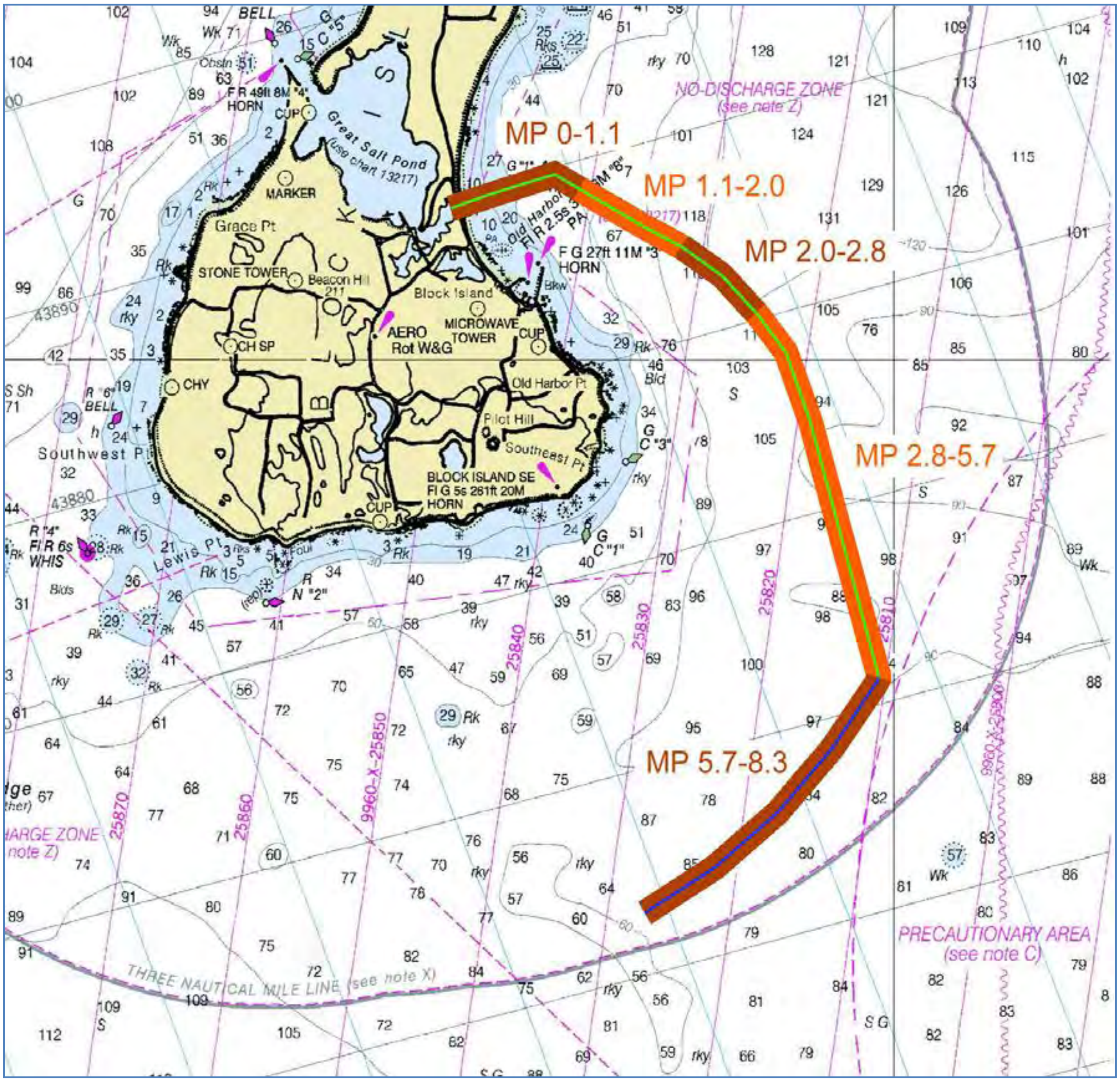


Figure 5. BIWF Export and Inter-Array Cables with mileposts.

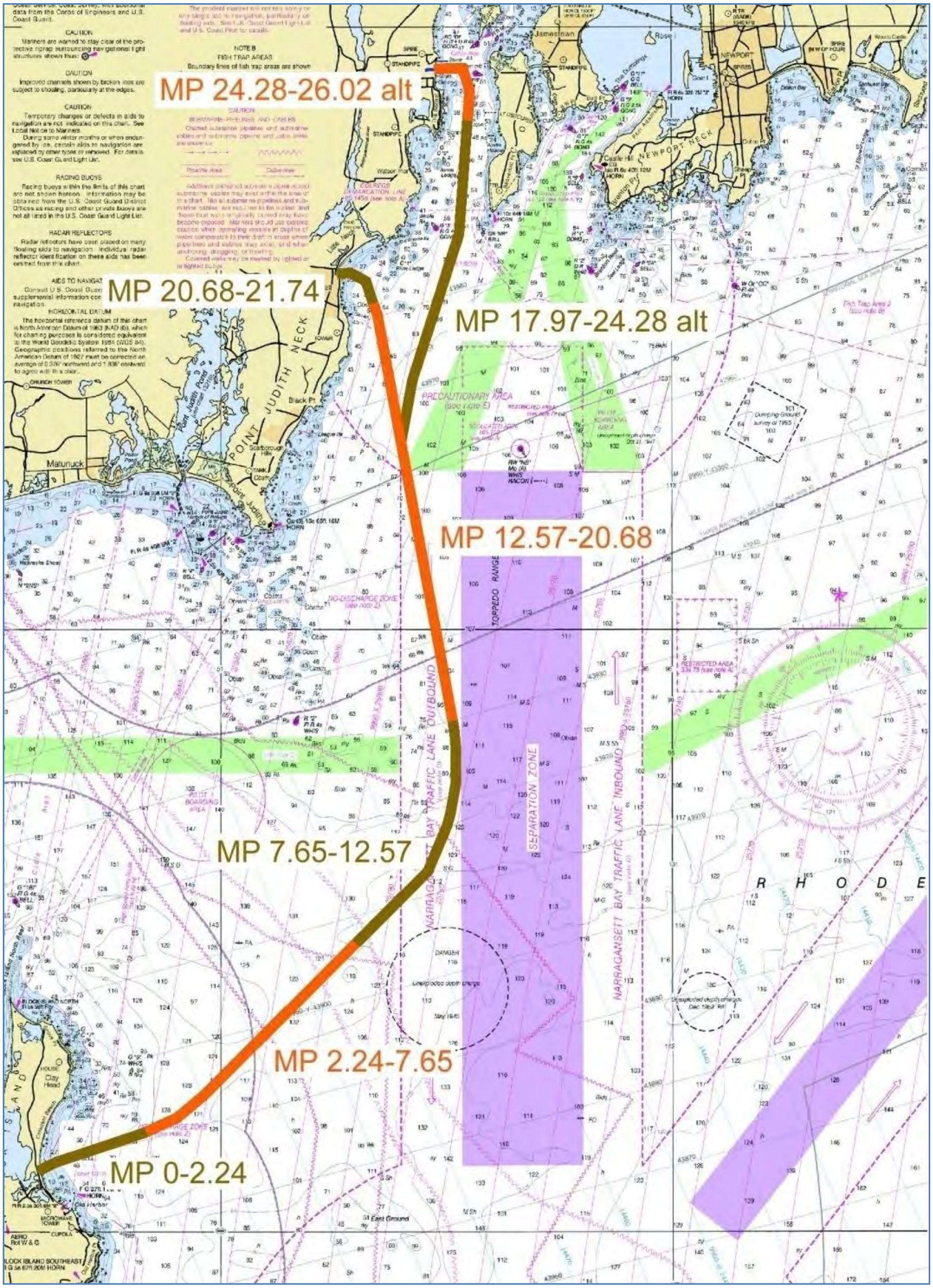


Figure 6. Proposed and alternative BITS routes with mile posts (MPs).

Narragansett Bay → Block Island

a

b

c

d

Figure 7. Sediment profile images along the BITS route, from left to right: sandy silt, sand waves, coarse sand and silty sand substrates.

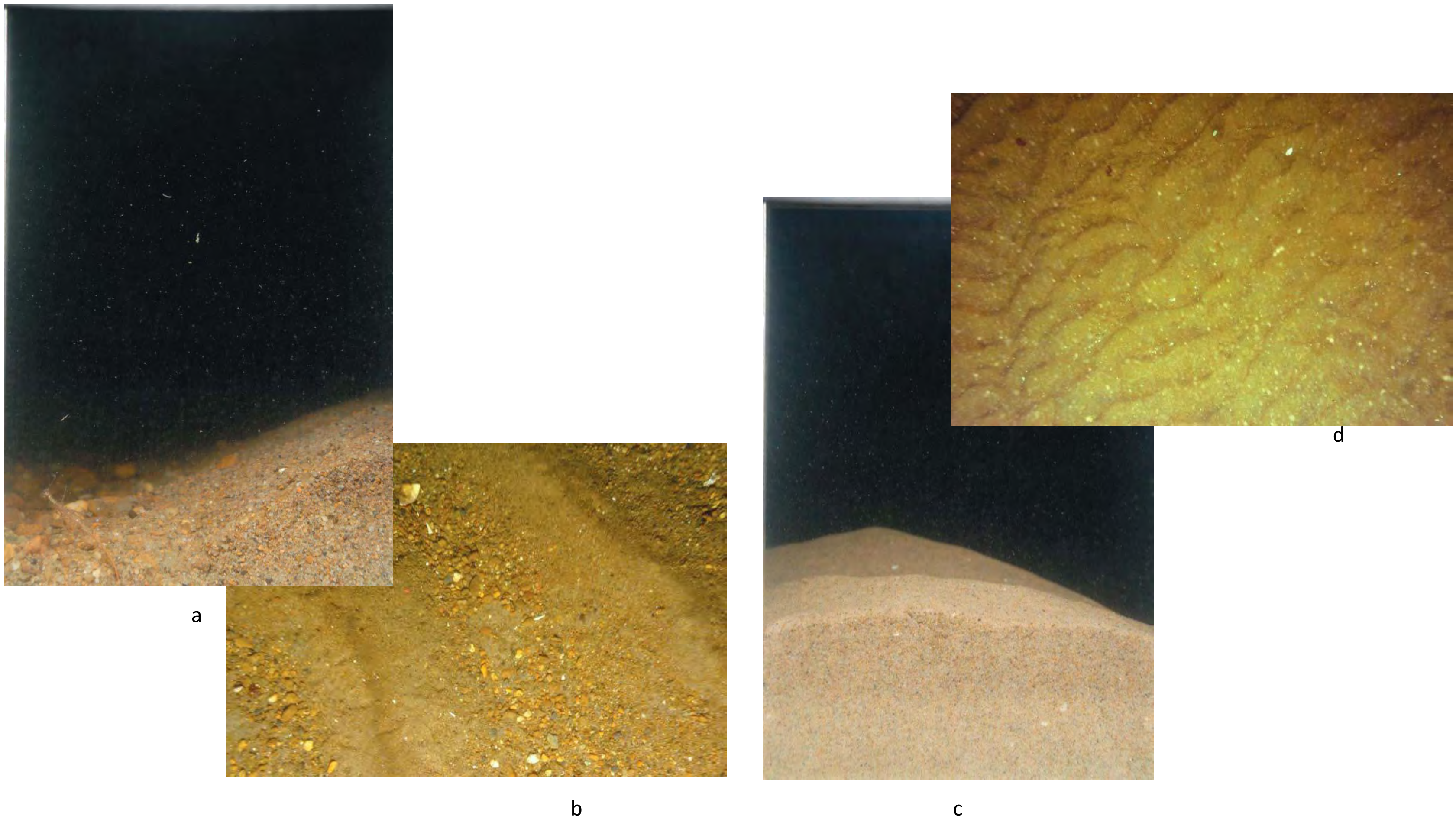


Figure 8. Sediment profile and plan-view images from the Inter-Array Cable area, from left to, right: medium-coarse sand wave and medium sand wave.

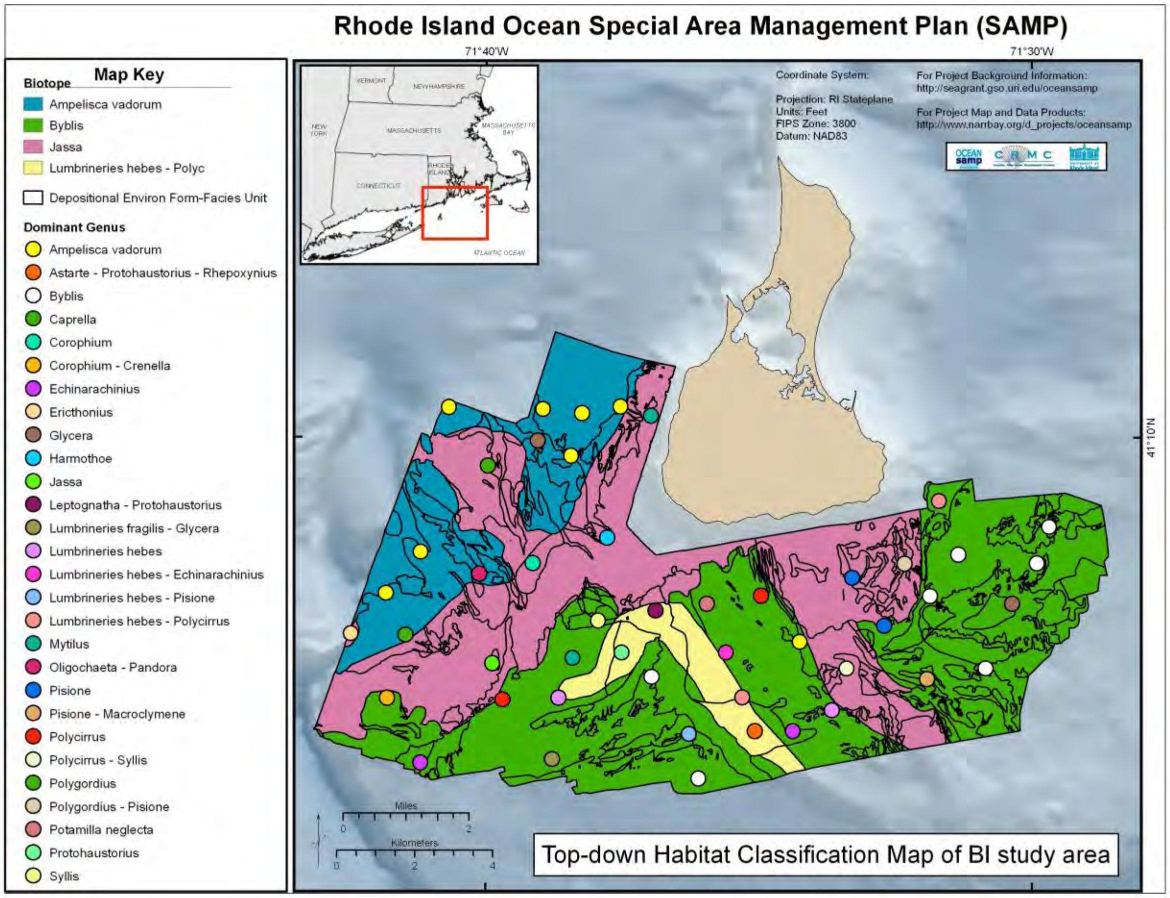


Figure 9. Distribution of major benthic infauna communities in the Block Island Ocean SAMP survey area. Source: Rhode Island Ocean SAMP 2010.

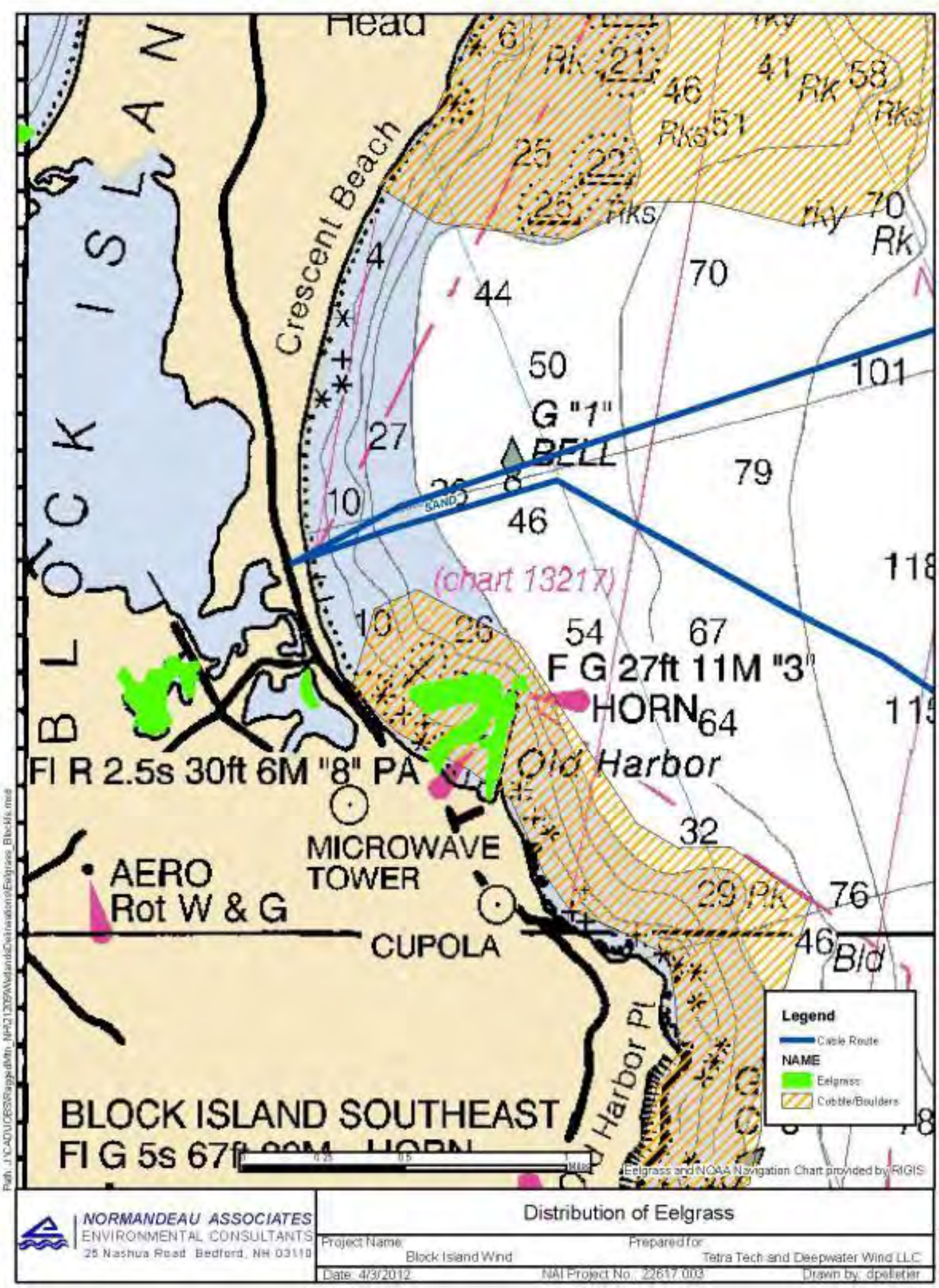


Figure 10. Distribution of eelgrass in the vicinity of the Block Island landfall.

Figure 11. Distribution of eelgrass in the vicinity of the alternative BITS landfalls.

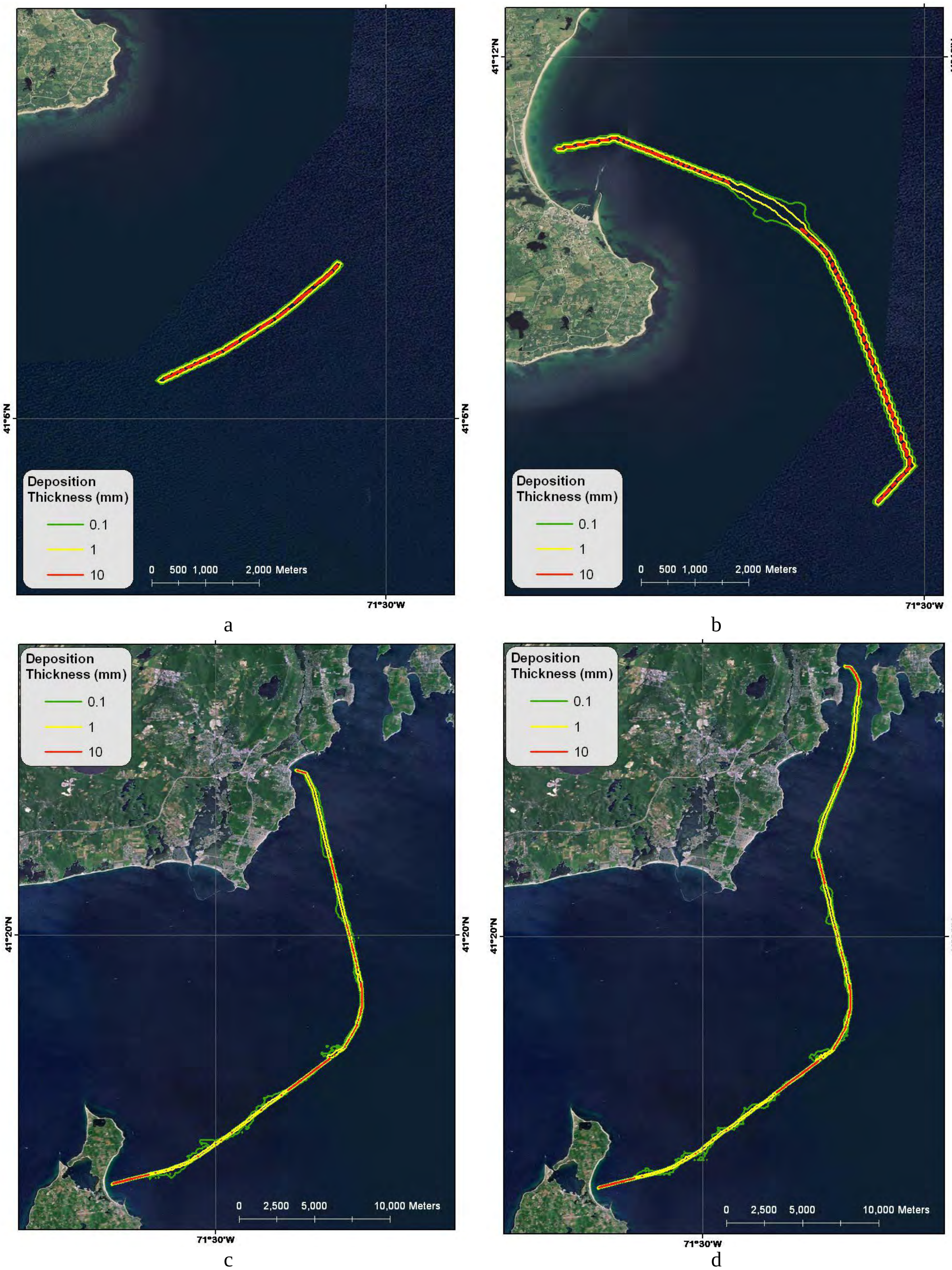
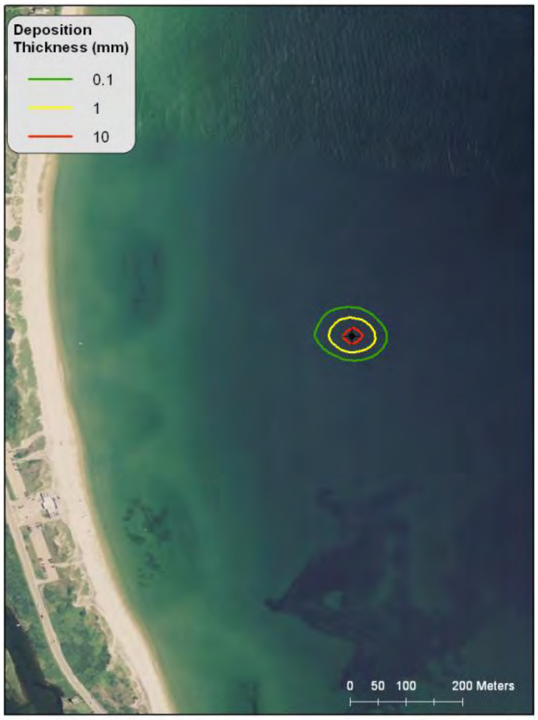
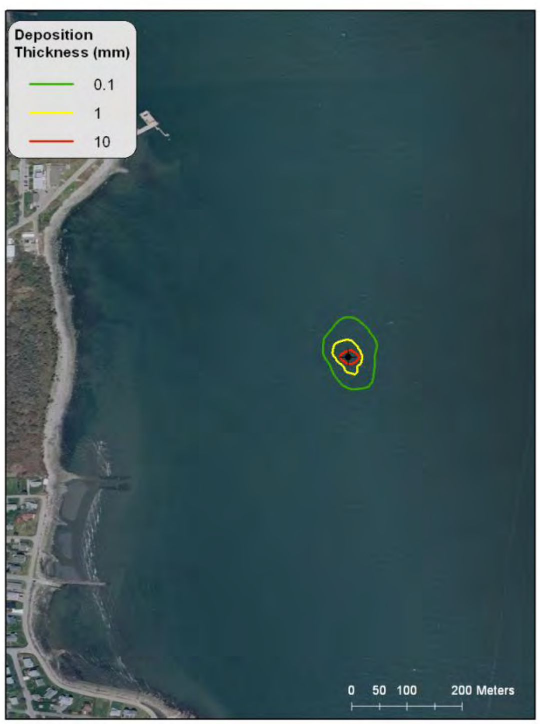


Figure 12. Predicted sediment deposition along: a. the Inter-Array Cable; b. the Export Cable; c. the proposed BITS route; and, d. the alternative BITS route. Source: RPS ASA 2012.



a

b



c

Figure 13. Predicted sediment deposition during refill of the cofferdam off landfalls at a. Block Island; b. Narragansett Town Beach; and c. URI Bay campus. Source: RPS ASA 2012.

Tables

Table 1. Substrate conditions in the Project footprint observed during geophysical investigations (source: OSI 2012a, 2012b).

Location	Water depth	Seafloor	Targets (rock and/or debris)
Block Island Wind Farm Export Cable (see Figure 5 for Mile Post [MP] locations)			
MP 0.0 – 1.1 (Sta 0+00 to 55+50)	0-56 ft; low relief on a gentle offshore slope	Primarily sand with some coarser material possible	High concentration of targets close to shore which appear to be primarily debris; moderate overall
MP 1.1-2.0 (Sta 55+50 to 105+60)	56-100 ft; rough bottom texture landward of Station 80+00, smoother bottom topography offshore	Seafloor sand and gravel with more abundant boulders landward of Sta 80+00; mainly sand with some gravel and silt offshore	Low concentration of targets
MP 2.0-2.8 (Sta 106+60 to 146+00	109-121 ft; generally smooth bottom topography	Silt-clay with sand, isolated coarse material possible	Targets low to locally moderate concentration
MP 2.8-5.7 (Sta 146+00 to 301+92)	87-115 ft; variable bottom topography	Primarily sand with gravel, some coarser material and silt possible locally	Targets low concentration with moderate patches
Inter-Array Cable (includes WTG footprint) (see Figure 5 for MP locations)			
MP 5.7-8.3 (Sta 301+92 to 438+79)	75-93 ft; variable bottom topography	Mainly sand and gravel, coarser material possible, some silt locally	Targets low concentration
BITS Alternative 1 (see Figure 6 for MP locations)			
MP 0.0-2.4 (Sta. 0+00 to 118+00)	0-116 ft; low local relief on gentle offshore slope	Primarily sand with some coarser & finer material	High concentration close to shore, low to mod overall
MP 2.4-7.65 (Sta 118+00 to 404+00)	118-129 ft; generally smooth bottom topography	Primarily silt and sand with coarser material possible.	Low concentration
MP 7.65-12.57 (sta. 404+00 to 664+00)	85-118 ft; more variable surface texture & relief; bottom slopes on either side of southern extension of Pt. Judith Shoal	Mainly sand with gravel and coarser material on shoal, sand & silt on flanks	Low to locally moderate concentration
MP 12.57-20.68 (Sta 664+00 to 1092+00)	59-103 ft, smooth topography, patches of increased bottom texture, some local relief	Mainly silt with sand, more sand & possible coarser material in shallower sections (MP 16.7-17.6)	Low to moderate concentration
MP 20.68-21.74 (Sta 1092+00 to 1147+89)	0-59 ft, gradual offshore slope	Primarily silt & sand offshore, sand & possible gravel closer to shore	Low to moderate concentration locally
BITS Alternative 2 (see Figure 6 for MP locations)			
MP 17.97-24.28 (sta. 948+93 to 1282+00)	45-99 ft; smooth bottom topography, minimal local relief	Mainly silt with some sand, coarser material possible	Low concentration
MP 24.26-26.02 (Sta 1282+00 to 1374+13)	0-48 ft, broad topographic features, steeper slopes locally	Primarily sand with silt and coarser material possible	Low –moderate to high concentration

Table 2. Summary of results from REMOTS® and plan view photographic sampling along the Export and Inter-Array Cables during initial siting (Source: CoastalVision and Germano & Associates 2010).

Location	Sediment Grain Size[a]	Benthic Habitat Type[b]
Export Cable	Silty sand – about 10% Sandy – about 80% Gravelly – about 10%	Silty sand – about 12% Mobile sand – about 62% Washed gravel – about 17% Undisturbed cobble – about 9%
Inter –Array Cable/Turbine Area	Sandy – about 44% Gravelly – about 56%	Mobile sand – about 19% Washed gravel – about 81%
APE	Sandy – about 73% Gravelly – about 18% Indeterminate – about 9%	Mobile sand – about 45% Washed gravel – about 40% Undisturbed cobble – about 15%
BITS[c]	Silt-clay – about 70% Sandy – about 30%	Soft silt – about 48% Silty sand – about 35% Mobile sand – about 14% Undisturbed cobble – about 2%

[a] as interpreted from REMOTS® images and plan view photographs

[b] **soft silt** =homogeneous muddy substrate; evidence of extensive infaunal activity (primarily polychaetes)
silty sand = fine to very fine sand with significant proportion of silt; evidence of infauna
mobile sand = fine to coarse sand with notable sand waves; some evidence of mobile epifauna (e.g., sea stars and sand dollars), burrows, and feeding pits
washed gravel = small gravel at varying densities over sediment surface; freeing of encrusting epifauna; typically in troughs between mobile sand waves
undisturbed cobble = larger-sized gravel, cobbles or boulders either continuous or, more typically, dispersed within an underlying sandy substrate; typically covered with epifauna and encrusting algae

[c] excludes the reach along the Point Judith Shoal because of later route realignment

Table 3. Summary of benthic infauna data from RI Ocean SAMP (courtesy of Dr. John King, URI).

Predominant Grain Size	Station	Number of Taxa	Total Abundance	Number of Taxa Comprising >70%	Key Taxa (in descending order of abundance)
Silty sand	7BI	23	369	1	*Ampelisca vadorum*
	17BI	22	409	6	*Harmothoe extenuata, Syllis* sp., *Polycirrus medusa, Metrella* sp., Ophiuroidea, *Neanthes arenocedonta*
	208BI	23	521	2	*Ampelisca vadorum, Leptocheirus pinguis*
Fine to medium sand	1BI	17	1344	1	*Ampelisca vadorum*
	23BI	8	679	1	*Byblis serrata*
	25BI	5	12	3	*Leptognatha caeca, Protohaustorius sp., Cirolana polita*
	37BI	27	1173	3	*Ampelisca vadorum, Leptocheirus pinguis, Lysianopsis alba*
	41BI	19	443	1	*Byblis serrata*
	108BI	23	325	2	*Ampelisca vadorum, Leptocheirus pinguis*
	508BI	14	456	1	*Byblis serrata*
Fine to coarse sand	708BI	15	290	1	*Byblis serrata*
Medium sand	43BI	19	117	5	*Lumbrineris hebes,* Tunicata, *Macroclymene zonalis, Aricidea catherinae, Glycera dibranchiata*
	808BI	7	47	2	*Byblis serrata, Protohaustorius sp.*
Medium to coarse sand	38BI	16	81	4	*Glycera dibranchiata, Polygordius sp., Lumbrineris fragilis, Cyclocardia borealis*
	42BI	8	30	3	*Astarte sp., Protohaustorius sp., Rheopoxynius hudsoni*
	908BI	8	32	2	*Byblis serrata, Cerastoderma pinnulatum*
	1008BI	14	72	4	*Byblis serrata, Glycera dibranchiata, Leptognatha caeca, Rheopoxynius hudsoni*
	1108BI	13	45	3	*Glycera dibranchiata, Leptognatha caeca, Lumbrineris fragilis*

(continued)

Table 3. (Continued)

Predominant Grain Size	Station	Number of Taxa	Total Abundance	Number of Taxa Comprising >70%	Key Taxa (in descending order of abundance)
Medium to very coarse sand	2BI	25	1541	1	*Ampelisca vadorum*
	9BI	12	23	4	*Erichthonius sp., Corophium sp., Sabellaria sp., Microdeutopus sp.*
	10BI	12	34	5	*Caprella equilibra, Goniada maculata, Ophiuroidea, Syllis sp., Astarte sp.*
	11BI	16	47	5	*Crenella sp., Corophium sp., Polycirrus medusa, Pisione remota, Polygordius sp.*
	16BI	25	1011	7	*Corophium sp., Anachis lafesnyi, Metrella sp., Jassa falcata, Caprella equilibra, Ophiuroidea, Pleusymtes glaber*
	20BI	24	242	5	*Mytilus edulis, Potamilla neglecta, Capitella capitata, Syllis sp., Polygordius sp.*
	22BI	16	122	5	*Lumbrineris hebes, Pisione remota, Aricidea catherinae, Cirolana polita, Glycera dibranchiata*
	28BI	13	71	4	*Polycirrus medusa, Lumbrineris hebes, Echinarachnius parma, Syllis sp.*
	31BI	17	142	4	*Polycirrus medusa, Syllis sp., Lumbrineris hebes, Polygordius sp.*
	33BI	20	330	4	*Polycirrus medusa, Pisione remota, Lumbrineris hebes, Syllis sp.*
	40BI	21	273	3	*Lumbrineris fragilis, Glycera dibranchiata, Macroclymene zonalis*
Coarse to very coarse sand	19BI	20	307	5	*Corophium sp., Polycirrus medusa, Tunicata, Polygordius sp., Mytilus edulis*
	308BI	18	178	4	*Mytilus edulis, Pagurus sp., Protohaustorius sp., Crassenella sp.*
	408BI	13	106	3	*Lumbrineris hebes, Polycirrus medusa, Unciola irrorata*
	1208BI	11	32	4	*Pisione remota, Macroclymene zonalis, Lumbrineris hebes, Polygordius sp.*

Table 4. Expected benthic community characteristics in the BIWF and BITS Project Areas.

Deepwater Wind Project Area	Soft Substrate Benthic Community	Hard Substrate Benthic Community[c]
WTGs and Inter-Array Cable, sandy	*Successional stage*[a]: indeterminate *Community*[b]: Surface tube-dwelling and burrowing amphipod dominant with burrowing polychaetes; low to moderate species richness, low abundance. Species characteristic of an intermediate to mature community.	Very rare
APE, sandy		Southwestern portion, hard bottom community dominated by coralline algae, sponges, hydroids, corals, anemones, and barnacles.
Export Cable – offshore, sandy	*Successional stage*: I on III *Community*: Surface tube-dwelling and burrowing amphipod dominant with burrowing polychaetes; low to moderate species richness, low abundance. Species characteristic of an intermediate to mature community.	Very rare
Export Cable – nearshore, sandy with some cobble or boulders	*Successional stage*: indeterminate *Community*: Surface tube-dwelling and burrowing amphipods, burrowing polychaetes, small bivalves; low to moderate species richness and abundance; several co-dominants	Rare, but where present characterized by dense macroalgae. Assume presence of associated fouling organisms such as amphipods, barnacles, mollusks, and hydroids
BITS Alternative 1 – nearshore Block Island (MP 0.0-2.4), sandy with some cobble or boulders		
BITS Alternative 1 – MP 2.4-7.65, silty sand	*Successional stage*: III and I on III *Community*: Surface tube-dwelling amphipod dominant with burrowing and sessile polychaetes; relatively high species richness, moderate abundance. Species characteristic of an intermediate to mature community.	Very rare
BITS Alternative 1 – MP 7.65-12.57, sandy area	*Successional stage*: III and I on III *Community*: surface tube-dwelling amphipods dominant with burrowing polychaetes; low to moderate species richness, low abundance. Species characteristic of an intermediate to mature community	Very rare
BITS Alternative 1 – MP 12.57-20.68 (silty sand)	*Successional stage*: III and I on III *Community*: Surface tube-dwelling amphipod dominated with burrowing and sessile polychaetes; relatively high species richness, moderate abundance. Species characteristic of an intermediate to mature community.	Very rare

(continued)

Table 4. (Continued)

Deepwater Wind Project Area	Soft Substrate Benthic Community	Hard Substrate Benthic Community[c]
BITS Alternative 1 – MP 20.68-21.74, silty sand to sand area towards mainland	*Successional stage*: I on III (Valente et al. [1992] – stage I) *Community*: Surface tube-dwelling amphipod dominated with burrowing and sessile polychaetes; relatively high species richness, moderate abundance. Species characteristic of an intermediate to mature community.	Rare
BITS Alternative 2 – MP 17.97-24.28, silty	*Successional stage*: III and I on III *Community*: Surface tube-dwelling amphipod dominated with burrowing and sessile polychaetes; relatively high species richness, moderate abundance. Species characteristic of an intermediate to mature community.	Rare
BITS Alternative 2 – MP 24.28-26.02, sandy	*Successional stage*: I on III (Valente et al. [1992] – stage I) *Community*: Surface tube-dwelling amphipod dominated with burrowing and sessile polychaetes; relatively high species richness, moderate abundance. Species characteristic of an intermediate to mature community.	Rare

[a] I = pioneering community; II = intermediate; III = equilibrium or mature; I on III = mature community with secondary pioneering community; indeterminate = successional dynamics in medium and coarser sands not well understood. Source: CoastalVision and Germano (2010)
[b] based on Ocean SAMP data from stations with similar sediment grain size; in WTG and APE, reflects data from samples collected in this area (data courtesy of Dr. John King, URI)
[c] based on OSI (2012a and 2012b) and video survey results

Table 5. Distribution of substrate conditions along video transects.

Transect	Approximate distance along transect (feet)												
	0-100	100-200	200-300	300-400	400-500	500-600	600-700	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300
VT-1	C	C	C	C	C	C	C	C	G	CB	CB	C	
VT-2	CB	CB	CB	CB	CB	CB	G	G	G	G			
VT-3	CB				G	CB		G	CB	CB	CB	CB	
VT-4	CB C		G	GCB	GCB	GCB	GCB	CB	S			CB	
VT-5	CB	CB	G	G CB			C	CB	CB		CB		
VT-6	GCB	GC	GCB	GCB	G	G	CBG	G		G			
VT-7	CBG		S	S		G	G	GCB	GCB	G	GCB		G
VT-8	GCB	GCB	GCB	GCB	G		GCB	GCB	GCB	GCB			
VT-9	GC	GC	GCB	GCB	GC	GCB	GCB	G		GCB			
VT-10	G	G	G	G	G	G			GC	GCB			
VT-11	GC	GC	G	G	G	G	G	GC	C	C			
VT-12	GC	GC	GC	GC	GC *	GC *	* GC	* GC	*	* GC	CB*		
VT-13	G	G	G	G	G	G	G	GC	GC	GC	GC		
VT-14	G	G	G	GCB	G	GC	GC	GC	GC	GC	GC	G	
VT-15	GC	GC	GC	GCB	GC	GCB	GCB	GCB	GC	GC			
VT-16	GCB	CB	CB	CB	CB	C	C						
VT-17				G	GCB	GCB	GCB		C				
VT-18	GCB	CB	CB	GCB	CB	CB	C	GC	GC	G			

Primary Substrate
- Sand
- Gravel
- Cobble/Boulder
- Sand with distinct areas of cobble
- Cobble with distinct areas of sand
- Gravel with distinct areas of cobble

Secondary Substrate
G = gravel (generally associated with sand waves, often with shell hash)
C = cobble (scattered)
B = boulder (scattered)
* cobble pavement

Table 6. Activities potentially affecting benthic resources.

Activity	Type of Impact	Type of Effect	Project Components			
			WTGs	Inter-Array Cable	Export Cable	BITS
Construction						
Jet Plow (subtidal)	Suspension of sediments (water quality)	Reducing feeding efficiency in filter feeders		x	x	x
	Deposition of suspended sediments	Burial of benthic organisms		x	x	x
Cable Crossing	Direct intrusion into the substrate	Crushing of surface and infaunal organisms				x
	Conversion of soft substrate to artificial hard substrate	Burial of existing benthos, replacement with hard substrate fouling community				x
HDD	Removal of substrate	Loss of habitat (temporary)			x	x
	Suspension of sediments	Reducing feeding efficiency in filter feeders			x	x
	Deposition of suspended sediments	Burial of benthic organisms			x	x
	Release of drilling muds	Burial of benthic organisms			x	x
		Reducing feeding efficiency in filter feeders			x	
	Spud barge placement	Loss of habitat (temporary)			x	x
Installation of WTGs – anchoring of support vessels	Direct intrusion into the substrate	Crushing of surface and infaunal organisms	x			
	Anchor cable sweep	Disturbance of substrate surface	x			
Installation of WTGs – placement of jackup barge	Direct intrusion into the substrate	Crushing of surface and infaunal organisms	x			
Installation of WTGs – insertion of legs, piles, braces, and mud mats	Loss of habitat	Permanent loss of natural seafloor; conversion to artificial hard substrate	x			
	Noise	Hammering of piles; potential effect on lobsters	x			
Operation						
Operation of wind farm	EMF	Potential effect on benthic fauna		x	x	x
	Habitat alteration	Colonization of artificial hard substrate	x			
	Habitat alternation/loss	Increased scour around footings	x			

(continued)

Table 6. (Continued)

Activity	Type of Impact	Type of Effect	Project Components			
			WTGs	Inter-Array Cable	Export Cable	BITS
Decommissioning						
Removal of WTGs	Removal of artificial hard substrate	Elimination of "reef-like" colonization	X			
	Disturbance of substrate – suspension of sediments into water column	Reducing feeding efficiency in filter feeders	X			
	Disturbance of substrate – deposition of resuspended sediments	Burial of benthic organisms	x			
Removal of cables	Suspension of sediments (water quality)	Reducing feeding efficiency in filter feeders		x	x	x
	Deposition of suspended sediments	Burial of benthic organisms		x	x	X

Table 7. Areas affected by re-deposition of sediments suspended during jet plowing.

Project Area	Approximate Distance	Surface Area of Open Trench	Approximate Area Experiencing Re-deposition Thickness of	
			≥1 mm (≥0.04 inch) Acres (hectares)	≥10 mm (≥0.4 inch) Acres (hectares)
Inter-Array Cable	2.1 mi (3.4 km)	1.3 acres (0.53 hectare)	67 (27)	21 (8.5)
Export Cable	5.9 mi (9.5 km)	3.6 acres (1.5 hectares)	193 (78)	58 (24)
Block Island HDD Cofferdam	--	--	0.7 (0.3)	0.1 (0.04)
BITS – Alternate 1	20.6 mi (33.2 km)	12.5 acres (5.1 hectares)	835 (338)	87 (35)
Narragansett HDD Cofferdam	--	--	2.2 (0.9)	0.7 (0.3)
BITS – Alternative 2	24.9 mi (40.0 km)	15.1 acres (6.1 hectares)	998 (404)	114 (46)
URI Bay Campus Cofferdam	--	--	0.6 (0.2)	0.1 (0.04)

Table 8. Substrate Areas Affected During Construction

Project Portion	Activity	Explanation	Impact Area Ft^2 (m^2)	Impact Area Acres (hectares)
BITS	Utility crossing – concrete mat area	Two utility crossings	3,200-14,400 (297-1,338)	0.07-0.33 (0.03-0.13)
	Anchoring over cable crossings	Two placements at each of two crossings	168 (16)	0.00 (0.00)
	<4 ft burial – concrete mat area (BITS 1 – BITS 2)	Up to 1% of route with insufficient cable burial	43,520-52,600 (4,045-4,888)	1.00-1.21 (0.41-0.49)
	Jackup barge at long-distance HDD cofferdams	Four placements at each of two cofferdams	904 (84)	0.02 (0.01)
	Cofferdams for long-distance HDD	Two locations	1,000 (93)	0.02 (0.01)
BIWF (5 WTGs)	Derrick barge (foundation installation)	Three anchor events per WTG	4,050 (376)	0.09 (0.04)
	Jack-up transportation barge	Two placements per WTG	9,000 (836)	0.21 (0.08)
	Jack-up barge (turbine installation)	Two placements per WTG	24,000 (2,230)	0.55 (0.22)
	<4 ft burial – concrete mat area (Inter-Array Cable)	Up to 1% of route with insufficient cable burial	4,400 (409)	0.10 (0.04)
	<4 ft burial – concrete mat area (Export Cable)	Up to 1% of route with insufficient cable burial	12,480 (1,160)	0.29 (0.12)
	Jackup barge at long distance HDD cofferdam (Export Cable)	Four placements at one cofferdam	452 (42)	0.01 (0.00)
	Cofferdam for long distance HDD (Export Cable)	One location	500 (47)	0.01 (0.00)
Total Habitat Disturbance (temporary effect)	**Anchoring and jackup barges**		**40,074 (3,724)**	**0.93 (0.37)**
Total Habitat Conversion (permanent effect)	**Protective mats**		**63,600-83,880 (5,911-7,796)**	**1.46-1.93 (0.59-0.78)**

Table 9. Summary of Studies Documenting Recovery of Soft Substrate Benthos to Mature (Stage III) Community

Study	Location	Stressor	Time to Recover
Germano et al. 1994	Coastal New England	Dredged material disposal	6 months to 1 year
Murray and Saffert 1999	Western Long Island Sound	Dredged material disposal	1 to 4 months
Kropp et al. 2002; Maciolek et al. 2004	Massachusetts Bay	Storms	1 to 2 years
Rhoads et al. 1978	Long Island Sound	Dredged material disposal	1 to 2 years
Rhoads et al. 1978	Long Island Sound	Azoic sediments	6 to 8 months
SAIC 2001	Central Long Island Sound	Dredged material disposal	< 5 years
SAIC 2002	Western Long Island Sound	Dredged material disposal	1-2 years

Appendix A

Deepwater Wind Block Island Wind Farm and Block Island Transmission System
Benthic Video Survey

Deepwater Wind
Block Island Wind Farm and Block Island Transmission System

Benthic Video Survey

April 2012

Deepwater Wind
Block Island Wind Farm and Block Island Transmission System

Benthic Video Survey

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April 2012

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1.0 Introduction

Deepwater Wind Block Island, LLC , a wholly owned subsidiary of Deepwater Wind Holdings, LLC, proposes to develop the Block Island Wind Farm (Wind Farm or BIWF), an approximately 30 megawatt (MW) offshore wind farm located approximately 3 miles (4.8 km) southeast of Block Island, Rhode Island. The Wind Farm is expected to consist of five , 6 MW wind turbine generators (WTGs), a submarine cable (approximately 2mi [3.2 km]) interconnecting the WTGs ("Inter-Array Cable") and a 34.5-kV transmission cable connecting the northernmost WTG to an interconnection point on Block Island ("Export Cable") (submarine section is approximately 6.2 mi [10 km]). An overview of the study area is shown in Figure 1.

In connection with the Wind Farm, Deepwater Wind Block Island Transmission, LLC, also a wholly owned indirect subsidiary of Deepwater Wind Holdings, LLC, proposes to construct a new transmission line, the Block Island Transmission System (BITS), between Block Island and the Rhode Island mainland (approximately 21.8 mi [35.1 km] to 25.9 mi [41.7 km]). As part of BITS, Deepwater Wind Block Island Transmission, LLC proposes to construct a new substation on Block Island. On the Rhode Island the BITS will interconnect with the existing Narragansett Electric (National Grid) system in Narragansett, Rhode Island.

For the purposes of this report, the two Deepwater Wind Holdings, LLC corporate entities associated with the development of the BIWF and BITS are collectively referred to as "Deepwater Wind." Likewise, the BIWF and BITS are collectively referred to as "the Project."

The WTGs, Inter-Array Cable and Export Cable are located, in their entirety, within 3 nmi (5.6 km) of the Block Island coast and are therefore within state waters, and outside of the jurisdiction of the Bureau of Ocean Energy Management (BOEM). By contrast, a 9.0 mi (14.8 km) portion of the BITS is on the Outer Continental Shelf (OCS) is within federal waters and is therefore subject BOEM jurisdiction. To maintain consistency in data collection and data available for Project design, the BIWF and BITS benthic survey protocol was, to the extent practical, developed in accordance with the following guidelines:

- BOEM's "Draft Guidelines for Benthic Habitat Surveys in the Atlantic for Offshore Wind Energy Development" dated July 21, 2011, and
- protocols recommended in BOEM's Interim Policy Leases for meteorological towers in the Mid-Atlantic entitled, "Guidelines for Biologically Sensitive Habitat Field Surveys and Reports."

In addition, discussions with the U.S. Army Corps of Engineers (USACE), National Marine Fisheries Service (NMFS), Rhode Island Department of Environmental Management (RIDEM), and Rhode Island Coastal Resource Management Council (CRMC) resulted in refinements to the survey protocol. The ultimate purpose of the survey was to ensure that all benthic habitats that could be affected by installation or operation of the Project would be characterized for impact assessment.

Previous studies conducted by Deepwater Wind evaluated soft substrates in the areas associated with the proposed footprint for the BIWF and offshore associated cable areas. In addition, as part of the Rhode Island Ocean Special Area Management Plan (RI Ocean SAMP), LaFrance et al. (2010) studied an area south of Block Island that encompasses the BIWF WTG array. The results of these studies showed that glacial moraine substrates (that include cobbles and boulders) are common within the Area of Potential Effect (APE) as defined in Figure 1 but were not studied previously. Benthic organisms associated with cobble and boulder habitats may be vulnerable to the indirect impacts of construction (e.g., sedimentation or disturbance from anchors and anchor cables) and therefore warranted further investigation and evaluation. As such, a video survey was designed to provide a more detailed characterization of the hard substrate resources identified within the proposed BIWF and BITS Project Areas that could be affected by the construction and operation of the Project so that potential impacts can be more accurately evaluated.

2.0 Survey Design

Normandeau developed the benthic survey to characterize benthic resources not previously surveyed in the area that could be affected by the construction of the BIWF and associated cabling (Inter-Array Cable and Export Cable) as well as the BITS. Soft substrate benthic resources have previously been evaluated in the BIWF Project Area by the RI Ocean SAMP and summarized in LaFrance et al. 2010. CoastalVision and Germano and Associates (2010) conducted a sediment profile imagery survey along the originally proposed BITS route as well as the proposed Export Cable route and in the BIWF area. These surveys were sufficient to characterize the soft substrate benthos potentially affected by all components of the Project. Hard substrate benthic resources in the vicinity of the Project cannot be surveyed by sediment profile imagery and were therefore examined in this study using underwater video.

Benthic resources beyond the immediate cable footprint have the potential to be affected indirectly, primarily by excess sedimentation during substrate disturbing activities such as cable installation. Normandeau considered a distance of 3280 ft (1000 m) from the cable centerline to be a conservatively distant boundary for this impact analysis for two reasons. First, BOEM's guidelines for benthic surveys for Interim Policy Leases recommended that hard substrates (and other sensitive benthic habitats) within 3280 ft (1000 m) of substrate-disturbing activities should be surveyed. Second, modeling for the BIWF/BITS Project conducted to assess sediment transport and deposition resulting from jet plowing to install each of the transmission cables has predicted that sedimentation exceeding 0.4 inch (10 mm) would not extend more than about 250 ft (75 m) from the cable centerline (RPS ASA 2012). Benthic resources could also experience other sources of impact in the APE (see Figure 1), specifically disturbance by anchoring and sweeping of anchor cables across the bottom during installation of the turbines.

2.1 Station Selection

Distribution of hard substrate in the APE and near the Export Cable and BITS was estimated from mapping available from the State of Rhode Island Geographic Information System (RIGIS) database (i.e., where "glacial moraine" is present). Glacial moraine is a highly variable substrate that may consist of material ranging from silt to boulders in any mixture. Because it is impossible to determine from the data available from the RIGIS database how much hard substrate suitable for benthic colonization actually occurs in the APE, Ocean Surveys Inc. (OSI) conducted a side scan sonar survey specifically designed to document the distribution of hard substrate in the areas identified in RIGIS as potential glacial moraine (black-hatched areas in Figure 1). The side scan sonar was run along parallel tracklines spaced 492 ft (150 m) apart providing 100 % overlapping coverage. OSI characterized the substrate conditions as one of five types (Table 1) or a hybrid of two types in areas where there were frequent transitions between types. Of these, Types 3, 4, and 5 may include hard substrate habitats in quantities that would trigger a need for further characterization of benthic resources (e.g., video surveys).

No areas were classified as Type 4 or 5. Examination of areas classified as Type 2 or Type 1-2 under high resolution showed that these types include heterogeneous substrates that include small areas of mixed substrates (e.g., coarser than sand, with and without boulders) that were considered useful to include in the video survey. Areas that are distant from construction activities, although still within the APE, were included in the video survey to serve as a type of control site. While these "control" areas were actually located within the potential impact zone, most of the impact of concern for hard substrates relates to excessive sedimentation which is expected to decline with distance from construction. Placing the control sites within the area that has been surveyed by side scan sonar increases the likelihood that they provide a similar physical habitat to areas nearer construction where impact may be greater.

Interpretation of the side scan sonar images in the APE, two areas along the Export Cable, and two areas along the BITS surveyed showed that hard substrate conditions were most likely to be present in the southwestern portion of the APE, a small area in the northeastern portion of the APE, and an area north of the Export Cable (Figure 2). Substrates in these areas were classified as Type 3 or Type 2-3 by OSI (see Table 1 for definitions of substrate classifications). The remainder of the area identified in RIGIS as "potential glacial moraine" was found to contain primarily fine grained sediments classified as Types 1, 2, and 1-2, including both areas surveyed along the BITS route.

The results of the side scan sonar survey were discussed with USACE, NMFS, BOEM, RIDEM, and CRMC in November 2011 to select transect locations. The agencies concurred that Type 3 substrates required additional characterization; these substrates became the primary focus of this survey. Video transects were placed in twelve locations where cobbles and boulders were likely to be present (Type 3 substrates), primarily within the APE; two locations where substrates were transitional, but were likely to contain cobbles or boulders; and four locations where interpretation of side scan sonar suggested the absence of cobbles or boulders (Figures 2 and 3). Once the preliminary assignment of transect locations was made based on low resolution side scan sonar images, the analyst at OSI examined the selected coordinates on high resolution images and adjusted the lines to ensure that the Type 3 transects crossed obvious cobble and boulders.

2.2 Survey Methods

The video survey was conducted on December 5-7, 2011. Transects ranged in length from approximately 1000 to 1300 ft (305 to 396 m) long, about 20-30 minutes of "flying" time at ¼ knot. Coordinates denoting the start and end points of the transects were recorded (Table 2), although most transects were not straight lines because of site conditions and currents (Figure 2 depicts planned tracklines).

The remotely operated vehicle (ROV), interfaced with the vessel's navigation system, was maintained a relatively constant elevation (about 3 ft [1 m]) off the bottom so that the field of view was consistent. The video was monitored in real time by both the ROV pilot and two biologists onboard the surface vessel to ensure quality was acceptable for detailed review. Targets (e.g., specific habitat features or organisms) identified by biologists were recorded. All survey imagery was recorded on DVD which continuously displays:

- Date and Time
- Elevation of ROV

- Depth of Water
- Coordinates of the ROV
- Heading of ROV

2.3 Analytical Methods

Video from each transect was independently viewed in its entirety by the two marine biologists who conducted the field survey. They recorded:

- General characterization of substrate including texture, microtopography, and presence and approximate thickness (absent, light, moderate, or heavy) of sedimentation (“drape”) covering hard substrates where:
  - Absent means that hard surface or encrusting or fouling organisms are clearly visible
  - Low means that a film of sediments covers less than 50 % of the hard substrate or fouling organisms
  - Moderate means that more than half of the hard substrate or organisms are covered or obliterated, and
  - Heavy means that most of the hard substrate or encrusting/fouling organisms are covered and indistinguishable;
- Presence and general characterization of epibenthic invertebrates (especially lobsters and crabs), and habitat;
- Presence/evidence and general characterization of submerged aquatic vegetation (macroalgae, seagrass);
- Presence and general characterization of shellfish;
- Presence and general characterization of fish and habitat; and
- Identification of organisms to the lowest practical taxonomic level using standard taxonomic keys for the geographic area.

Observations were summarized every 100 ft (30.5 m). Representative screen shots were saved as image files.

Relative abundance of organisms was based on the following criteria:

Abundant = if the species appears on more than 50 % of the screens, i.e. length of the video monitor from top to bottom (representing, on average, 3 linear feet of substrate),

Common = if the species appears in 25 to 50 % of the screens, and

Present = if the species is observed in any of the screens.

Countable organisms such as fish, crustaceans, and mollusks were enumerated, although videography is not a statistically rigorous method for collecting quantitative data on mobile organisms. These results should thus be used only as supplemental information to document the presence of these species in the Project Area.

3.0 Results

The eighteen transects surveyed by video are representative of the various substrate conditions within the Project Area. Emphasis was placed on substrates classified by OSI as Type 3 where hard substrate (i.e., cobbles and boulder; no bedrock outcrops were observed in the Project Area) was likely to occur because this substrate was not well documented in previous Project-specific surveys. Based on the side scan sonar surveys for the BIWF, APE and the alternative BITS routes, hard substrate is relatively rare within the general Project Area. Hard substrate has the potential to provide important habitat for benthic organisms and fish with affinity to structures. Documenting this habitat type was important because it could experience indirect impacts from the Project.

3.1 Substrate Conditions

Descriptions of substrate conditions are qualitative, based on the observations from the videos. In general, transects where hard substrate was expected to occur had similar types of substrates. Transects where interpretation of side scan sonar images suggested that hard substrates were rare or absent also had similar substrate conditions. Discussion of the survey results is grouped by expected substrate conditions.

Areas Likely to Contain Cobble or Boulders

Twelve of the video transects (VT-1 through VT-10, VT-17, and VT-18) were located in substrate classified as likely to include boulders and cobble (Figure 2; Table 3) based on interpretation of side scan sonar images. Video footage confirmed that these features did exist occasionally along these transects but few areas were observed where cobble and boulders were the exclusive substrate. The predominant substrate was medium to coarse sand. Sand waves were observed along most transects (VT-18 was the exception) and typically gravel and shell debris occurred in the troughs between waves. Cobble and boulders were scattered along the transects and in many of them, there were distinct patches of these hard substrates (Table 4). Cobble "pavement," or areas where the hard substrate was embedded, was observed only along Transect VT-12. Where cobble and boulders occurred, they did not extend more than about 2 ft (0.6 m) above the seafloor. Ten of these transects were located in the southwest portion of the APE, west of the turbine array. The other two transects were located north of the Export Cable.

Occasionally the video camera rested near the seafloor and biologists observed transport of sand just above the water column-seafloor interface. There was no evidence of sedimentation on the hard substrate, as denoted by the absence of "drape" (Table 3).

Areas Likely to be Predominantly Sandy

Four transects (VT-11 through VT-14; all within the APE [Figure 2]) were located in areas where side scan sonar images were classified as fine-grained with sand waves, with some possibility of containing cobble or boulders. In each case, the predominant substrate observed in the videos was medium-coarse sand (Table 5). Troughs associated with the sand waves contained shell debris, gravel, and, in one case (VT-12), cobble. Hard substrate was present but typically only included cobble and it was generally scattered. Height above the substrate was less than one foot. No drape was observed.

Two transects (VT-15 and VT-16), located in the northeast portion of the APE and outside the footprint of the wind farm and Export Cable, were placed in substrates categorized as transitional between predominantly sandy and "likely-to-include-some-hard-substrate". Side scan sonar images from Transect VT-15 were categorized as Type 2-3. Transect VT-16 was oriented so that it transitioned from an area categorized as Type 2-3 to an area categorized as Type 1-2. The sand matrix was similar to that observed throughout the Project Area. Sand waves with shell debris in the troughs were observed. Cobbles were observed occasionally. Vertical relief was typically less than 18 in (46 cm). There was no evidence of sedimentation on the cobble.

Based on the side scan sonar survey within the APE, most substrates in transects likely to be predominantly sandy consisted of fine to coarse granular material (silt to sand). Transects VT-11 through VT-14 were located in this type of material. Although cobble was present in each of these transects, the predominant substrate seen in the video was medium to coarse sand. Sand waves were prevalent with gravel and shell hash observed in the troughs. Vertical relief was less than 18 in (46 cm).

Other areas surveyed using side scan sonar (south side of the Export Cable and two locations along the BITS route where RIGIS database suggested the possible presence of glacial moraine) were classified as fine-grained to coarse grained substrates. Video images of these areas were not recorded because the purpose of the video survey was to focus on habitat conditions in hard substrates. It is assumed that conditions observed along Transects VT-11 through VT-14 were representative for similar substrate classifications in the entire Project Area.

3.2 Biotic Conditions

Variability in the substrate conditions along transects VT-1 through VT-18 provided a range of habitat conditions for benthic biota (Tables 3 and 5). Eleven taxa, including three types of algae and eight invertebrates, were found exclusively on or in direct association with cobble or boulders. Coralline (corallinales) and erect red algae (rhodophyta) were observed on most transects and generally ranged from present to abundant. Green algae (chlorophyta) occurred only on Transects VT-3, VT-5, and VT-13. Sessile or encrusting invertebrates observed on most transects included sponges (porifera), cnidarians (cnidaria), polychaete worms (polychaeta), mollusks (mollusca), and arthropods (arthropoda). The echinoderm blood star *Henricia sanguinolenta* was also found on cobble and boulders. Figures 3 through 8 provide examples of substrate and biotic characteristics of representative transects. Additional images of biota are shown in Photos 1 through 17.

Soft substrate organisms were observed less regularly and are undoubtedly underrepresented in video observations because many reside within the sediment rather than on the surface.

Areas Likely to Contain Cobble or Boulders

Three types of algae (coralline, red, and green) were observed along the Transects VT-1 through 10 and VT-17 through 18, always associated with hard substrate. Coralline and red algae were the most frequently observed. Green alga was observed occasionally, likely limited by water depth.

Seven invertebrate phyla (porifera, cnidaria, polychaeta, mollusca, arthropoda, echinodermata, and bryozoa) were recorded along the transects. Sponges included an unidentified encrusting species and the erect sponge *Polymastia* sp. Unidentified hydroids, the northern stony coral (*Astrangia poculata*) and the northern red anemone (*Urticina feline*) comprised the cnidarians fauna. The only polychaetes observed were the calcareous tube-dwelling spirorbids (spirorbidae); these were found associated with red algae. All sponges, cnidarians, and polychaetes were found exclusively in association with hard substrates.

At least four species of bivalve mollusks (sea scallop [*Placopecten magellanicus*], *Astarte* sp., ocean quahog [*Arctica islandica*], and horse mussel [*Modiolus modiolus*]) were present in the Project Area on one or more transects. *Astarte* was observed most frequently. With the exception of horse mussels, bivalves were found in areas of sand and were not associated with hard substrate.

Barnacle, sand shrimp, and hermit crabs comprised the arthropods observed along the transects. Barnacles were found on all transects on hard substrate. Hermit crabs and sand shrimp occurred on about half the transects and were associated with sand. No lobsters were observed. Their generally nocturnal habits and ability to react quickly make them difficult to document on a general video survey so the lack of observations certainly does not indicate they are absent from the Project Area.

Echinoderms included two species of sea stars (*Asterias* sp. and the blood star *Henricia sanguinolenta*) and the sand dollar (*Echinorachnias parma*). Blood stars were usually, but not always, observed on hard substrate and were more common than *Asterias*. Bryozoans were observed on two transects. Other evidence of invertebrate activity included castings on the sand surface and tubes.

Eight species of fish were observed. Cunner (*Tautogolabrus adspersus)* was the most common. Many individuals were unidentifiable, but may have been black sea bass (*Centropristis striata*). At least two species of flounder (winter [*Pseudopleuronectes americanus*] and windowpane flounder [*Scophthalmus aquosus*]), the goosefish (*Lophius americanus*), and at least one species of skate (little and/or winter skate [*Leucoraja erinaceus* or *L. ocellata*) were present. Skate egg cases were found on one transect (Table 3).

Areas Likely to be Predominantly Sandy

Although transects in the sandy areas of the APE (Transects VT-11 through VT-16) contained relatively low amounts of cobble or boulders, several organisms specialized for living in attachment to hard substrate were present, including red, green, and coralline algae, sponges, coral, anemones, and barnacles. The blood star was also found on these transects on hard substrate.

The chestnut clam (*Astarte* sp.) was the most common bivalve observed. Sea scallops and an unidentified bivalve were rare as was the moon snail. A few hermit crabs (*Pagurus* spp. and *P. pollicaris*) and sand shrimp (*Crangon septemspinosa*) as well as one *Cancer* crab were recorded. Counts of sea stars (*Asterias* sp.) were higher than on the rocky transects while counts of the blood star were lower. Sand dollars (*Echinorachnius parma*) were rare.

Observations of what appeared to be invertebrate castings at a greater frequency than along the rocky transects suggested that infaunal organisms were more prevalent in the sandy substrate.

At least four species of fish were present in generally low numbers along the sandy transects. Juvenile black sea bass were recorded in the highest numbers, usually in association with hard substrate. Skates (little and/or winter skates) were the next most common fish. Skate egg cases were seen more frequently on these transects than on the rocky transects.

4.0 References

LaFrance, M., E. Shumchenia, J. King, R. Pockalny, B. Oakley, S. Pratt, and J. Boothroyd. 2010. Benthic Habitat Distribution and Subsurface Geology in Selected Sites from the Rhode Island Ocean Special Area Management Study Area. Technical Report #4. 98pp.

CoastalVision and Germano & Associates. 2010. Sediment Profile and Plan View Imaging Report. Evaluation of Sediment and Benthos Characteristics Along Potential Cable Routes and Turbine Locations for the Proposed Block Island Wind Farm. Prepared for Ecology and Environment.

RPS ASA. 2012. Sediment Transport Analysis of Block Island Wind Farm Cable Installation. Draft Report. Prepared for Tetra Tech EC. 73 pp + appendices.

Photos

Photo Documentation

Photo 1.
VT13-6. *Astarte* sp.

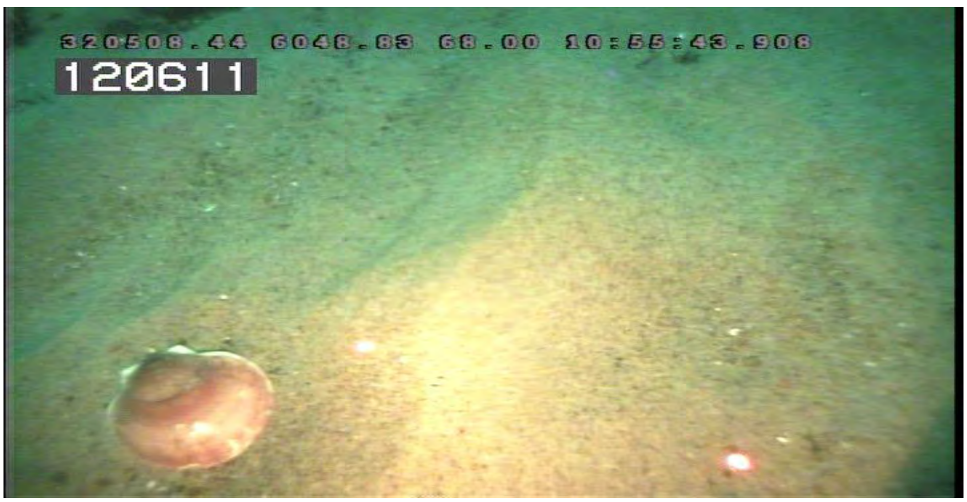

Photo 2.
VT9-2. Sea scallop (*Placopecten magellanicus*)

Photo 3.
VT8- 6. Goosefish (*Lophius americanus*)

Photo 4.
VT6-9. Tautog (*Tautoga onitis*)

Photo 5.
VT 9-5. Juvenile black sea bass (*Centropristis striata*) hiding in tube

Photo 6.
VT 1. Skate (*Leucoraja* spp.; probably little skate)

Photo 7.
VT 15-9. Skate egg cases

Photo 8.
VT 12-7. Sea star (*Asterias* spp.)

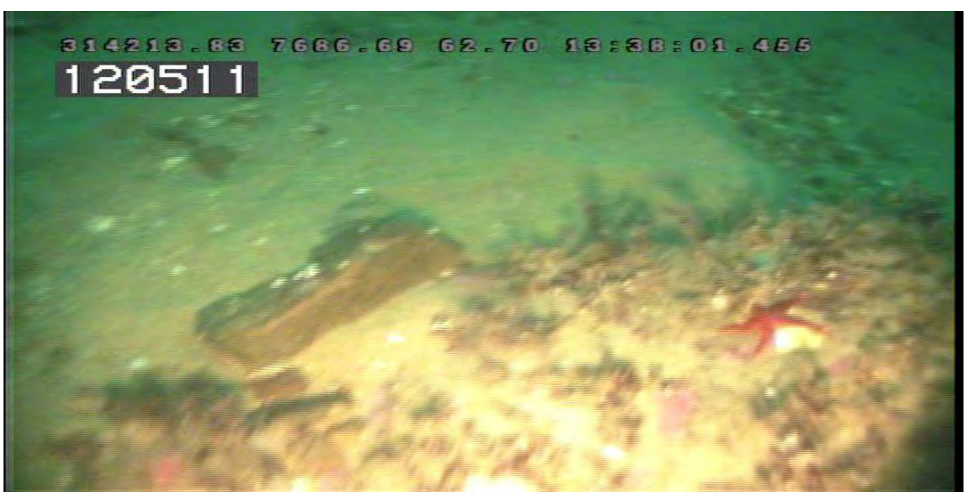

Photo 9.
VT 5-10. Blood Star (*Henricia sanguinolenta*)

Photo 10.
VT 10-2. Tubular sponge (*Polymastia* sp.) in cobble area

Photo 11.
VT 10-1. Sponge (*Polymastia* sp.) in area with shifting sands over gravel

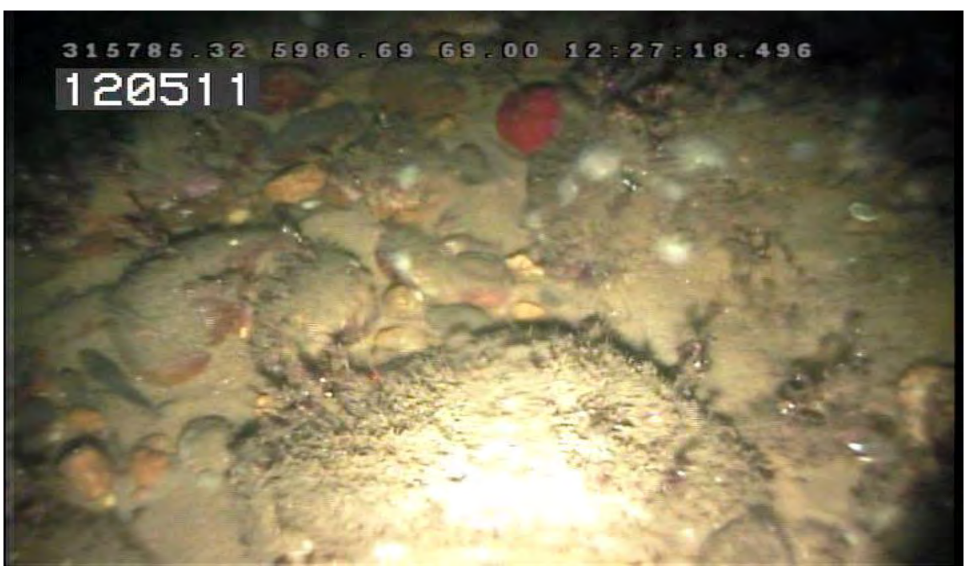

Photo 12.
VT 3-9. Northern red sea anemone (*Utricina feline*), and white coral (*Astrangia poculata*)

Photo 13.
VT 7-7. Cobble habitat with northern red sea anemones, white coral, crustose algae, red macroalgae, spirorbid worms, and barnacles

Photo 14.
VT 4-3. Sand and gravel habitat with barnacle covered boulder/ledge

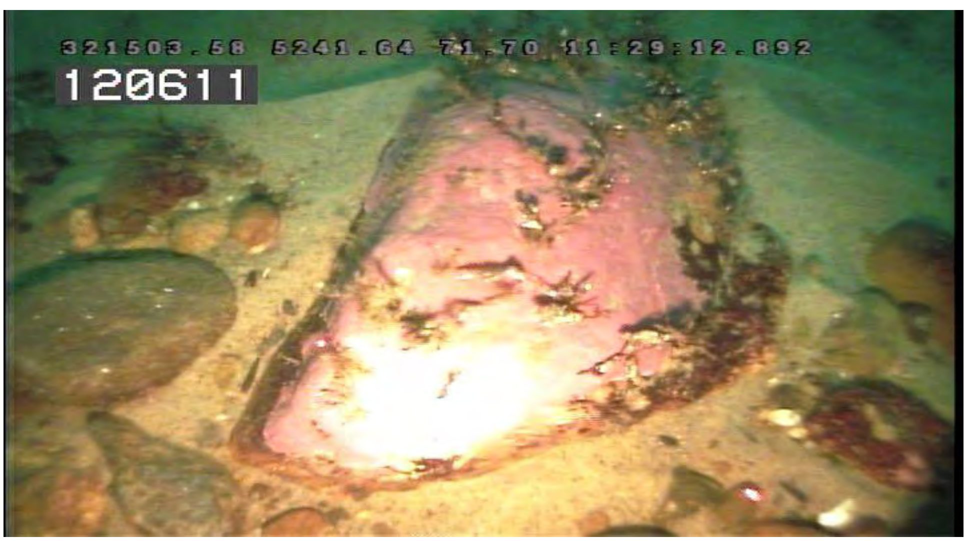

Photo 15.
VT 8-2. Encrusting coralline algae, possibly *Clathromorphum* sp. or *Leptophyllum* sp.

Photo 16.
VT 17-1. Cobble area with barnacle and hydroid cover

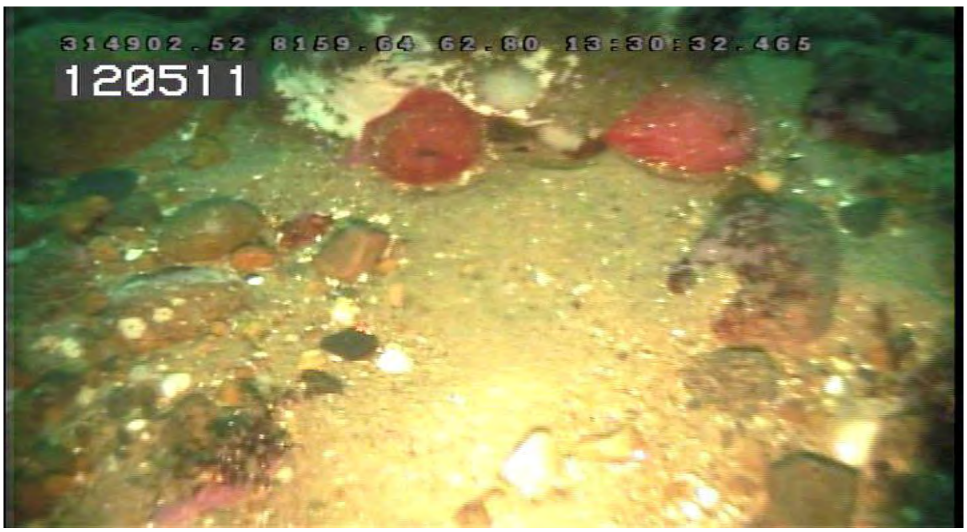

Photo 17.
VT 5-2. Northern red sea anemone (*Utricina felina*), white coral (*Astrangia poculata*) and an encrusting sponge

Figures

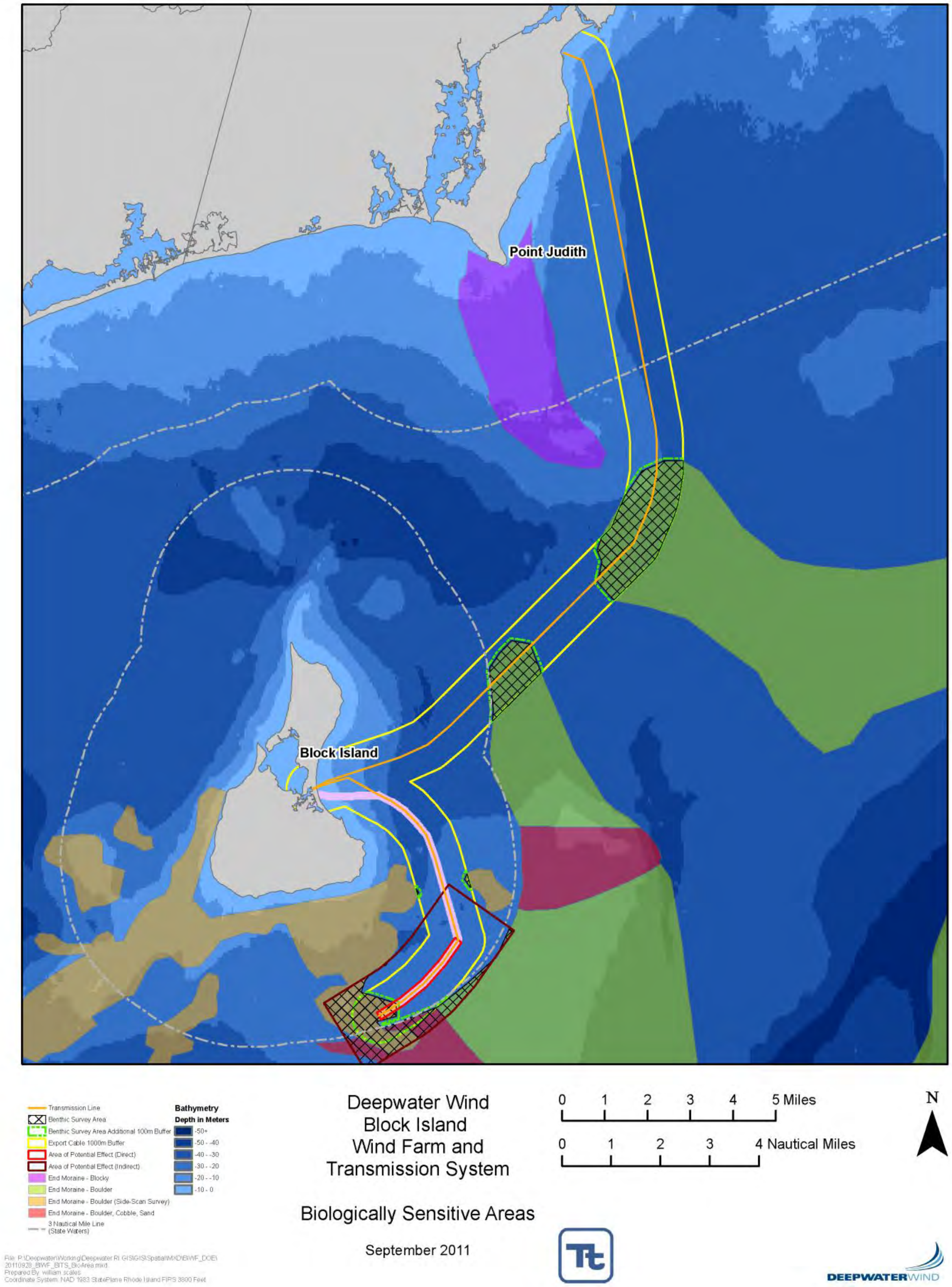

Figure 1. Study area for the Deepwater Wind Block Island Wind Farm Benthic Video Survey. (Note: cross-hatching indicates where glacial moraine was expected to occur).

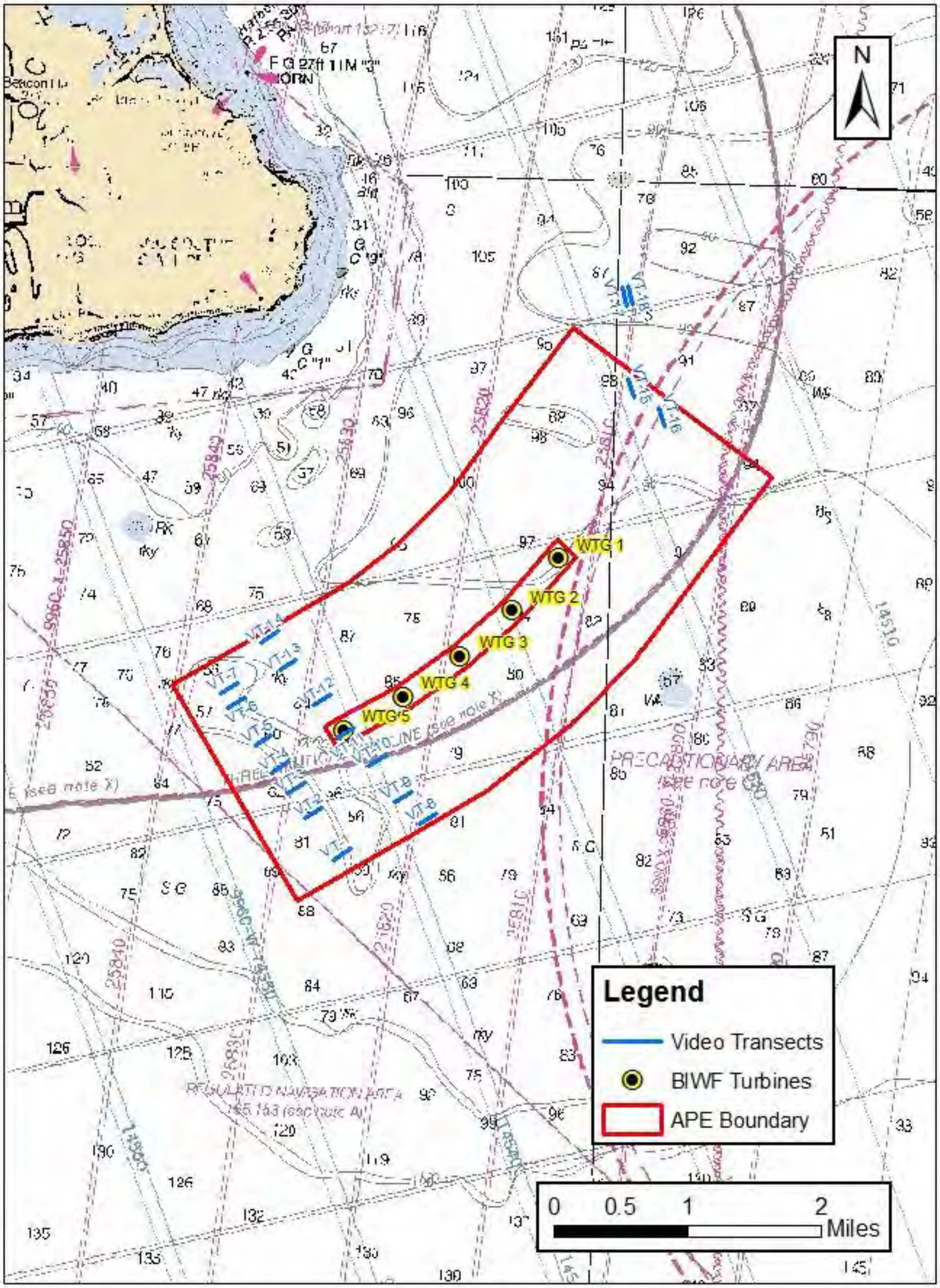

Figure 2. Video transects within the APE.

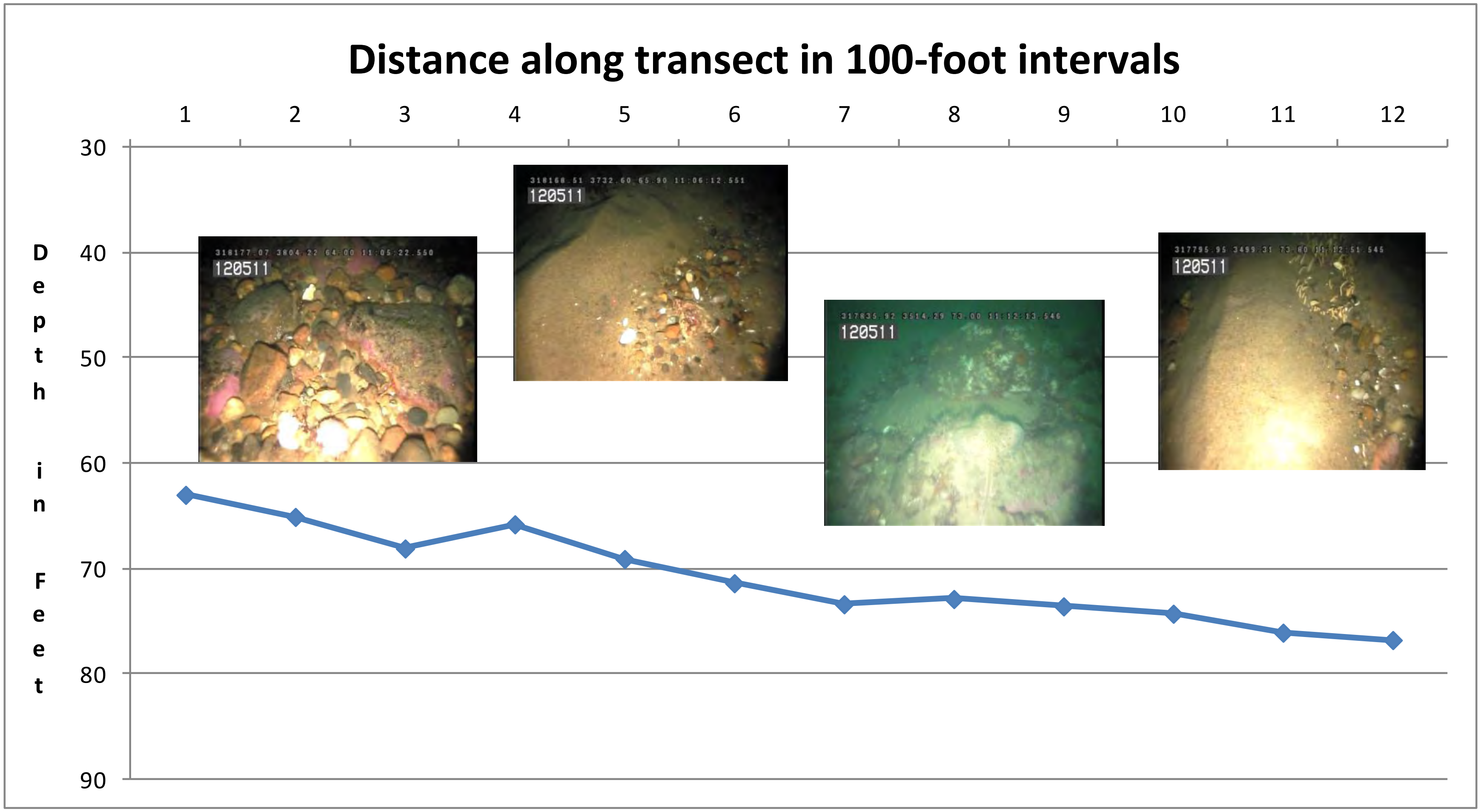

Figure 3. Conditions along video transect VT-1 in southwestern portion of the APE, from left to right: cobble and gravel with crustose algae; gravel in sand wave trough; skate; tubular sponge. (Depth not adjusted for tide)

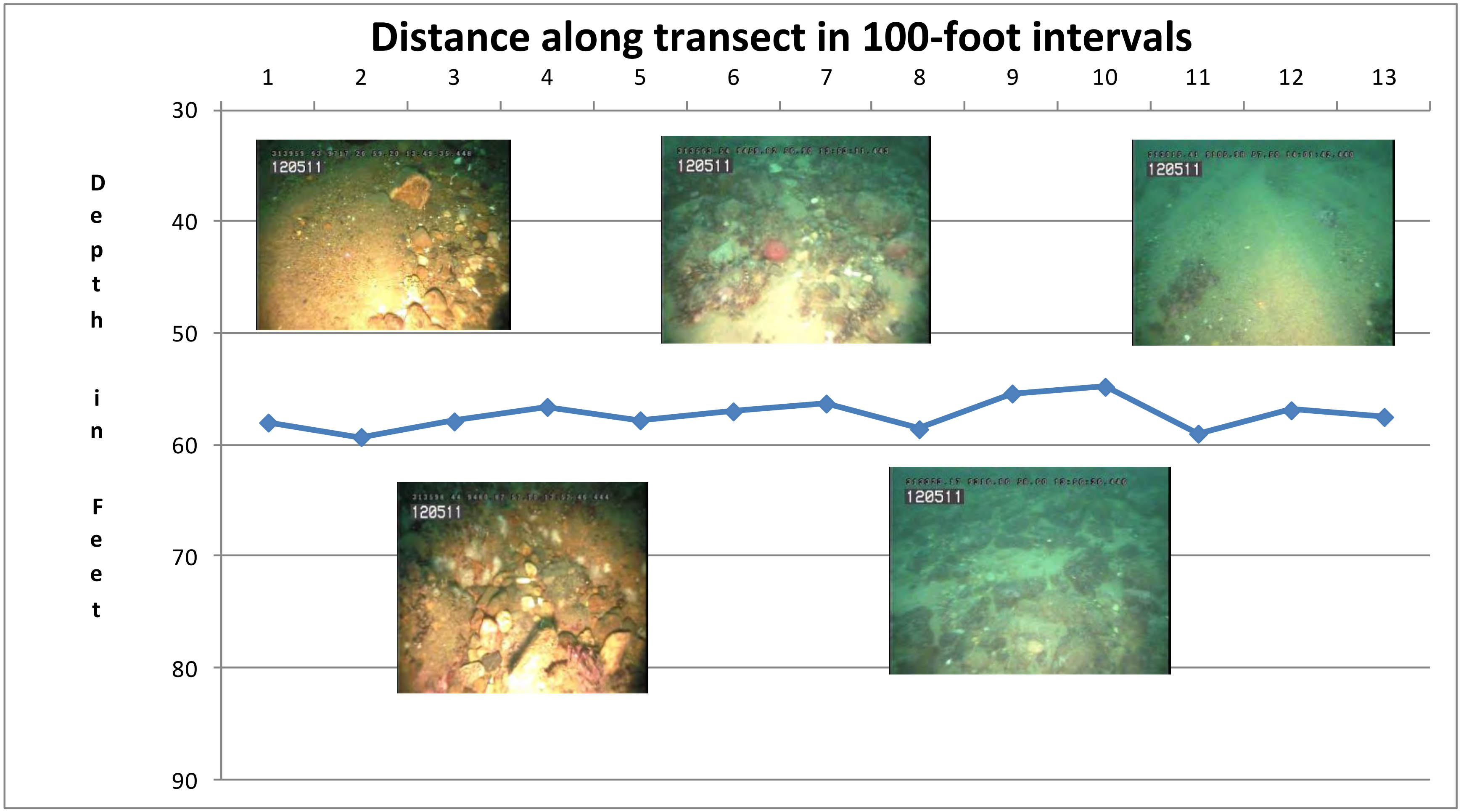

Figure 4. Conditions along video transect VT-6 in southwestern portion of the APE, from left to right: sand wave; cobble with northern white coral and crustose algae; sand and cobble with northern red sea anemone; plan view of cobble-strewn area; and plan view of typical sand waves. (Depth not adjusted for tide)

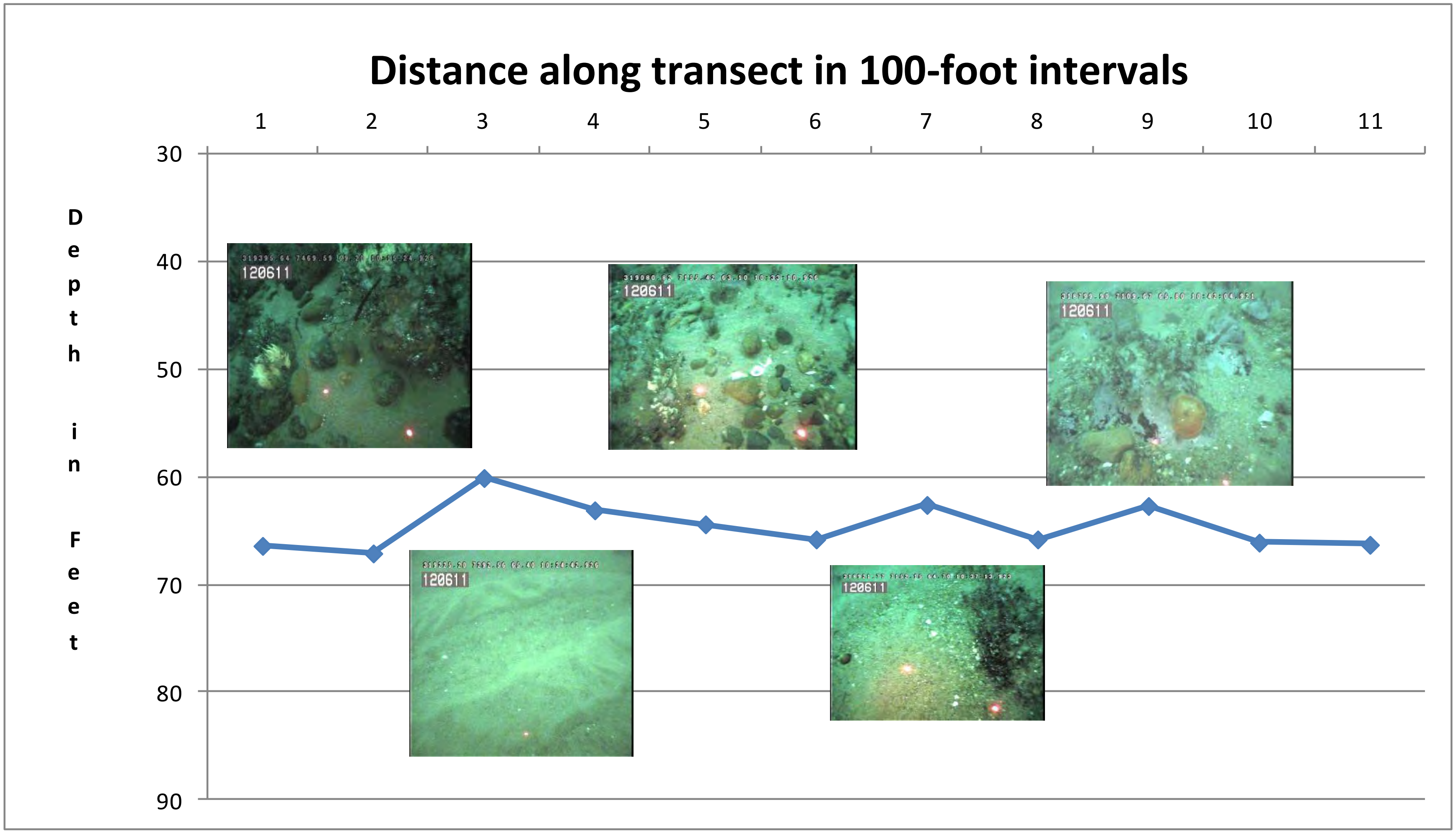

Figure 5. Conditions along video transect VT-10 in southwestern portion of the APE, from left to right: cobble in sand matrix with red algae and tubular sponge; sand substrate; sand and gravel mix with encrusting sponge; sand with Astarte clam; cobble and sand with northern red sea anemone. (Depth not adjusted for tide)

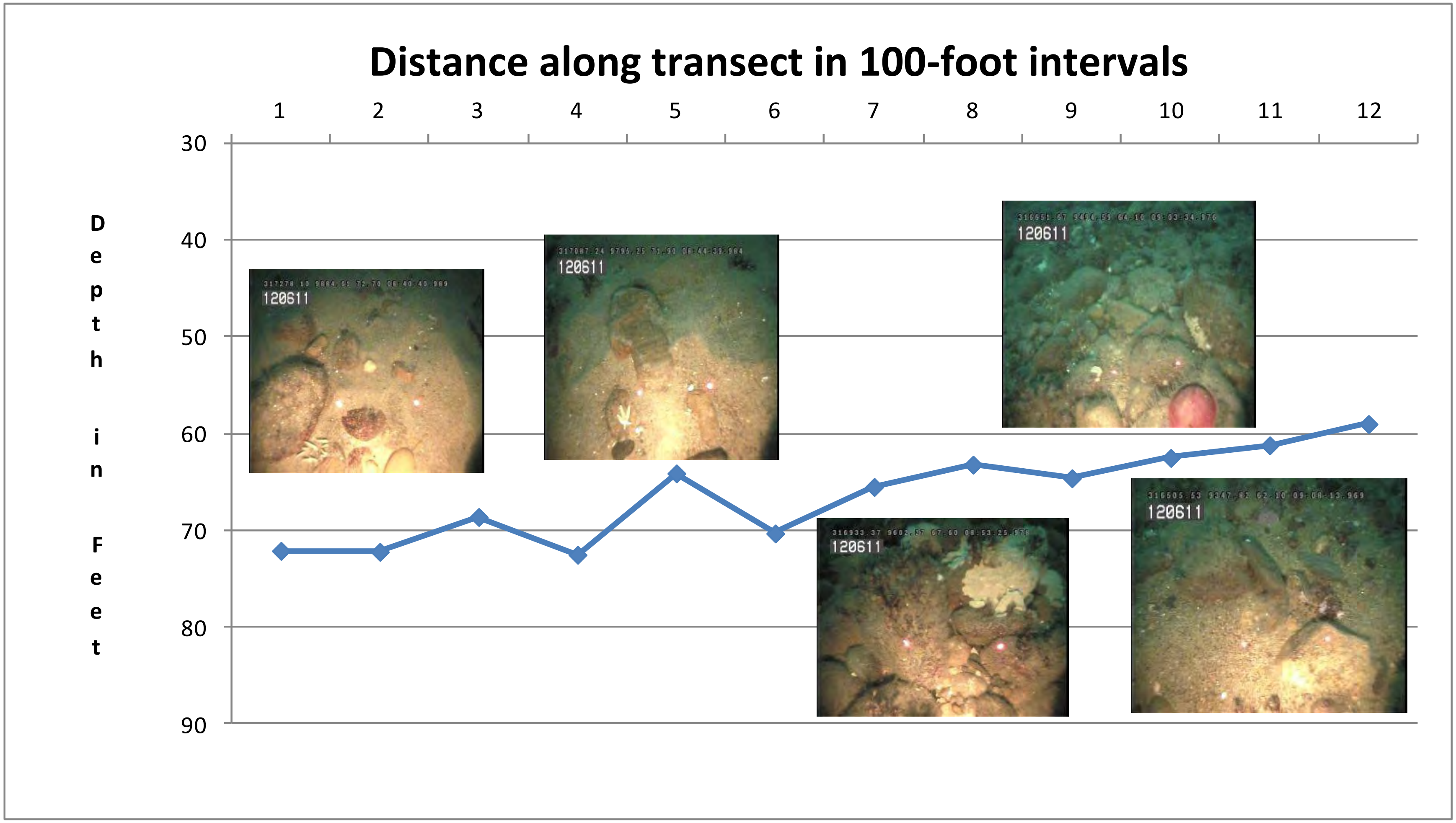

Figure 6. Conditions along video transect VT-12 in southwestern portion of the APE, from left to right: tubular sponge in sand and cobble; sea star on gravel-sand mix; cobble and gravel with crustose algae and encrusting sponge; northern red sea anemone on cobble; sandy cobble area with juvenile black sea bass. (Depth not adjusted for tide)

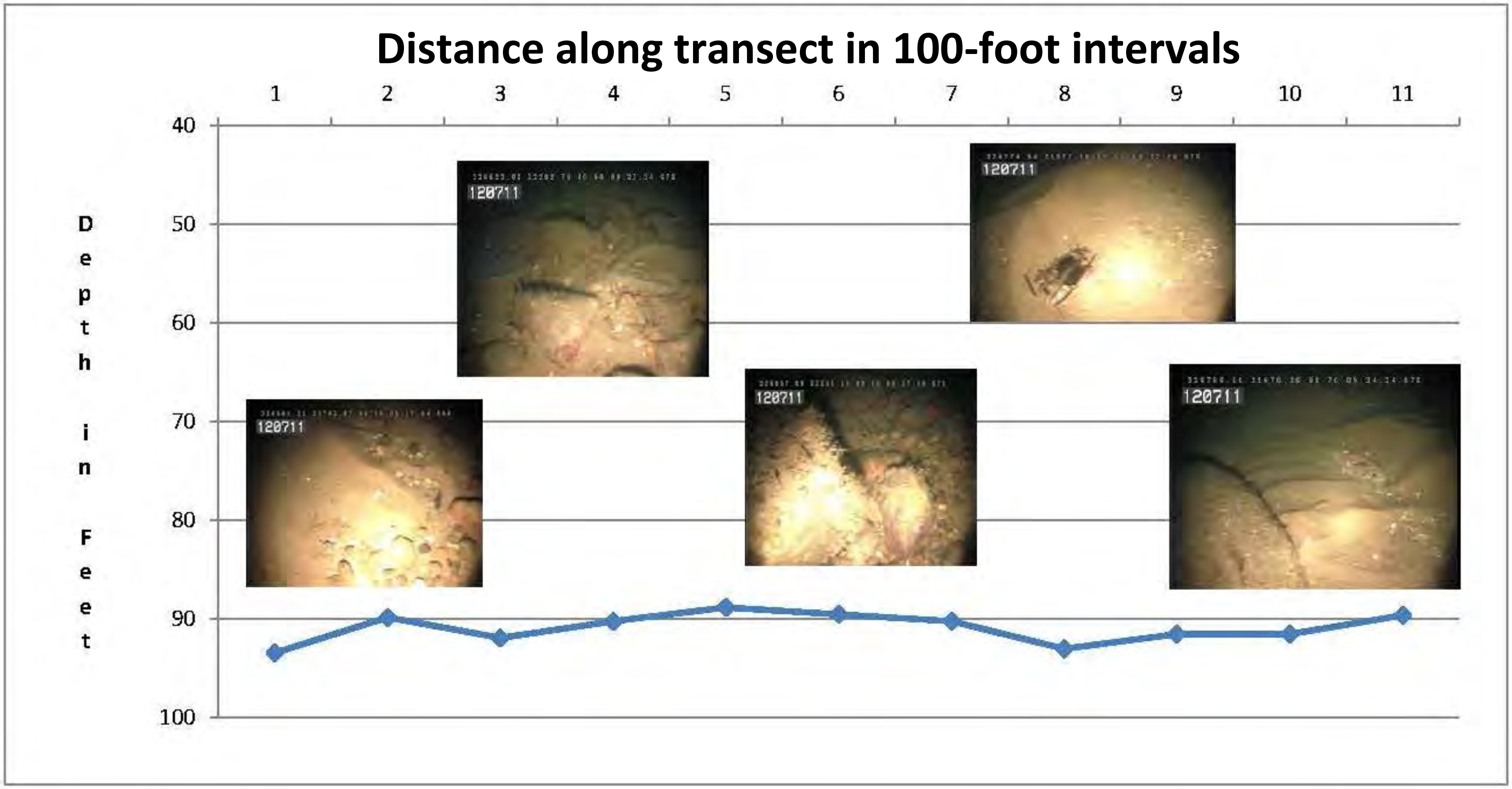

Figure 7. Conditions along video transect VT-15 in northeastern portion of the APE, from left to right: fine to medium sand with scattered gravel; cobble with light layer of silt/fine sand covering crustose algae; cobble with covering of hydroids; skate egg cases; fine sand with boulder and scattered shell hash in sand wave trough. (Depth not adjusted for tide)

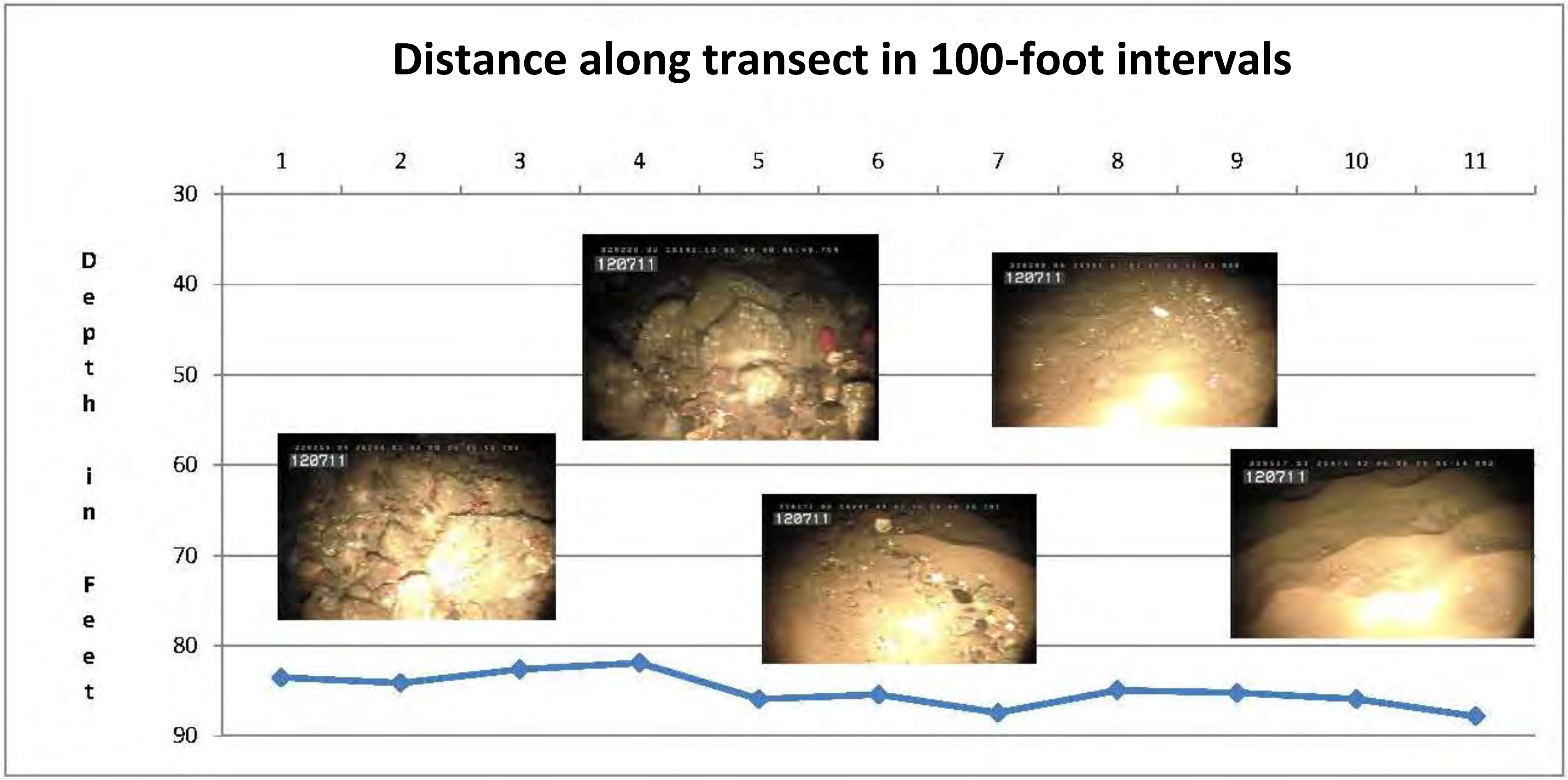

Figure 8. Conditions along video transect VT-17 near the Export Cable, from left to right: cobble and gravel with blood stars, barnacles, and light covering of silt; cobble with northern red sea anemone; sand with scattered gravel; fine to medium sand; sand with small invertebrate castings. (Depth not adjusted for tide)

Tables

Table 1. Substrate types identified by OSI from side scan sonar in Deepwater Wind Farm and Cable surveys.

Type	Description
1	Low reflectivity, low relief, drag marks common, interpreted as fine grained sediments (mostly silt and fine sand) with possible boulders
2	Medium to high reflectivity, moderate relief, sand ribbons distinctive, interpreted as medium to coarse grained sand and gravel, possible isolated boulders
3	Low to high reflectivity, low to moderate relief, interpreted as complex mixture of alternating bottom types including fine to coarse grained sediments and boulders
4	Low to high reflectivity, moderate to high relief, abundant boulders, interpreted as glacial moraine deposits including silt, sand, gravel, and boulders
5	High reflectivity, high relief, interpreted as bedrock outcrops on seafloor

Table 2. Coordinates for Video Transects.

Video Transect	Start		End	
	Easting	Northing	Easting	Northing
VT-1	318175	3752	317456	3265
VT-2	316965	5336	316300	4891
VT-3	316243	6284	315578	5848
VT-4	315570	7107	314905	6662
VT-5	314891	8134	314262	7728
VT-6	313776	9580	313131	9178
VT-7	313518	10175	312814	9730
VT-8	321494	5220	320819	4788
VT-9	320518	6072	319811	5624
VT-10	319434	7447	318754	7023
VT-11	318114	8527	317449	8082
VT-12	317172	9802	316507	9357
VT-13	315786	11150	315121	10705
VT-14	315046	12260	314381	11815
VT-15	328556	22621	328793	21866
VT-16	329790	21514	330027	20759
VT-17	328211	26228	328447	25474
VT-18	328429	26291	328665	25536

All Coordinates are referenced to Rhode Island State Plane (Zone RI-3800), US Feet.

Table 3. Summary of physical and biological features observed in video transects within the BIWF APE and near the Export Cable in areas classified as Type 3 from side scan sonar images.

FEATURES	VT-1	VT-2	VT-3	VT-4	VT-5	VT-6	VT-7	VT-8	VT-9	VT-10	VT-17	VT-18
SUBSTRATE												
sand waves present	yes; 5-6 inches high	yes; gravel and shell debris in troughs										no
sand texture	medium - coarse											
hard substrates	gravel, cobble, few boulders	occasional cobble and boulders	Occasional cobbles or small boulders mixed among sand waves Some distinct areas of predominantly cobble and boulders									
Drape	low											
Relief	low			low- moderate					low	low-moderate		
BIOTA												
Algae												
Coralline algae *	c-a	P	p-c	c	c-a	p-c	p-a	p-c	p	c-a	r-p	r-p
red algae *	p	P	p-c	p-c	c-a	p-c	p-a	p-c	p-c	c-a		
green algae *			r-p		p							
Sponges												
Unidentified encrusting sponge *		P	P	r-p	p	p	p-c	P	r-p	P	r-p	r-p
Sponge (*Polymastia* spp.) *	p	r-p	r-p	r-p	r	r-p (11)	r-p	p-c (69)	p (15)	p (33)		r (2)
Large unidentified sponge							r (6)			r (5)		r (2)
Cnidarians												
Hydroids *	c-a	p-c	p-c	P	p	p-c	p-a	p-c	r-p	c	r-a	P
Jellyfish							r (1)			2		r (4)
Northern stony coral (*Astrangia poculata*) *	p-c	p-c	p	p-c	p-c	p-c	p-c		p	p-c	r-c	r-p
Northern red anemone (*Urticina felina*) *	p	r (5)	r-p (15)	r (6)	r	p	r-p	r-p (15)		r (9)	r-c (45)	r (19)
Polychaetes												
Spirorbids *	p on algae	p on algae	p on algae	p-c on algae	p-c on algae	p-c on algae	p-a on algae	p on algae	p on algae	p-c on algae		
Mollusks												
Sea scallop (*Placopecten magellanicus*)	1								1 (?)			
Chestnut clam (*Astarte spp.)*	1	1 (?)					r (1)	r (6) (?)	r-p (11) (?)	r (2) (?)	r (4)	r (1) (?)
Unidentified bivalve	1		R			1 (?)	r (1)	r (5)		r (1)	r (7)	r (1)
Ocean quahog (*Arctica islandica*)									r (1)			
Horse mussel (*Modiolus modiolus*) *					r (2)							
Arthropods												
Barnacles *	p	p	p-c	p-c	p-c	p-c	p-c	p	r-p	p	p-a	r-p
Hermit crab (*Pagurus* spp.)	r 1)					r (1)on sand		r (12)	r (2)	r (1)	1 r sand	
Hermit crab (*Pagurus pollicaris*)												
Sand shrimp (*Crangon septemspinosa*)			r	r (1)			r (1)	r (1)	r (3)	r (2)	r-p (29)	r (17)
Echinoderms												
Sea star *(Asterias spp.)*						r (2)	r (1)	r (1)				
Blood star *(Henricia sanguinolenta)*	r-p *	r (4) *	r (11) *	r (4) *	r (1) *	r (3) *	r-p (13) *	r (7)	r (1) *	r (4)	r-c (59) *	r (7) *
Common sand dollar *(Echinarachnius parma)*	r (1)							4 r			P	p
Bryozoans												
Spiral tufted bryozoan (*Bugula turrita*)				p *							r (1)	
Unidentified invertebrates												
Invertebrate casings/activity		r-p on sand	p on sand					p on sand	p on sand		p on sand	p on sand
Tube invertebrate										1		

(continued)

Table 3. (Continued)

	TRANSECTS IN AREAS CATEGORIZED AS TYPE III SUBSTRATES BY OSI											
FEATURES	**VT-1**	**VT-2**	**VT-3**	**VT-4**	**VT-5**	**VT-6**	**VT-7**	**VT-8**	**VT-9**	**VT-10**	**VT-17**	**VT-18**
Fish												
Tautog (*Tautog onitis*)						1						
Cunner (*Tautogolabrus adspersus*)	p *	1	p-c (23) *	p (16) *	p-c (27) *		p-c *		1	3		
Goosefish (*Lophius americanus*)					1			1		2		
Black sea bass (*Centropistis striata*)									r (2)	7	4	
Unidentifiable fish	p-c *	p (7) *	p-c (129) *	p-c (72) *	p-c (54) *	p-c (87) *	p-c *; p on sand	p (17) *	p (20) *	p-c (81) *	19	r-p (14)
Winter flounder (*Pseudopleuronectes americanus*)	1								1			
Windowpane (*Scophthalmus aquosus*)												r (1)
unidentified flounder	1			1								
Skate (*Leucoraja* spp.; likely little skate, *L. erinacea*)	3	1	2		1	3	2 sand		1	2		
skate egg case												r (2)

* found on or in association with hard substrate

a = abundant (>50%) p= present (~ 5-25%)

c = common (25-50%) r = rare (~ 5%)

Relief: low =<18" above the surface or embedded; moderate = 18-24"; high = >24"

(?) mollusks – cannot determine if living

Table 4. Distribution of substrate conditions along video transects.

Transect	Approximate distance along transect (feet)												
	0-100	100-200	200-300	300-400	400-500	500-600	600-700	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300
VT-1	C	C	C	C	C	C	C	C	G	CB	CB	C	
VT-2	CB	CB	CB	CB	CB	CB	G	G	G	G			
VT-3	CB				G	CB		G	CB	CB	CB	CB	
VT-4	CB C		G	GCB	GCB	GCB	GCB	CB	S			CB	
VT-5	CB	CB	G	G CB			C	CB	CB		CB		
VT-6	GCB	GC	GCB	GCB	G	G	CBG	G		G			
VT-7	CBG		S	S		G	G	GCB	GCB	G	GCB		G
VT-8	GCB	GCB	GCB	GCB	G		GCB	GCB	GCB	GCB			
VT-9	GC	GC	GCB	GCB	GC	GCB	GCB	G		GCB			
VT-10	G	G	G	G	G	G			GC	GCB			
VT-11	GC	GC	G	G	G	G	G	GC	C	C			
VT-12	GC	GC	GC	GC	GC *	GC *	* GC	* GC	*	* GC	CB*		
VT-13	G	G	G	G	G	G	G	GC	GC	GC	GC		
VT-14	G	G	G	GCB	G	GC	GC	GC	GC	GC	GC	G	
VT-15	GC	GC	GC	GCB	GC	GCB	GCB	GCB	GC	GC			
VT-16	GCB	CB	CB	CB	CB	C	C						
VT-17				G	GCB	GCB	GCB		C				
VT-18	GCB	CB	CB	GCB	CB	CB	C	GC	GC	G			

Primary Substrate

- Sand
- Gravel
- Cobble/Boulder
- Sand with distinct areas of cobble
- Cobble with distinct areas of sand
- Gravel with distinct areas of cobble

Secondary Substrate

G = gravel (generally associated with sand waves, often with shell hash)
C = cobble (scattered)
B = boulder (scattered)
* cobble pavement

Table 5. Summary of physical and biological features observed in video transects within the BIWF APE in areas substrates classified as Type 1/2 or 2/3 from side scan sonar images.

	Transects					
FEATURES	**VT-11**	**VT-12**	**VT-13**	**VT-14**	**VT-15**	**VT-16**
SUBSTRATE						
Sand waves	Yes; gravel and shell hash in troughs	Yes; gravel, shell hash, cobble in troughs	Yes, gravel and shell hash in troughs			Yes; shell hash in troughs
Sand texture	Medium-coarse					Fine-medium-coarse
Hard substrates	Scattered cobble and cobble patches	Transition to cobble pavement	Transition to cobble/boulder area	Occasional cobble	Occasional cobble; patch of boulders	Occasional cobbles
Drape	low	low	low	low	low	low
Relief	low	low	low	low	low, low-mod	low
SSS classification	1-2	1-2	1-2	1-2	2-3	2-3 to 1-2
BIOTA						
Algae						
Coralline algae *	p-c	p-c	p-c	r-p	r	
Red algae *	p-c	p-c	p-c	r-p	r-p	
Green algae *			r-p			
Porifera						
Unidentified sponge *	r	p-c	r-p			
Polymastia spp.		r (18)		r (1)		
Cnidarians						
Hydroids *	r	c-a	r-c	r	p	r-p
Jellyfish						r (1)
Northern stony coral (*Astrangia poculata)*	r-p *	r-p*	r-p*	r-p *	r (1)	
Northern red anemone (*Urticina felina*) *		r (11)	r (3)		r-p (20)	
Unidentified anemone					1	
Polychaetes						
Spirorbids	p on algae	p on algae	p-c on	r on algae		
Mollusks						
Sea scallop *(Placopecten magellanicus)*	1 Alive ?		2 Alive?			1 Alive?
Chestnut clam *(Astarte spp.)*	9 flat, 4 vertical (r)	5 flat, 1 r	150+ flat, 109+ vertical (r-a)	34 flat, 10 vertical (p-c)		1 flat r
Unidentified bivalve		r (7)				
Moon shell (*Lunatia heros*?)			r (1)			
Crustaceans						
Barnacles *	r	r	r-p	r	r	r
Cancer spp.						r (1)
Hermit crab (*Pagurus spp.)*		r (2)				r (1)
Sand shrimp (*Crangon septemspinosa)*	3 r	1 r	4 r	2 r	31 r	3 r
Echinoderms						
Sea star *(Asterias spp.)*	r (2) on sand	r-p (14) *	r (1) *	r (1) *	r (2) *	
Blood star *(Henricia sanguinolenta) **	r (2)	r (5)	r (1)	r (2)		
Common sand dollar *(Echinarachnius parma)*	r (3)	r (1) on sand		r (2)		p-c
Unidentified invertebrates						
Invertebrate casings/activity	r	p on sand	p on sand	p on sand	p on sand	p on sand
Fish						
Windowpane (*Scophthalmus aquosus*)				1		
Juvenile black sea bass (*Centropristis striata*)		20 mostly near/over hard substrate	1			
Sculpin (*Myoxocephalus* spp.)	1 small		1 *			
Unidentified fish	2	c *	r (12)	1	r (6)	
Little skate (*Leucoraja erinacea*)	8	1	2			
Skate (*Leucoraja* sp.)	4 (1 likely Little Skate)	1 (likely Little skate}		3 (likely all Little skates)		
Skate egg case		r (2)	r (1)		p (12)	r (6)

* Found on or in association with hard substrate
a = abundant (>50%)   p = present (~5 – 25%)
c = common (25-50%)   4 = rare (~5%)

Relief: low = <18" above the surface or embedded; moderate = 18-24"; high = >24"
Mollusks: "flat" mollusks may be empty shells

APPENDIX C

The Block Island Transmission System Submarine Cable Phase I Marine Archeology Remote Sensing Identification Survey Report

Report Contains Confidential Site Location Information
NOT FOR PUBLIC DISTRIBUTION

Provided Under Separate Cover

APPENDIX D

Air Emissions Analysis

Air Emissions Analysis

Block Island Wind Farm
and
Block Island Transmission System

Prepared by:

Tetra Tech EC, Inc

on behalf of:

Deepwater Wind Block Island, LLC and

Deepwater Wind Block Island Transmission, LLC

APRIL 2012

TABLE OF CONTENTS

1.0 INTRODUCTION

Deepwater Wind Block Island, LLC, a wholly owned indirect subsidiary of Deepwater Wind Holdings, LLC, proposes to develop the Block Island Wind Farm (BIWF), a 30 megawatt (MW) offshore wind farm located approximately 3 miles southeast of Block Island, Rhode Island. The BIWF will consist of five (5), 6 MW wind turbine generators, a submarine cable interconnecting the WTGs (Inter-Array Cable), and a 34.5 kilovolt (kV) transmission cable from the northernmost WTG to an interconnection point on Block Island (Export Cable). In connection with the BIWF, Deepwater Wind Block Island Transmission, LLC, a wholly owned indirect subsidiary of Deepwater Wind Holdings, LLC, proposes to develop the Block Island Transmission System (BITS), a 34.5 kV bi-directional submarine transmission cable from Block Island to the Rhode Island mainland. For the purposes of this report, the two Deepwater Wind Holdings, LLC corporate entities associated with the development of the BIWF and BITS are collectively referred to as “Deepwater Wind.” Likewise, the BIWF and BITS are collectively referred to as “the Project.”

The purpose of this document is to quantify air emissions from the construction and operation of the proposed BIWF and Block Island Transmission System BITS, and illustrate the methods used to quantify emissions.

1.1 Description of Project Emissions

There are no emissions of air pollutants (criteria air pollutants, hazardous air pollutants, or greenhouse gases) from wind turbines, and this fact is a key driver for this Project. Electrical power generated by the wind turbines will reduce the need for electrical power generated from the combustion of fossil fuel. However, equipment (primarily diesel-fueled equipment) is needed to construct the BIWF and BITS, and there are also some emissions from crew boats and related equipment needed to periodically maintain the wind turbines after they become operational. This report quantifies emissions from vessels and equipment associated with both construction and operation of the Project. If the turbines are decommissioned at some point in the future, there would also be emissions associated with decommissioning, but these are highly speculative (in part because they would probably occur in the distant future) and would probably be comparable to (but lower than) emissions from construction.

1.2 Report Organization

Section 2 of this report provides a summary background with regard to methodologies used to estimate emissions (more details are provided in Attachment A). Section 3 summarizes the construction activities for the project, and describes the associated emissions associated with these activities. Section 4 describes activities associated with Project operation, and describes the associated emissions. Section 5 summarizes the emissions information and also provides information relevant to the potential applicability of General Conformity regulations. Details of calculations are provided in Attachment A.

2.0 EMISSIONS CALCULATION METHODOLOGY

In general, emissions were calculated by multiplying activity data for the Project (e.g., kilowatt-hours of output per engine, horsepower-hours of output per engine, etc.) by emission factors (grams per kWh, grams per hp-hr, etc.) There are three types of emissions sources associated with Project construction and operation, each with distinct emissions calculation methodologies:

1. For commercial marine vessels (CMVs), emissions have been calculated using emission factors from the US EPA report "Current Methodologies and Best Practices in Preparing Port Emission Inventories",[1] and related materials;

2. For emissions from construction and other nonroad engines, US EPA's NONROAD emissions model has been used; and

3. For on-road vehicles, EPA's MOBILE6.2 emissions model has been used, along with input files provided by the Rhode Island Department of Environmental Management (RI DEM).

All calculations reflect the use of diesel fuel with a sulfur content of 0.0015% (15 ppmw), i.e., the maximum sulfur allowed by 40 CFR 80, Subpart I. The 15 ppmw limit is currently in effect for onroad vehicle diesel fuel and nonroad engine (NR) diesel fuel, and applies to locomotive and marine (LM) diesel fuel beginning June 1, 2012 (i.e., before construction of the BIWF and BITS commences).

For CMVs and other nonroad engines, emission factors are expressed per kilowatt-hour or horsepower-hour of output (1 hp = 0.746 kW). Based on experience, Deepwater Wind identified the types of CMVs and other equipment needed for construction, estimated the approximate sizes of the main and auxiliary engines (in horsepower), and identified the number of hours of operation and average % load so that horsepower-hours of power could be estimated. For each CMV, the corresponding fuel usage was calculated so that total fuel use could also be quality-checked for reasonableness by Deepwater Wind. Conservatism on the order of 10-20% was incorporated to account for the fact that the CMVs and other equipment will be provided by contractors and exact specifications cannot be precisely known this far in advance.

Additional details regarding the methodologies are provided in Attachment A.

[1] ICF Consulting, "Current Methodologies and Best Practices in Preparing Port Emission Inventories", prepared for the US EPA Office of Policy, Economics, and Innovation, Sector Strategies Program (Washington, DC) by ICF Consulting (Fairfax, VA), January 5, 2006.

3.0 EMISSIONS FROM PROJECT CONSTRUCTION

The first construction activities to commence will be the onshore construction activities, commencing during the 2013-2014 winter season and continuing into the spring. These activities will include:

(1) activities at Quonset Point (including preparation of the port facilities to support construction phase Project activities, including activities such as assembly of sets of wind turbine jackets from the jackets and transition decks shipped in from the Gulf of Mexico, and load-out/tie-down of the foundation components onto the installation barges);

(2) BIWF land cable activities (i.e., horizontal directional drill (HDD)) for the cable landfall on Block Island, installation of the Export Cable on Block Island between the HDD entry point and the Block Island Power Company (BIPCO) property, expansion of the existing BIPCO substation;

(3) Construction of the Block Island Substation; and

(4) BITS land cable activities (HDD for the cable landfall on Block Island and Narragansett, installation of the BITS cable on Block Island in the same trench as the BIWF Export Cable, installation of the cable between the HDD site and the mainland terminus).

Offshore construction is expected to begin in the spring of 2014 and to be completed by the end of the 2014 construction season. For the BIWF these activities include:

(1) Shipping of the wind turbine jackets and transition decks to the site;

(2) Pre-installation checks of the seabed within 100 feet of the jacket installation locations;

(3) Transportation of the foundation components from Quonset Point to the BIWF offshore construction site, and foundation installation (piles and jacket legs first, followed by the boat landing, transition decks, and other appurtenance);

(4) Transportation of the wind turbines from Quonset Point to the BIWF site using material barges, and installation using jack-up or anchored derrick barges (lower tower, upper tower, nacelle, and blades);

(5) Installation and burial of the underwater Inter-Array cable system and underwater portion of the Export Cable connecting the BIWF to Block Island;

(6) Construction of the Block Island Substation (50% of this is attributed to BIWF, and the other 50% is attributed to BITS); and

(7) Commissioning activities (a crew boat will be the only vessel needed for these activities).

For the BITS, offshore construction activities will include installation and burial of the cabling between Block Island and Narragansett.

Detailed equipment listings and activity information for each of these activities is provided in Attachment A to this report. Emissions from construction activities are summarized in Tables 3-1 through 3-3 below.

Table 3-1. Construction Emissions in 2013.

	2013 – All Emissions					
	VOC tons	NOx tons	CO tons	PM_{10} tons	SO_2 tons	GHG tons CO_2 e
Quonset	0.80	7.16	4.26	0.43	0.011	1,145
BIWF land cable	0.29	2.49	1.47	0.19	0.004	404
Substation BI	0.70	5.77	3.29	0.53	0.007	851
BITS land cable	0.14	1.24	0.74	0.10	0.002	202
BIWF	0	0	0	0	0	0
BITS	0	0	0	0	0	0
TOTAL	1.9	16.7	9.8	1.25	0.024	2,602

Table 3-2. Construction Emissions in 2014.

	2014 – All Emissions					
	VOC tons	NOx tons	CO tons	PM_{10} tons	SO_2 tons	GHG tons CO_2 e
Quonset	5.0	49.4	24.8	3.1	0.06	6,665
BIWF land cable	0.1	1.2	0.7	0.1	0.00	202
Substation BI	0.4	3.5	2.0	0.3	0.00	509
BITS land cable	0.6	5.0	2.9	0.4	0.01	808
BIWF	11.8	344.6	42.6	22.0	0.22	21,866
BITS	5.8	161.8	17.8	9.8	0.10	10,010
TOTAL	23.7	565.5	90.8	35.6	0.39	40,060
O&M	0.1	3.8	0.5	0.3	0.00	278
TOTAL	23.8	569.3	91.4	35.9	0.40	40,338

Table 3-3. Construction Emissions in 2014, on land or in state waters only.

	2014 – Land or State Waters Only					
	VOC tons	NOx tons	CO tons	PM_{10} tons	SO_2 tons	GHG tons CO_2 e
Quonset	5.0	49.4	24.8	3.1	0.06	6,665
BIWF land cable	0.1	1.2	0.7	0.1	0.00	202
Substation BI	0.4	3.5	2.0	0.3	0.00	509
BITS land cable	0.6	5.0	2.9	0.4	0.01	808
BIWF	10.2	299.8	37.5	19.2	0.19	19,083
BITS	4.1	116.2	13.3	7.1	0.07	7,233
TOTAL	20.5	475.2	81.3	30.2	0.34	34,499

4.0 EMISSIONS FROM PROJECT OPERATION

Project operation is expected to commence by the end of 2014. Deepwater Wind expects that Operations and Maintenance (O&M) will be based out of facilities located in the Point Judith area. The facilities will be a combination of office, construction yard, and a small quayside facility. Deepwater Wind expects to utilize an existing waterfront parcel in the Point Judith area.

These facilities will house the Project's administrative support offices, the warehouse facility and maintenance shop for all offshore generating units, as well as a marine terminal for the Project's offshore support and logistics vessels. The essential link between the O&M facilities and the offshore WTGs will be flexible marine transportation services to facilitate frequent inspections and maintenance activities.

Annual emissions during project operation are as shown in Tables 3-4 and 3-5 below. It is expected that operational emissions during calendar year 2014 will be no more than 10% of annual operational emissions (since the project is not scheduled to be operational until the end of 2014). Details of how these emissions were calculated are presented in Attachment A.

Table 3-4. Annual Operational Emissions.

	2015 – All Emissions					
	VOC tons	NOx tons	CO tons	PM_{10} tons	SO_2 tons	GHG tons CO_2 e
TOTAL	0.8	21.4	2.8	1.4	0.01	1,572

Table 3-5. Annual Operational Emissions.

	2015 – Land or State Waters Only					
	VOC tons	NOx tons	CO tons	PM_{10} tons	SO_2 tons	GHG tons CO_2 e
TOTAL	0.7	17.9	2.4	1.2	0.01	1,348

It should be noted that these emissions calculations do not reflect any credit associated with displacing emissions from BIPCO and mainland generating facilities. For example, for CO_2, RIDEM identified that emissions from BIPCO have been 10,328 tons/yr (1,910 lb/MWh),[2] and the latest marginal emissions rates from ISO New England (for calendar year 2010) are 943 lb/MWh. This means that the 105,120 MWh/yr projected to be provided by this project would displace at least 50,000 tons of CO_2 emissions from BIPCO and the mainland.

[2] RI DEM, 2010, Advisory Opinion, Public Utility Commission Docket No. 4185, July 20, 2010.

5.0 SUMMARY AND GENERAL CONFORMITY

As shown in Sections 3 and 4, NO_x is the criteria pollutant emitted in the largest quantities; emissions are highest during peak construction activities in 2014 (567.6 tons, when considering construction and 10% of operational emissions, of which 476.9 tons are on land or in State territorial waters) and are considerably lower in 2013 and post-construction (16.7 tons and 21.4 tons per year, respectively).

Technically, Rhode Island is still classified as a nonattainment area for ozone, even though US EPA more recently identified it as meeting the 1997 ozone standard (i.e., 8-hour average concentrations of 0.08 ppm or less) and has also proposed that it be classified as “attainment/unclassifiable” with respect to the latest ozone standard (8-hour average concentrations of 0.075 ppm or less). It is currently expected that Rhode Island will be formally reclassified as “attainment/unclassifiable” in the spring or summer of 2013, prior to the commencement of Project construction activities, and that therefore EPA General Conformity regulations will not apply. However, if that reclassification does not occur, General Conformity requirements would be triggered by the fact that emissions in 2014 exceed 100 tons, and emissions offsets would need to be procured prior to construction.

ATTACHMENT A

EMISSIONS CALCULATION METHODOLOGY

The following pages in this Attachment identify the emission factors and other inputs to the emissions calculations identified in this report. As described in Section 2, there are three primary categories for which emissions were calculated:

- Commercial marine vessels (CMVs);
- Other nonroad engines; and
- On-road vehicles.

Commercial Marine Vessels (CMVs)

The US EPA guidance for CMV emissions referenced in Section 2.0 categorizes tugboats, crew boats, etc. as harborcraft and identifies the emission factors shown in Table A-1 below. (Although emission factors for PM are listed as being based on much higher fuel sulfur contents, to be conservative, the emission factors were not adjusted downward to account for the 15 ppmw sulfur diesel.)

Table A-1 Emission Factors from US EPA guidance.

	Emission Factors, g/k Wh				
	NOx	CO	HC	PM_{10}*	PM_{25}*
Category 1 engines (<5 L/cylinder) 37-75 kW	11.0	2.0	027	0.9	0.87
75-130 kW	10.0	1.7	0.27	0.4	0.39
130-225 kW	10.0	1.5	0.27	0.4	0.39
225-450 kW	10.0	1.5	0.27	0.3	0.29
450-560 kW	10.0	1.5	0.27	0.3	0.29
560-1000 kW	10.0	1.5	0.27	0.3	0.29
1000+ kW	13.0	2.5	0.27	0.3	0.29
Category 2 engines (<5 L/cylinder)	13.2	1.10	0.50	0.72	0.58

*Cited as being based on 1.5% fuel sulfur content

Source: ICF Consulting, "Current Methodologies and Best Practices in Preparing Port Emission Inventories", prepared for the US EPA Office of Policy, Economics, and Innovation, Sector Strategies Program (Washington, DC) by ICF Consulting (Fairfax, VA), January 5, 2006, p. 28.

Emissions of SO_2 and CO_2 were conservatively based on an average fuel consumption of 0.054 gal/hp-hr = 0.072 gal/kWh (based on a conversion factor of 0.746 kW/hp), fuel density of 3.3 kg/gal, sulfur content of 0.0015% (15 ppmw), and carbon content of 87% by weight; these result in emission factors of

$$\frac{0.072\text{ g}}{\text{kWh}} \times \frac{3.3\text{ kg}}{\text{gal}} \times \frac{0.015\text{ g S}}{\text{kg}} \times \frac{64\text{ g SO}_2}{32\text{ g S}} = 0.007\text{ g SO}_2\text{/kWh} = 0.005\text{ g SO}_2\text{/hp-hr}$$

$$\frac{0.072\text{ g}}{\text{kWh}} \times \frac{3.3\text{ kg}}{\text{gal}} \times \frac{870\text{ g C}}{\text{kg}} \times \frac{44\text{ g CO}_2}{12\text{ g C}} = 760\text{ g CO}_2\text{/kWh} = 567\text{ g CO}_2\text{/hp-hr}$$

Emissions of CH_4 and N_2O were based on US EPA emission factors for marine diesels (0.230 g CH_4/kg fuel and 0.080 g N_2O/kg fuel, respectively):[3]

$$\frac{0.230\ \text{g CH}_4}{\text{kg}} \times \frac{3.3\ \text{kg}}{\text{gal}} \times \frac{0.072\ \text{gal}}{\text{kWh}} = 0.055\ \text{g CH}_4\text{/kWh} = 0.041\ \text{g CH}_4\text{/hp-hr}$$

$$\frac{0.080\ \text{g N}_2\text{O}}{\text{kg}} \times \frac{3.3\ \text{kg}}{\text{gal}} \times \frac{0.072\ \text{gal}}{\text{kWh}} = 0.019\ \text{g N}_2\text{O/kWh} = 0.014\ \text{g N}_2\text{O/hp-hr}$$

Other Nonroad Engines

For cranes, forklifts, pumps, generators, and other nonroad engines, emission factors were calculated using EPA's NONROAD2008a emission model. To calculate emission factors for this project, a run was conducted for summer 2013, using the options shown in Figure A-1. (Temperature inputs were obtained from RI DEM[4] but do not impact diesel emissions calculated by NONROAD.[5])

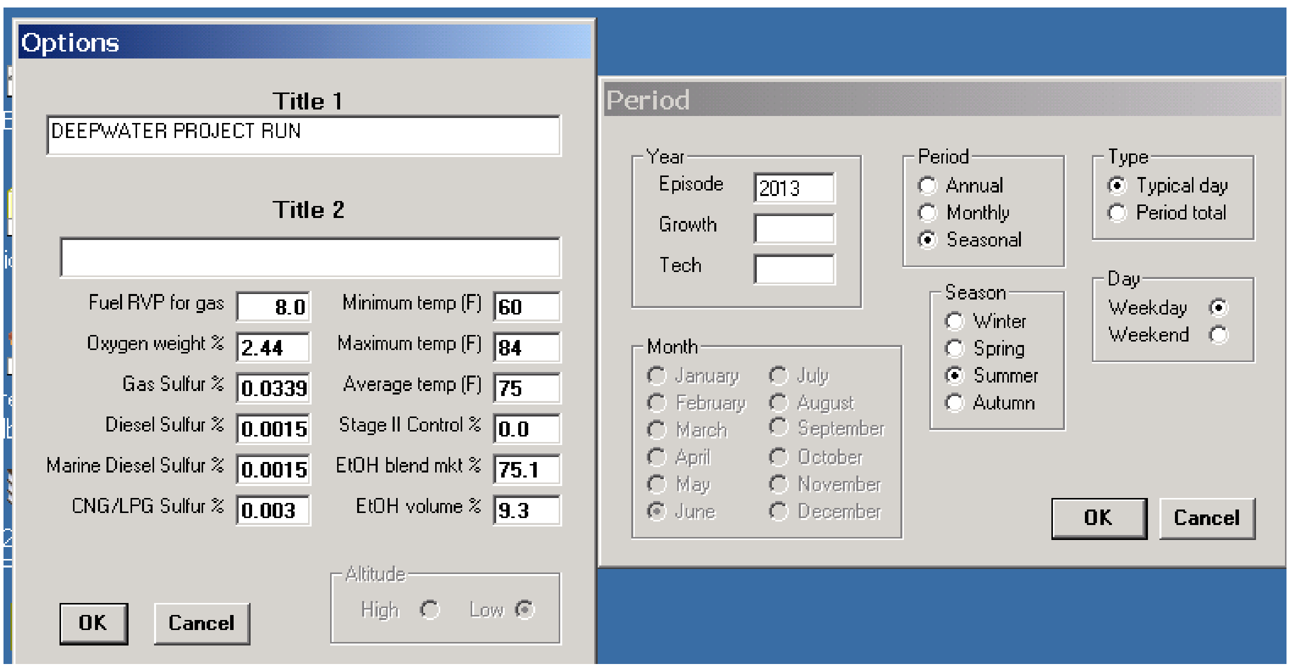

Figure A-1 NONROAD Model Input Options

[3] US EPA (2008) "Direct Emissions from Mobile Combustion Sources". Climate Leaders: Greenhouse Gas Inventory Protocol, Core Module Guidance. EPA430-K-08-004. May.

[4] Ron Marnicio (RI DEM), electronic mail message to Todd Tamura (Tetra Tech), Dec. 14, 2011.

[5] US EPA, Temperature Corrections for Non-road Exhaust Emissions, EPA420-R-05-014 (NR-001c), December 2005.

On-Road Engines

Emissions associated with on-road vehicles are negligible compared to those from the CMVs and nonroad engines, due in part to smaller engine sizes and more stringent emission standards. MOBILE6.2 model input files were provided by RI DEM for purposes of calculating emissions.

SUMMARY - AIR EMISSIONS FOR DEEPWATER BIWF/BITS PROJECT
2013

	2013 - All Emissions									**2013 - Land or State Waters Only**								
	VOC	NOx	CO	PM10	SO2	GHG	CO2	CH4	N2O	VOC	NOx	CO	PM10	SO2	GHG	CO2	CH4	N2O
	tons	tons	tons	tons	tons	tons CO_2e	tons	tons	tons	tons	tons	tons	tons	tons	tons CO_2e	tons	tons	tons
Quonset	0.80	7.16	4.26	0.43	0.011	1,145	1,125	0.13	0.06	0.80	7.16	4.26	0.43	0.011	1,145	1,125	0.13	0.06
BIWF land cable	0.29	2.49	1.47	0.19	0.004	404	398	0.04	0.02	0.29	2.49	1.47	0.19	0.004	404	398	0.04	0.02
Substation BI	0.70	5.77	3.29	0.53	0.007	851	843	0.05	0.02	0.70	5.77	3.29	0.53	0.007	851	843	0.05	0.02
BITS land cable	0.14	1.24	0.74	0.10	0.002	202	199	0.02	0.01	0.14	1.24	0.74	0.10	0.002	202	199	0.02	0.01
BIWF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BITS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**1.9**	**16.7**	**9.8**	**1.25**	**0.024**	**2,602**	**2,565**	**0.24**	**0.10**	**1.9**	**16.7**	**9.8**	**1.25**	**0.024**	**2,602**	**2,565**	**0.24**	**0.10**
O&M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**1.9**	**16.7**	**9.8**	**1.25**	**0.024**	**2,602**	**2,565**	**0.24**	**0.10**	**1.9**	**16.7**	**9.8**	**1.25**	**0.024**	**2,602**	**2,565**	**0.24**	**0.10**

BITS ONLY

2013 - All Emissions									
VOC	NOx	CO	PM10	SO2	GHG	CO2	CH4	N2O	
tons	tons	tons	tons	tons	tons CO_2e	tons	tons	tons	
0.80	7.16	4.26	0.43	0.011	1,145	1,125	0.13	0.06	Quonset*
0.35	2.88	1.65	0.27	0.004	425	422	0.02	0.01	Substation BI**
0.14	1.24	0.74	0.10	0.002	202	199	0.02	0.01	BITS land cable
0	0	0	0	0	0	0	0	0	BITS
1.29	11.29	6.64	0.80	0.016	1,773	1,746	0.17	0.08	**TOTAL**
0.49	4.13	2.38	0.36	0.006	627	621	0.04	0.02	**TOTAL (no Quonset)**

*Includes BITS and BIWF

**BITS portion only (50% of total emissions from substation construction)

BIWF ONLY

2013 - All Emissions									
VOC	NOx	CO	PM10	SO2	GHG	CO2	CH4	N2O	
tons	tons	tons	tons	tons	tons CO_2e	tons	tons	tons	
0.80	7.16	4.26	0.43	0.011	1,145	1,125	0.13	0.06	Quonset*
0.29	2.49	1.47	0.19	0.004	404	398	0.04	0.02	BIWF land cable
0.35	2.88	1.65	0.27	0.004	425	422	0.02	0.01	Substation BI**
0	0	0	0	0	0	0	0	0	BIWF
1.43	12.53	7.38	0.89	0.018	1,975	1,945	0.19	0.08	**TOTAL**

*Includes BITS and BIWF

**BIWF portion only (50% of total emissions from substation construction)

SUMMARY - AIR EMISSIONS FOR DEEPWATER BIWF/BITS PROJECT
2014

	2014 - All Emissions									2014 - Land or State Waters Only								
	VOC	NOx	CO	PM10	SO2	GHG	CO2	CH4	N2O	VOC	NOx	CO	PM10	SO2	GHG	CO2	CH4	N2O
	tons	tons	tons	tons	tons	tons CO_2e	tons	tons	tons	tons	tons	tons	tons	tons	tons CO_2e	tons	tons	tons
Quonset	5.0	49.4	24.8	3.1	0.06	6,665	6,571	0.60	0.26	5.0	49.4	24.8	3.1	0.06	6,665	6,571	0.60	0.26
BIWF land cable	0.1	1.2	0.7	0.1	0.00	202	199	0.02	0.01	0.1	1.2	0.7	0.1	0.00	202	199	0.02	0.01
Substation BI	0.4	3.5	2.0	0.3	0.00	509	504	0.03	0.01	0.4	3.5	2.0	0.3	0.00	509	504	0.03	0.01
BITS land cable	0.6	5.0	2.9	0.4	0.01	808	796	0.08	0.03	0.6	5.0	2.9	0.4	0.01	808	796	0.08	0.03
BIWF	11.8	344.6	42.6	22.0	0.22	21,866	21,664	1.55	0.55	10.2	299.8	37.5	19.2	0.19	19,083	18,907	1.35	0.48
BITS	5.8	161.8	17.8	9.8	0.10	10,010	9,918	0.71	0.25	4.1	116.2	13.3	7.1	0.07	7,233	7,166	0.51	0.18
TOTAL	**23.7**	**565.5**	**90.8**	**35.6**	**0.39**	**40,060**	**39,653**	**2.99**	**1.11**	**20.5**	**475.2**	**81.3**	**30.2**	**0.34**	**34,499**	**34,143**	**2.59**	**0.97**
O&M	0.1	2.1	0.3	0.1	0.00	157	156	0.01	0.00	0.1	1.8	0.2	0.1	0.00	135	134	0.01	0.00
TOTAL	**23.8**	**567.6**	**91.1**	**35.7**	**0.39**	**40,217**	**39,809**	**3.00**	**1.12**	**20.6**	**476.9**	**81.5**	**30.3**	**0.34**	**34,634**	**34,277**	**2.60**	**0.98**

BITS ONLY

2014 - All Emissions									
VOC	NOx	CO	PM10	SO2	GHG	CO2	CH4	N2O	
tons	tons	tons	tons	tons	tons CO_2e	tons	tons	tons	
5.00	49.40	24.76	3.07	0.061	6,665	6,571	0.60	0.26	Quonset*
0.21	1.74	1.01	0.16	0.002	254	252	0.01	0.01	Substation BI**
0.57	4.98	2.94	0.38	0.007	808	796	0.08	0.03	BITS land cable
5.78	161.77	17.82	9.76	0.100	10,010	9,918	0.71	0.25	BITS
11.56	217.88	46.54	13.37	0.171	17,738	17,537	1.40	0.55	**TOTAL**
6.56	168.48	21.77	10.30	0.110	11,073	10,966	0.80	0.29	**TOTAL (no Quonset)**

BIWF ONLY

2014 - All Emissions									2014 - Land or State Waters Only								
VOC	NOx	CO	PM10	SO2	GHG	CO2	CH4	N2O	VOC	NOx	CO	PM10	SO2	GHG	CO2	CH4	N2O
tons	tons	tons	tons	tons	tons CO_2e	tons	tons	tons	tons	tons	tons	tons	tons	tons CO_2e	tons	tons	tons
5.00	49.40	24.76	3.07	0.061	6,665	6,571	0.60	0.26	5.00	49.40	24.76	3.07	0.061	6,665	6,571	0.60	0.26
0.14	1.24	0.74	0.10	0.002	202	199	0.02	0.01	0.14	1.24	0.74	0.10	0.002	202	199	0.02	0.01
0.21	1.74	1.01	0.16	0.002	254	252	0.01	0.01	0.21	1.74	1.01	0.16	0.002	254	252	0.01	0.01
11.78	344.65	42.56	21.97	0.218	21,866	21,664	1.55	0.55	10.23	299.82	37.54	19.19	0.192	19,083	18,907	1.35	0.48
17.14	397.03	69.07	25.29	0.283	28,987	28,687	2.18	0.82	15.58	352.20	64.05	22.52	0.257	26,204	25,929	1.98	0.75

SUMMARY - ANNUAL AIR EMISSIONS FOR DEEPWATER BIWF/BITS PROJECT
2015 AND BEYOND

	2015 - All Emissions									**2015 - Land or State Waters Only**								
	VOC	NOx	CO	PM10	SO2	GHG	CO2	CH4	N2O	VOC	NOx	CO	PM10	SO2	GHG	CO2	CH4	N2O
	tons	tons	tons	tons	tons	tons CO_2e	tons	tons	tons	tons	tons	tons	tons	tons	tons CO_2e	tons	tons	tons
Quonset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BIWF land cable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Substation BI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BITS land cable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BIWF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BITS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**0.0**	**0.0**	**0.0**	**0.0**	**0.00**	**0**	**0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.00**	**0**	0	0	0
O&M	0.8	21.4	2.8	1.4	0.01	1,572	1,559	0.1	0.0	0.7	17.9	2.4	1.2	0.01	1,348	1,337	0.1	0.0
TOTAL	**0.8**	**21.4**	**2.8**	**1.4**	**0.01**	**1,572**	**1,559**	**0.1**	**0.0**	**0.7**	**17.9**	**2.4**	**1.2**	**0.01**	**1,348**	**1,337**	**0.1**	**0.0**

EMISSIONS AT QUONSET POINT

Construction Equipment	HP per unit	fuel	Emiss. Factor ID	hrs per day	Load Factor	2013												2014												Total Equip. Months	Fuel Use 2013 gal	2014 gal	total gal
						J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D				
Land-based Nonroad Equip.																																	
Crane - Crawler	500	diesel	111	18	40%										0	0	0	0	0	0	0	1	2	2	1					6	0	33,860	33,860
Crane - Crawler	350	diesel	111	18	40%										0	0	0	0	0	0	0	1	2	2	1					6	0	23,702	23,702
15 Ton Picker	150	diesel	109	12	60%										1	1	1	1	1	1	1	1	1	1	1					11	5,078	13,541	18,619
60 Ton Hydraulic Crane	290	diesel	110	18	40%										1	1	1	1	1	1	1	1	1	1	1					11	9,819	26,184	36,003
Seawater Pumps	450	diesel	126	24	100%										0	0	0	0	0	2	2	2	2	2	2					12	0	203,011	203,011
Forklift 8000 lbs	75	diesel	117	18	60%										1	1	1	1	1	1	1	1	1	1	1					11	4,277	11,406	15,684
Diesel Welder	55	diesel	129	18	50%										2	2	2	2	2	2	3	3	3	3	3					27	6,075	21,263	27,338
Generator	440	diesel	124	24	40%										2	2	2	2	2	2	2	2	2	2	2					22	39,700	105,867	145,567
Air Compressor	55	diesel	127	18	40%										1	1	1	1	1	1	1	1	1	1	1					11	2,069	5,517	7,586
Light Tower	50	diesel	102	24	60%										2	2	2	2	2	2	4	4	4	4	4					32	7,523	32,601	40,125
Multi-wheeled trailer	400	diesel	154	18	60%										0	0	0	0	0	0	0	1	1	1	1					4	0	35,346	35,346
Onroad Vehicles																																	
Tandem Truck	200	diesel	154	18	50%										1	1	1	1	1	1	1	1	1	1	1					11	9,720	25,920	35,640
Pickup F150	200	petrol	151	18	25%										2	2	2	2	2	2	2	3	3	3	3					26	9,720	32,400	42,120
Fuel Truck	200	diesel	154	18	40%										1	1	1	1	1	1	1	1	1	1	1					11	7,776	20,736	28,512
Dutch bike	1	man	(N/A)	24	80%										1	1	1	1	1	1	1	1	1	1	1					11	0	0	0
																														Total	101,758	591,353	693,111

Calculations assume equipment is used 7 days/wk - i.e 30 days/month

EMISSIONS AT QUONSET POINT

						Emissions - 2013								Emissions - 2014							
Construction Equipment	HP per unit	fuel	Emiss. Factor ID	hrs per day	Load Factor	VOC tons	NOx tons	CO tons	PM10 tons	SO2 tons	CO2 tons	CH4 tons	N2O tons	VOC tons	NOx tons	CO tons	PM10 tons	SO2 tons	CO2 tons	CH4 tons	N2O tons
Land-based Nonroad Equip.																					
Crane - Crawler	500	diesel	111	18	40%	0.00	0.00	0.00	0.00	0.0000	0	0.000	0.000	0.16	2.8	0.71	0.11	0.003	379	0.02	0.010
Crane - Crawler	350	diesel	111	18	40%	0.00	0.00	0.00	0.00	0.0000	0	0.000	0.000	0.11	2.0	0.50	0.08	0.002	265	0.02	0.007
15 Ton Picker	150	diesel	109	12	60%	0.03	0.35	0.09	0.02	0.0005	57	0.003	0.001	0.08	0.9	0.23	0.06	0.001	152	0.01	0.004
60 Ton Hydraulic Crane	290	diesel	110	18	40%	0.05	0.63	0.13	0.03	0.0009	110	0.006	0.003	0.13	1.7	0.35	0.07	0.002	293	0.02	0.007
Seawater Pumps	450	diesel	126	24	100%	0.00	0.00	0.00	0.00	0.0000	0	0.000	0.000	1.53	20.6	6.53	1.01	0.020	2,271	0.13	0.058
Forklift 8000 lbs	75	diesel	117	18	60%	0.02	0.25	0.18	0.02	0.0004	48	0.003	0.001	0.04	0.7	0.49	0.05	0.001	128	0.01	0.003
Diesel Welder	55	diesel	129	18	50%	0.13	0.56	0.64	0.09	0.0006	68	0.004	0.002	0.46	2.0	2.24	0.33	0.002	238	0.01	0.006
Generator	440	diesel	124	24	40%	0.30	4.03	1.26	0.19	0.0039	444	0.025	0.011	0.80	10.7	3.37	0.51	0.010	1,184	0.07	0.030
Air Compressor	55	diesel	127	18	40%	0.02	0.17	0.09	0.01	0.0002	23	0.001	0.001	0.04	0.5	0.25	0.04	0.001	62	0.00	0.002
Light Tower	50	diesel	102	24	60%	0.06	0.67	0.25	0.05	0.0008	84	0.005	0.002	0.24	2.9	1.07	0.21	0.003	365	0.02	0.009
Multi-wheeled trailer	400	diesel	154	18	60%	0.00	0.00	0.00	0.00	0.0000	0	0.000	0.000	0.76	3.2	3.72	0.55	0.004	395	0.02	0.010
Onroad Vehicles																					
Tandem Truck	200	diesel	154	18	50%	0.03	0.19	0.07	0.01	0.0010	109	0.000	0.000	0.08	0.52	0.19	0.02	0.0027	290	0.001	0.001
Pickup F150	200	petrol	151	18	25%	0.15	0.15	1.49	0.00	0.0018	95	0.080	0.034	0.50	0.50	4.96	0.02	0.0058	317	0.266	0.113
Fuel Truck	200	diesel	154	18	40%	0.02	0.16	0.06	0.01	0.0008	87	0.000	0.000	0.07	0.42	0.15	0.02	0.0022	232	0.001	0.001
Dutch bike	1	man	(N/A)	24	80%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
						0.80	7.16	4.26	0.43	0.0109	1125	0.128	0.056	5.00	49.4	24.8	3.1	0.061	6,571	0.60	0.26

Calculations assume equipment is used 7 days/wk - i.e 30 days/mo

BIWF LAND CABLE ACTIVITIES

Construction Equipment	HP per unit	fuel	Emiss. Factor ID	hrs per day	Load Factor	2013												2014												Total Equip.	Fuel Use 2013	2014	total
						J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	Months	gal	gal	gal
Land-based Nonroad Equip.																																	
Concrete Saw	100	diesel	106	4	90%											1	1	1												3	506	253	760
Mounted Impact Hammer (Hoe Ram)	100	diesel	116	4	90%											1	1	1												3	506	253	760
Dump Truck	200	diesel	114	10	50%											1	1	1												3	1,268	634	1,902
Concrete Truck	250	diesel	114	4	50%											1	1	1												3	634	317	951
Flatbed Truck (Material Supply)	150	diesel	113	6	50%											1	1	1												3	571	285	856
Crane-road	200	diesel	110	6	50%											1	1	1												3	752	376	1,129
Paver	200	diesel	100	4	50%											1	1	1												3	507	254	761
Earth Compactor	200	diesel	101	4	75%											1	1	1												3	761	380	1,141
Tracked Excavator	200	diesel	105	10	50%											1	1	1												3	1,268	634	1,902
Chop Saw	200	diesel	107	2	75%											1	1	1												3	380	190	570
Bobcat	80	diesel	104	6	50%											1	1	1												3	338	169	507
Winch Truck	200	diesel	114	4	50%											1	1	1												3	507	254	761
Air Compressor	100	diesel	128	12	50%											1	1	1												3	836	418	1,254
waterpump	100	diesel	125	24	40%											1	1	1												3	1,336	668	2,004
HDD Drilling Machine	300	diesel	103	12	75%											1	1	1												3	3,383	1,691	5,074
Mud Pumps	100	diesel	125	12	75%											2	2	2												6	2,505	1,253	3,758
Generator	200	diesel	123	12	75%											2	2	2												6	4,510	2,255	6,765
Slurry Plant	100	diesel	108	12	75%											1	1	1												3	1,253	626	1,879
Desilter	100	diesel	119	12	75%											1	1	1												3	1,254	627	1,881
Shale Shaker	100	diesel	119	12	75%											1	1	1												3	1,254	627	1,881
Backhoe	100	diesel	115	4	75%											1	1	1												3	491	246	737
Boom Truck	100	diesel	113	6	50%											1	1	1												3	380	190	571
Loader	100	diesel	115	6	50%											1	1	1												3	491	246	737
Crane	200	diesel	110	6	50%											1	1	1												3	752	376	1,129
Diesel Welder	55	diesel	129	4	50%											1	1	1												3	180	90	270
Light Tower	50	diesel	102	24	60%											2	2	2												6	2,006	1,003	3,009
Onroad Vehicles																																	
Tandem Truck	200	diesel	154	18	50%											1	1	1												3	2,592	1,296	3,888
Pickup F150 1	200	petrol	151	18	25%											2	2	2												6	2,592	1,296	3,888
Fuel Truck	200	diesel	154	18	40%											1	1	1												3	2,074	1,037	3,110
																														Total	35,888	17,944	53,833

Calculations assume equipment is used 7 days/wk - i.e., 30 days/month

BIWF LAND CABLE ACTIVITIES

						Emissions - 2013								Emissions - 2014							
Construction Equipment	HP per unit	fuel	Emiss. Factor ID	hrs per day	Load Factor	VOC tons	NOx tons	CO tons	PM10 tons	SO2 tons	CO2 tons	CH4 tons	N2O tons	VOC tons	NOx tons	CO tons	PM10 tons	SO2 tons	CO2 tons	CH4 tons	N2O tons
Land-based Nonroad Equip.																					
Concrete Saw	100	diesel	106	4	90%	0.00	0.04	0.03	0.00	0.0000	6	0.000	0.000	0.00	0.0	0.02	0.00	0.000	3	0.00	0.000
Mounted Impact Hammer (Hoe Ram)	100	diesel	116	4	90%	0.00	0.04	0.03	0.00	0.0000	6	0.000	0.000	0.00	0.0	0.02	0.00	0.000	3	0.00	0.000
Dump Truck	200	diesel	114	10	50%	0.00	0.05	0.02	0.00	0.0001	14	0.001	0.000	0.00	0.0	0.01	0.00	0.000	7	0.00	0.000
Concrete Truck	250	diesel	114	4	50%	0.00	0.03	0.01	0.00	0.0001	7	0.000	0.000	0.00	0.0	0.00	0.00	0.000	4	0.00	0.000
Flatbed Truck (Material Supply)	150	diesel	113	6	50%	0.00	0.03	0.01	0.00	0.0001	6	0.000	0.000	0.00	0.0	0.01	0.00	0.000	3	0.00	0.000
Crane-road	200	diesel	110	6	50%	0.00	0.05	0.01	0.00	0.0001	8	0.000	0.000	0.00	0.0	0.00	0.00	0.000	4	0.00	0.000
Paver	200	diesel	100	4	50%	0.00	0.03	0.01	0.00	0.0000	6	0.000	0.000	0.00	0.0	0.00	0.00	0.000	3	0.00	0.000
Earth Compactor	200	diesel	101	4	75%	0.00	0.05	0.01	0.00	0.0001	9	0.000	0.000	0.00	0.0	0.01	0.00	0.000	4	0.00	0.000
Tracked Excavator	200	diesel	105	10	50%	0.01	0.06	0.02	0.00	0.0001	14	0.001	0.000	0.00	0.0	0.01	0.00	0.000	7	0.00	0.000
Chop Saw	200	diesel	107	2	75%	0.00	0.03	0.01	0.00	0.0000	4	0.000	0.000	0.00	0.0	0.00	0.00	0.000	2	0.00	0.000
Bobcat	80	diesel	104	6	50%	0.00	0.02	0.02	0.00	0.0000	4	0.000	0.000	0.00	0.0	0.01	0.00	0.000	2	0.00	0.000
Winch Truck	200	diesel	114	4	50%	0.00	0.02	0.01	0.00	0.0000	6	0.000	0.000	0.00	0.01	0.00	0.00	0.0000	3	0.000	0.000
Air Compressor	100	diesel	128	12	50%	0.01	0.07	0.04	0.01	0.0001	9	0.001	0.000	0.00	0.03	0.02	0.00	0.0000	5	0.000	0.000
waterpump	100	diesel	125	24	40%	0.02	0.13	0.07	0.01	0.0001	15	0.001	0.000	0.01	0.06	0.04	0.01	0.0001	7	0.000	0.000
HDD Drilling Machine	300	diesel	103	12	75%	0.03	0.35	0.10	0.02	0.0003	38	0.002	0.001	0.01	0.18	0.05	0.01	0.0002	19	0.001	0.000
Mud Pumps	100	diesel	125	12	75%	0.03	0.24	0.13	0.02	0.0002	28	0.002	0.001	0.01	0.12	0.07	0.01	0.0001	14	0.001	0.000
Generator	200	diesel	123	12	75%	0.04	0.46	0.13	0.03	0.0004	50	0.003	0.001	0.02	0.23	0.07	0.01	0.0002	25	0.001	0.001
Slurry Plant	100	diesel	108	12	75%	0.01	0.13	0.07	0.01	0.0001	14	0.001	0.000	0.01	0.06	0.03	0.01	0.0001	7	0.000	0.000
Desilter	100	diesel	119	12	75%	0.01	0.10	0.05	0.01	0.0001	14	0.001	0.000	0.00	0.05	0.03	0.00	0.0001	7	0.000	0.000
Shale Shaker	100	diesel	119	12	75%	0.01	0.10	0.05	0.01	0.0001	14	0.001	0.000	0.00	0.05	0.03	0.00	0.0001	7	0.000	0.000
Backhoe	100	diesel	115	4	75%	0.01	0.04	0.05	0.01	0.0000	5	0.000	0.000	0.00	0.02	0.03	0.00	0.0000	3	0.000	0.000
Boom Truck	100	diesel	113	6	50%	0.00	0.02	0.01	0.00	0.0000	4	0.000	0.000	0.00	0.01	0.00	0.00	0.0000	2	0.000	0.000
Loader	100	diesel	115	6	50%	0.01	0.04	0.05	0.01	0.0000	5	0.000	0.000	0.00	0.02	0.03	0.00	0.0000	3	0.000	0.000
Crane	200	diesel	110	6	50%	0.00	0.05	0.01	0.00	0.0001	8	0.000	0.000	0.00	0.02	0.00	0.00	0.0000	4	0.000	0.000
Diesel Welder	55	diesel	129	4	50%	0.00	0.02	0.02	0.00	0.0000	2	0.000	0.000	0.00	0.01	0.01	0.00	0.0000	1	0.000	0.000
Light Tower	50	diesel	102	24	60%	0.01	0.18	0.07	0.01	0.0002	22	0.001	0.001	0.01	0.09	0.03	0.01	0.0001	11	0.001	0.000
Onroad Vehicles																					
Tandem Truck	200	diesel	154	18	50%	0.01	0.05	0.02	0.00	0.0003	29	0.000	0.000	0.00	0.03	0.01	0.00	0.0001	15	0.000	0.000
Pickup F150 1	200	petrol	151	18	25%	0.04	0.04	0.40	0.00	0.0005	25	0.021	0.009	0.02	0.02	0.20	0.00	0.0002	13	0.011	0.005
Fuel Truck	200	diesel	154	18	40%	0.01	0.04	0.02	0.00	0.0002	23	0.000	0.000	0.00	0.02	0.01	0.00	0.0001	12	0.000	0.000
						0.29	2.49	1.47	0.19	0.0037	398	0.040	0.017	0.14	1.2	0.7	0.1	0.002	199	0.02	0.01

Calculations assume equipment is used 7 days/wk - i.e., 30 days/mc

BLOCK ISLAND SUBSTATION CONSTRUCTION ACTIVITIES

Construction Equipment	HP per unit	fuel	Emiss. Factor ID	hrs per day	Load Factor	2013												2014												Total Equip. Months	Fuel Use 2013 gal	Fuel Use 2014 gal	Fuel Use total gal
						J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D				
Land-based Nonroad Equip.																																	
Crane - Crawler	350	diesel	111	18	40%										1	1	1	1	1											5	11,851	7,901	19,751
15 Ton Picker	150	diesel	109	12	60%										1	1	1	1	1											5	5,078	3,385	8,463
60 Ton Hydraulic Crane	290	diesel	110	18	40%										1	1	1	1	1											5	9,819	6,546	16,365
Forklift 8000 lbs	75	diesel	117	18	60%										1	1	1	1	1											5	4,277	2,852	7,129
Concrete Truck	250	diesel	114	4	50%											1	1	1												3	1,585	793	2,378
Flatbed Truck (Material Supply)	150	diesel	113	6	50%										1	1	1	1	1											5	2,140	1,427	3,566
Paver	200	diesel	100	4	50%											1	1	1												3	1,268	634	1,902
Earth Compactor	200	diesel	101	4	75%											1	1	1												3	1,902	951	2,852
Excavator	200	diesel	105	10	50%										1	1	1	1												4	4,755	1,585	6,340
Air Compressor	100	diesel	128	12	50%										1	1	1	1												4	3,135	1,045	4,180
waterpump	100	diesel	125	24	40%										1	1	1	1												4	5,010	1,670	6,680
Diesel Welder	55	diesel	129	4	50%											1	1	1												3	450	225	675
Light Tower	50	diesel	102	24	60%										2	2	2	2	2											10	7,523	5,016	12,539
Onroad Vehicles																																	
Tandem Truck	200	diesel	154	18	50%										1	1	1	1	1											5	11,046	7,364	18,409
Pickup F150 1	200	petrol	154	18	25%										1	1	1	1	1											5	5,523	3,682	9,205
																														Total	75,361	45,073	120,434

Calculations assume equipment is used 7 days/wk - i.e., 30 days/month

BLOCK ISLAND SUBSTATION CONSTRUCTION ACTIVITIES

Emissions - 2013								Emissions - 2014							
VOC tons	NOx tons	CO tons	PM10 tons	SO2 tons	CO2 tons	CH4 tons	N2O tons	VOC tons	NOx tons	CO tons	PM10 tons	SO2 tons	CO2 tons	CH4 tons	N2O tons
0.06	0.98	0.25	0.040	0.0011	133	0.0076	0.0034	0.038	0.65	0.17	0.027	0.00077	88	0.0051	0.0022
0.03	0.35	0.09	0.022	0.0005	57	0.0032	0.0014	0.019	0.23	0.06	0.014	0.00033	38	0.0022	0.0010
0.05	0.63	0.13	0.028	0.0009	110	0.0063	0.0028	0.032	0.42	0.09	0.018	0.00062	73	0.0042	0.0019
0.02	0.25	0.18	0.019	0.0004	48	0.0027	0.0012	0.011	0.17	0.12	0.012	0.00028	32	0.0018	0.0008
0.01	0.07	0.02	0.004	0.0001	18	0.0010	0.0005	0.003	0.03	0.01	0.002	0.00007	9	0.0005	0.0002
0.01	0.10	0.04	0.011	0.0002	24	0.0014	0.0006	0.006	0.07	0.03	0.007	0.00013	16	0.0009	0.0004
0.01	0.07	0.02	0.005	0.0001	14	0.0008	0.0004	0.003	0.04	0.01	0.002	0.00006	7	0.0004	0.0002
0.01	0.11	0.04	0.007	0.0002	21	0.0012	0.0005	0.005	0.06	0.02	0.004	0.00009	11	0.0006	0.0003
0.02	0.24	0.08	0.016	0.0004	53	0.0030	0.0014	0.007	0.08	0.03	0.005	0.00014	18	0.0010	0.0005
0.02	0.24	0.13	0.022	0.0003	35	0.0020	0.0009	0.008	0.08	0.04	0.007	0.00010	12	0.0007	0.0003
0.06	0.49	0.27	0.050	0.0005	56	0.0032	0.0014	0.019	0.16	0.09	0.017	0.00017	19	0.0011	0.0005
0.01	0.04	0.05	0.007	0.00005	5	0.0003	0.0001	0.005	0.02	0.02	0.003	0.00002	3	0.0001	0.0001
0.06	0.67	0.25	0.048	0.0008	84	0.0048	0.0021	0.037	0.45	0.17	0.032	0.00050	56	0.0032	0.0014
0.24	1.01	1.16	0.171	0.0011	124	0.0071	0.0031	0.158	0.68	0.77	0.114	0.00075	82	0.0047	0.0021
0.12	0.51	0.58	0.086	0.0006	62	0.0035	0.0016	0.079	0.34	0.39	0.057	0.00037	41	0.0024	0.0010
0.70	5.77	3.29	0.53	0.0073	843	0.048	0.021	0.43	3.5	2.0	0.3	0.0044	504	0.03	0.01

BITS LAND CABLE ACTIVITIES

Construction Equipment	HP per unit	fuel	Emiss. Factor ID	hrs per day	Load Factor	2013												2014												Total Equip. Months	Fuel Use 2013 gal	2014 gal	total gal
						J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D				
Land-based Nonroad Equip.																																	
Concrete Saw	100	diesel	106	4	90%												1	1	1	1	1									5	253	1,013	1,266
Mounted Impact Hammer (Hoe Ram)	100	diesel	116	4	90%												1	1	1	1	1									5	253	1,013	1,266
Dump Truck	200	diesel	114	10	50%												1	1	1	1	1									5	634	2,536	3,170
Concrete Truck	250	diesel	114	4	50%												1	1	1	1	1									5	317	1,268	1,585
Flatbed Truck (Material Supply)	150	diesel	113	6	50%												1	1	1	1	1									5	285	1,141	1,427
Crane-road	200	diesel	110	6	50%												1	1	1	1	1									5	376	1,505	1,881
Paver	200	diesel	100	4	50%												1	1	1	1	1									5	254	1,014	1,268
Earth Compactor	200	diesel	101	4	75%												1	1	1	1	1									5	380	1,521	1,902
Tracked Excavator	200	diesel	105	10	50%												1	1	1	1	1									5	634	2,536	3,170
Chop Saw	200	diesel	107	2	75%												1	1	1	1	1									5	190	760	951
Bobcat	80	diesel	104	6	50%												1	1	1	1	1									5	169	676	845
Winch Truck	200	diesel	114	4	50%												1	1	1	1	1									5	254	1,015	1,268
Air Compressor	100	diesel	128	12	50%												1	1	1	1	1									5	418	1,672	2,090
waterpump	100	diesel	125	24	40%												1	1	1	1	1									5	668	2,672	3,340
HDD Drilling Machine	300	diesel	103	12	75%												1	1	1	1	1									5	1,691	6,766	8,457
Mud Pumps	100	diesel	125	12	75%												2	2	2	2	2									10	1,253	5,010	6,263
Generator	200	diesel	123	12	75%												2	2	2	2	2									10	2,255	9,020	11,275
Slurry Plant	100	diesel	108	12	75%												1	1	1	1	1									5	626	2,505	3,131
Desilter	100	diesel	119	12	75%												1	1	1	1	1									5	627	2,508	3,135
Shale Shaker	100	diesel	119	12	75%												1	1	1	1	1									5	627	2,508	3,135
Backhoe	100	diesel	115	4	75%												1	1	1	1	1									5	246	982	1,228
Boom Truck	100	diesel	113	6	50%												1	1	1	1	1									5	190	761	951
Loader	100	diesel	115	6	50%												1	1	1	1	1									5	246	982	1,228
Crane	200	diesel	110	6	50%												1	1	1	1	1									5	376	1,505	1,881
Diesel Welder	55	diesel	129	4	50%												1	1	1	1	1									5	90	360	450
Light Tower	50	diesel	102	24	60%												2	2	2	2	2									10	1,003	4,012	5,016
Onroad Vehicles																																	
Tandem Truck	200	diesel	154	18	50%												1	1	1	1	1									5	1,296	5,184	6,480
Pickup F150 1	200	petrol	151	18	25%												2	2	2	2	2									10	1,296	5,184	6,480
Fuel Truck	200	diesel	154	18	40%												1	1	1	1	1									5	1,037	4,147	5,184
																														Total	17,944	71,777	89,721

Calculations assume equipment is used 7 days/wk - i.e., 30 days/month

BITS LAND CABLE ACTIVITIES

						Emissions - 2013								Emissions - 2014							
Construction Equipment	HP per unit	fuel	Emiss. Factor ID	hrs per day	Load Factor	VOC tons	NOx tons	CO tons	PM10 tons	SO2 tons	CO2 tons	CH4 tons	N2O tons	VOC tons	NOx tons	CO tons	PM10 tons	SO2 tons	CO2 tons	CH4 tons	N2O tons
Land-based Nonroad Equip.																					
Concrete Saw	100	diesel	106	4	90%	0.00	0.02	0.02	0.00	0.0000	3	0.000	0.000	0.01	0.1	0.07	0.01	0.000	11	0.00	0.000
Mounted Impact Hammer (Hoe Ram)	100	diesel	116	4	90%	0.00	0.02	0.02	0.00	0.0000	3	0.000	0.000	0.01	0.1	0.07	0.01	0.000	11	0.00	0.000
Dump Truck	200	diesel	114	10	50%	0.00	0.03	0.01	0.00	0.0001	7	0.000	0.000	0.01	0.1	0.03	0.01	0.000	28	0.00	0.001
Concrete Truck	250	diesel	114	4	50%	0.00	0.01	0.00	0.00	0.0000	4	0.000	0.000	0.00	0.1	0.02	0.00	0.000	14	0.00	0.000
Flatbed Truck (Material Supply)	150	diesel	113	6	50%	0.00	0.01	0.01	0.00	0.0000	3	0.000	0.000	0.00	0.1	0.02	0.01	0.000	13	0.00	0.000
Crane-road	200	diesel	110	6	50%	0.00	0.02	0.00	0.00	0.0000	4	0.000	0.000	0.01	0.1	0.02	0.00	0.000	17	0.00	0.000
Paver	200	diesel	100	4	50%	0.00	0.01	0.00	0.00	0.0000	3	0.000	0.000	0.00	0.1	0.02	0.00	0.000	11	0.00	0.000
Earth Compactor	200	diesel	101	4	75%	0.00	0.02	0.01	0.00	0.0000	4	0.000	0.000	0.01	0.1	0.03	0.01	0.000	17	0.00	0.000
Tracked Excavator	200	diesel	105	10	50%	0.00	0.03	0.01	0.00	0.0001	7	0.000	0.000	0.01	0.1	0.04	0.01	0.000	28	0.00	0.001
Chop Saw	200	diesel	107	2	75%	0.00	0.01	0.00	0.00	0.0000	2	0.000	0.000	0.00	0.1	0.02	0.00	0.000	9	0.00	0.000
Bobcat	80	diesel	104	6	50%	0.00	0.01	0.01	0.00	0.0000	2	0.000	0.000	0.00	0.0	0.04	0.01	0.000	8	0.00	0.000
Winch Truck	200	diesel	114	4	50%	0.00	0.01	0.00	0.00	0.0000	3	0.000	0.000	0.00	0.04	0.01	0.00	0.0001	11	0.001	0.000
Air Compressor	100	diesel	128	12	50%	0.00	0.03	0.02	0.00	0.0000	5	0.000	0.000	0.01	0.13	0.07	0.01	0.0002	19	0.001	0.000
waterpump	100	diesel	125	24	40%	0.01	0.06	0.04	0.01	0.0001	7	0.000	0.000	0.03	0.26	0.14	0.03	0.0003	30	0.002	0.001
HDD Drilling Machine	300	diesel	103	12	75%	0.01	0.18	0.05	0.01	0.0002	19	0.001	0.000	0.06	0.71	0.19	0.04	0.0007	76	0.004	0.002
Mud Pumps	100	diesel	125	12	75%	0.01	0.12	0.07	0.01	0.0001	14	0.001	0.000	0.06	0.49	0.27	0.05	0.0005	56	0.003	0.001
Generator	200	diesel	123	12	75%	0.02	0.23	0.07	0.01	0.0002	25	0.001	0.001	0.08	0.92	0.27	0.05	0.0009	101	0.006	0.003
Slurry Plant	100	diesel	108	12	75%	0.01	0.06	0.03	0.01	0.0001	7	0.000	0.000	0.03	0.26	0.13	0.02	0.0003	28	0.002	0.001
Desilter	100	diesel	119	12	75%	0.00	0.05	0.03	0.00	0.0001	7	0.000	0.000	0.02	0.19	0.10	0.02	0.0002	28	0.002	0.001
Shale Shaker	100	diesel	119	12	75%	0.00	0.05	0.03	0.00	0.0001	7	0.000	0.000	0.02	0.19	0.10	0.02	0.0002	28	0.002	0.001
Backhoe	100	diesel	115	4	75%	0.00	0.02	0.03	0.00	0.0000	3	0.000	0.000	0.02	0.09	0.10	0.02	0.0001	11	0.001	0.000
Boom Truck	100	diesel	113	6	50%	0.00	0.01	0.00	0.00	0.0000	2	0.000	0.000	0.00	0.04	0.02	0.00	0.0001	9	0.000	0.000
Loader	100	diesel	115	6	50%	0.00	0.02	0.03	0.00	0.0000	3	0.000	0.000	0.02	0.09	0.10	0.02	0.0001	11	0.001	0.000
Crane	200	diesel	110	6	50%	0.00	0.02	0.00	0.00	0.0000	4	0.000	0.000	0.01	0.10	0.02	0.00	0.0001	17	0.001	0.000
Diesel Welder	55	diesel	129	4	50%	0.00	0.01	0.01	0.00	0.0000	1	0.000	0.000	0.01	0.03	0.04	0.01	0.0000	4	0.000	0.000
Light Tower	50	diesel	102	24	60%	0.01	0.09	0.03	0.01	0.0001	11	0.001	0.000	0.03	0.36	0.13	0.03	0.0004	45	0.003	0.001
Onroad Vehicles																					
Tandem Truck	200	diesel	154	18	50%	0.00	0.03	0.01	0.00	0.0001	15	0.000	0.000	0.02	0.10	0.04	0.00	0.0005	58	0.000	0.000
Pickup F150 1	200	petrol	151	18	25%	0.02	0.02	0.20	0.00	0.0002	13	0.011	0.005	0.08	0.08	0.79	0.00	0.0009	51	0.043	0.018
Fuel Truck	200	diesel	154	18	40%	0.00	0.02	0.01	0.00	0.0001	12	0.000	0.000	0.01	0.08	0.03	0.00	0.0004	46	0.000	0.000
						0.14	1.24	0.74	0.10	0.0019	199	0.020	0.009	0.57	5.0	2.9	0.4	0.007	796	0.08	0.03

Calculations assume equipment is used 7 days/wk - i.e., 30 days/mc

BIWF MARINE CONSTRUCTION

Block Island Wind Farm

	vessels/equipment	number of units on site	1. DP 2.Anch 3.Spud	dimensions (ft) length x width x depth (draft)	propulsion	Emission Factor Used (see EFs worksheet)	activity	hp	fuel	operating days within BIWF safety zone state waters	days outside BIWF safety zone state waters	days in federal waters	hrs/day	average load (%)	fuel use full load (gal/day) per unit	fuel use full load (gal/day) per unit	fuel use actual (gal/day) all units	fuel use full load (kg/day) all units	Emissions - tot VOC tons
1	towing tug a/b/c - main engines	3		180 x 45 x 40 (20)	2 propellers 9 ft diam.	1	transport foundations	6000	diesel	20	2	5	24	33%	4000	7776	7698	38556	1.58
	-aux. engines	3			1 bow thruster 4ft diam	2		100	diesel	20	2	5	24	50%	80	130	194	771.12	0.02
2	transportation barge a/b/c -aux. engines	3		400 x 120 x 25 (12)	none	2	transport foundations	200	diesel	20	2	5	24	10%	160	259	78	1542.24	0.01
3	towing tug d - main engines	1		180 x 45 x 40 (20)	2 propellers 9 ft diam.	1	transport foundation piles	6000	diesel	20	2	5	24	33%	4000	7776	2566	12852	0.53
	-aux. engines	1			1 bow thruster 4ft diam	2		100	diesel	20	2	5	24	50%	80	130	65	257.04	0.01
4	transportation barge d -aux. engines	1		400 x 120 x 25 (12)	none	2	transport foundation piles	200	diesel	20	2	5	24	10%	160	259	26	514.08	0.00
5	Derrick barge - main engines	1	1+2	500 x 140 x 40 (25)	2 propellers 9 ft diam.	1	install foundations	5000	diesel	40	5	5	24	25%	3350	6480	1620	10763.55	0.62
	-aux. engines	1			1 bow thruster 4ft diam	2		500	diesel	40	5	5	24	50%	350	648	324	1124.55	0.07
	main crane	1				112		1000	diesel	40	5	5	24	25%	700	1253	313	2249.1	0.12
	crawler crane	1				111		500	diesel	40	5	5	24	25%	350	627	157	1124.55	0.04
6	anchor handling tug e - main engines	1		180 x 45 x 40 (20)	2 propellers 9 ft diam.	1	support Derrick barge	6000	diesel	35	5	10	24	25%	4000	7776	1944	12852	0.74
	-aux. engines	1			1 bow thruster 4ft diam	2		100	diesel	35	5	10	24	50%	80	130	65	257.04	0.01
7	crew boat	2		70 x 30 x 15 (5)	2 waterjet engines 24"	2	transport crew	2000	diesel	180	150	35	14	50%	1400	1512	1512	8996.4	2.27
	-aux. engines	2			or twin screw 3 ft	2		100	diesel	180	150	35	14	50%	80	76	76	514.08	0.11
8	Cablelay barge - main engines	1	1	400 x 120 x 40 (18)	4 propellers 8 ft diam.	1	install submarine cable	8000	diesel	30	5	5	24	25%	5300	10368	2592	17028.9	0.79
	-aux. engines	1			1 bow thruster 4ft diam	2		500	diesel	30	5	5	24	50%	350	648	324	1124.55	0.05
	turntable	1				2		500	diesel	30	5	5	24	25%	700	648	162	2249.1	0.03
	crawler crane	1				111		350	diesel	30	5	5	24	25%	350	439	110	1124.55	0.02
9	Material barge - jet waterpump	1		120 x 50 x 20 (10)		2	waterjet plow	1000	diesel	30	5	5	24	25%	4000	1296	324	12852	0.05
	-aux. engines	1				2		200	diesel	30	5	5	24	50%	80	259	130	257.04	0.02
10	work vessel a	1	1+2	300 x 80 x 25 (10)	4 thrusters 6 ft diam	1	connect cables BIWF	6000	diesel	45	5	5	24	40%	4000	7776	3110	12852	1.30
	-aux. engines	1				2	back-up generator	500	diesel	45	5	5	24	40%	350	648	259	1124.55	0.06
	crawler crane	1				110		250	diesel	45	5	5	24	40%	180	314	125	578.34	0.03
11	work vessel b - main generator	1	2+3	300 x 80 x 25 (10)	4 thrusters 6 ft diam	1	build cofferdam Block Island	4000	diesel	20	5	2	24	50%	2700	5184	2592	8675.1	0.53
	-aux. engines	1				2		200	diesel	20	5	2	24	50%	160	259	130	514.08	0.01
	crawler crane	1				110		250	diesel	20	5	2	24	50%	180	314	157	578.34	0.02
12	tug g - main engines	1		160 x 40 x 35 (18)	2 propellers 8 ft diam.	1	support work vessel a\b	4000	diesel	20	2	5	24	33%	2700	5184	1711	8675.1	0.35
	-aux. engines	1			1 bow thruster 3ft diam	2		80	diesel	20	2	5	24	33%	65	104	34	208.845	0.00
13	transportation barge f	2	3	300 x 90 x 22 (12)	no	2	transport turbines	500	diesel	12	20	5	24	25%	350	648	324	2249.1	0.05
14	towing tug f - main engines	2		160 x 40 x 35 (18)	2 propellers 8 ft diam.	1	tow turbine transportation barge	5000	diesel	20	2	5	24	33%	3350	6480	4277	21527.1	0.88
	-aux. engines	2			1 bow thruster 3ft diam	2		80	diesel	20	2	5	24	50%	65	104	104	417.69	0.01
15	jack-up barge - main engines	1	1+3	500 x 140 x 50 (25)	2 propellers 9 ft diam.	1	install turbines	8000	diesel	20	2	2	24	30%	5300	10368	3110	17028.9	0.57
	-aux. engines	1			1 bow thruster 4ft diam	2		500	diesel	20	2	2	24	30%	350	648	194	1124.55	0.02
	main crane	1				112		800	diesel	20	2	2	24	50%	560	1002	501	1799.28	0.09
	fork lift	1				110		300	diesel	20	2	2	24	50%	240	376	188	771.12	0.02
	crawler crane	1				111		500	diesel	20	2	2	24	50%	350	627	314	1124.55	0.04
16	tug h - main engines	1		160 x 40 x 35 (18)	2 propellers 8 ft diam.	1	support jack-up barge	5000	diesel	20	2	5	24	33%	3350	6480	2138	10763.55	0.44
	-aux. engines	1			1 bow thruster 3ft diam	2		80	diesel	20	2	5	24	50%	65	104	52	208.845	0.01
17	helicopter - main engines	1		54 x 15 x 17	4 blades 52 ft diam	helicopter	(emergency) crew transport	3700	aviation fuel	20	0	0	6	80%	400		0	1285.2	0.14
18	support vessel - main engines	2		50 x 15 x 20 (6)	2 propellers 2 ft diam.	2	observation / crew transport	1000	diesel	20	2	5	24	33%	3350	1296	855	21527.1	0.09
					1 bow thruster 1ft diam														
																TOTAL	40,455	gal	11.8

BIWF MARINE CONSTRUCTION

	Block Island Wind Farm		al							Emissions - State Waters							
	vessels/equipment	number of units on site	NOx tons	CO tons	PM10 tons	SO2 tons	CO2 tons	CH4 tons	N2O tons	VOC tons	NOx tons	CO tons	PM10 tons	SO2 tons	CO2 tons	CH4 tons	N2O tons
1	towing tug a/b/c - main engines	3	41.8	3.48	2.28	0.0227	2,406	0.174	0.0605	1.29	34.0	2.84	1.86	0.0185	1,961	0.142	0.0493
	-aux. engines	3	0.9	0.16	0.07	0.0006	61	0.004	0.0015	0.02	0.7	0.13	0.06	0.0005	50	0.004	0.0012
2	transportation barge a/b/c -aux. engines	3	0.4	0.06	0.03	0.0002	24	0.002	0.0006	0.01	0.3	0.05	0.02	0.0002	20	0.001	0.0005
3	towing tug d - main engines	1	13.9	1.16	0.76	0.0076	802	0.058	0.0202	0.43	11.3	0.95	0.62	0.0062	654	0.047	0.0164
	-aux. engines	1	0.3	0.05	0.02	0.0002	20	0.001	0.0005	0.01	0.2	0.04	0.02	0.0002	17	0.001	0.0004
4	transportation barge d -aux. engines	1	0.1	0.02	0.01	0.0001	8	0.001	0.0002	0.00	0.1	0.02	0.01	0.0001	7	0.000	0.0002
5	Derrick barge - main engines	1	16.3	1.36	0.89	0.0088	938	0.068	0.0236	0.56	14.7	1.22	0.80	0.0080	844	0.061	0.0212
	-aux. engines	1	2.7	0.49	0.22	0.0018	188	0.014	0.0047	0.06	2.4	0.44	0.20	0.0016	169	0.012	0.0042
	main crane	1	1.8	0.42	0.07	0.0015	175	0.010	0.0045	0.11	1.6	0.38	0.06	0.0014	158	0.009	0.0040
	crawler crane	1	0.6	0.17	0.03	0.0008	88	0.005	0.0022	0.03	0.6	0.15	0.02	0.0007	79	0.005	0.0020
6	anchor handling tug e - main engines	1	19.5	1.63	1.07	0.0106	1,125	0.081	0.0283	0.59	15.6	1.30	0.85	0.0085	900	0.065	0.0226
	-aux. engines	1	0.5	0.10	0.04	0.0004	38	0.003	0.0009	0.01	0.4	0.08	0.04	0.0003	30	0.002	0.0008
7	crew boat	2	92.4	16.81	7.56	0.0602	6,389	0.462	0.1606	2.05	83.6	15.20	6.84	0.0545	5,777	0.417	0.1452
	-aux. engines	2	4.6	0.84	0.38	0.0030	319	0.023	0.0080	0.10	4.2	0.76	0.34	0.0027	289	0.021	0.0073
8	Cablelay barge - main engines	1	20.8	1.74	1.14	0.0113	1,200	0.087	0.0302	0.69	18.2	1.52	0.99	0.0099	1,050	0.076	0.0264
	-aux. engines	1	2.2	0.39	0.18	0.0014	150	0.011	0.0038	0.05	1.9	0.35	0.16	0.0012	131	0.009	0.0033
	turntable	1	1.1	0.20	0.09	0.0007	75	0.005	0.0019	0.02	0.9	0.17	0.08	0.0006	66	0.005	0.0017
	crawler crane	1	0.4	0.09	0.01	0.0004	49	0.003	0.0012	0.02	0.3	0.08	0.01	0.0004	43	0.002	0.0011
9	Material barge - jet waterpump	1	2.2	0.39	0.18	0.0014	150	0.011	0.0038	0.05	1.9	0.35	0.16	0.0012	131	0.009	0.0033
	-aux. engines	1	0.9	0.16	0.07	0.0006	60	0.004	0.0015	0.02	0.8	0.14	0.06	0.0005	53	0.004	0.0013
10	work vessel a	1	34.4	2.87	1.88	0.0187	1,981	0.143	0.0498	1.18	31.3	2.61	1.71	0.0170	1,800	0.130	0.0453
	-aux. engines	1	2.4	0.43	0.20	0.0016	165	0.012	0.0041	0.05	2.2	0.39	0.18	0.0014	150	0.011	0.0038
	crawler crane	1	0.4	0.09	0.02	0.0007	77	0.004	0.0020	0.03	0.4	0.08	0.02	0.0006	70	0.004	0.0018
11	work vessel b - main generator	1	14.1	1.17	0.77	0.0076	810	0.059	0.0204	0.49	13.0	1.09	0.71	0.0071	750	0.054	0.0189
	-aux. engines	1	0.6	0.11	0.05	0.0004	41	0.003	0.0010	0.01	0.5	0.10	0.04	0.0004	38	0.003	0.0009
	crawler crane	1	0.3	0.06	0.01	0.0004	47	0.003	0.0012	0.02	0.2	0.05	0.01	0.0004	44	0.003	0.0011
12	tug g - main engines	1	9.3	0.77	0.51	0.0050	535	0.039	0.0134	0.29	7.6	0.63	0.41	0.0041	436	0.031	0.0110
	-aux. engines	1	0.2	0.03	0.01	0.0001	11	0.001	0.0003	0.00	0.1	0.02	0.01	0.0001	9	0.001	0.0002
13	transportation barge f	2	2.0	0.37	0.16	0.0013	139	0.010	0.0035	0.04	1.7	0.32	0.14	0.0011	120	0.009	0.0030
14	towing tug f - main engines	2	23.2	1.93	1.27	0.0126	1,337	0.097	0.0336	0.72	18.9	1.58	1.03	0.0103	1,089	0.079	0.0274
	-aux. engines	2	0.5	0.09	0.04	0.0003	32	0.002	0.0008	0.01	0.4	0.07	0.03	0.0002	26	0.002	0.0007
15	jack-up barge - main engines	1	15.0	1.25	0.82	0.0081	864	0.062	0.0217	0.52	13.8	1.15	0.75	0.0075	792	0.057	0.0199
	-aux. engines	1	0.8	0.14	0.06	0.0005	54	0.004	0.0014	0.02	0.7	0.13	0.06	0.0005	50	0.004	0.0012
	main crane	1	1.4	0.32	0.05	0.0012	135	0.008	0.0034	0.09	1.3	0.29	0.05	0.0011	123	0.007	0.0031
	fork lift	1	0.3	0.06	0.01	0.0004	51	0.003	0.0013	0.02	0.3	0.05	0.01	0.0004	46	0.003	0.0012
	crawler crane	1	0.6	0.16	0.03	0.0007	84	0.005	0.0021	0.03	0.6	0.15	0.02	0.0007	77	0.004	0.0020
16	tug h - main engines	1	11.6	0.97	0.63	0.0063	668	0.048	0.0168	0.36	9.5	0.79	0.52	0.0051	545	0.039	0.0137
	-aux. engines	1	0.2	0.04	0.02	0.0002	16	0.001	0.0004	0.00	0.2	0.03	0.02	0.0001	13	0.001	0.0003
17	helicopter - main engines	1	0.2	1.28	0.02	0.0147	84	0.002	0.0027	0.14	0.2	1.28	0.02	0.0147	84	0.002	0.0027
18	support vessel - main engines	2	3.9	0.70	0.32	0.0025	267	0.019	0.0067	0.08	3.2	0.57	0.26	0.0021	218	0.016	0.0055
			344.6	42.6	22.0	0.22	21,664	1.6	0.5	10.2	299.8	37.5	19.2	0.19	18,907	1.4	0.5

BITS MARINE CONSTRUCTION

	Block Island Transmission System																		Emissions - tot
	vessels/equipment	number of units on site	1. DP 2.And 3.Spu	dimensions (ft) length x width x depth (draft)	propulsion	Emission Factor Used (see EFs worksheet)	activity	hp	fuel	operating days within BITS constr zone state waters	operating days outside BITS constr zone state waters	operating days within BITS constr zone federal waters	hrs/day	average load (%)	fuel use full load (gal/day) per unit	fuel use full load (gal/day) per unit	fuel use actual (gal/day) all units	fuel use full load (kg/day) all units	VOC tons
1	material barge a -aux. engines	1		275 x 80 x 20 (8)	none	2	support pipelay operations	200	diesel	30	5	15	24	25%	160	259	65	514.08	0.01
2	tug a - main engines	1		160 x 40 x 35 (18)	2 propellers 8 ft diam.	1	tow material barges	4000	diesel	30	5	15	24	33%	2700	5184	1711	8675.1	0.65
	-aux. engines	1			1 bow thruster 3ft diam	2	general support	80	diesel	30	5	15	24	33%	65	104	34	208.845	0.01
3	Cablelay barge - main engines	1	1	400 x 120 x 40 (18)	4 propellers 8 ft diam.	1	install submarine cable	8000	diesel	30	5	15	24	33%	5300	10368	3421	17028.9	1.30
	-aux. engines	1			1 bow thruster 4ft diam	2		500	diesel	30	5	15	24	33%	350	648	214	1124.55	0.04
	turntable	1				2		500	diesel	30	5	15	24	60%	350	648	389	1124.55	0.08
	crawler crane	1				111		350	diesel	30	5	15	24	60%	250	439	263	803.25	0.06
1	tug b - main engines	1		160 x 40 x 35 (18)	2 propellers 8 ft diam.	1	support cablelay barge	4000	diesel	30	5	15	24	33%	2700	5184	1711	8675.1	0.65
	-aux. engines	1			1 bow thruster 3ft diam	2	general support	80	diesel	30	5	15	24	33%	65	104	34	208.845	0.01
4	Material barge - jet waterpump	1		120 x 50 x 20 (10)		2	waterjet plow	1000	diesel	30	5	15	24	50%	700	1296	648	2249.1	0.13
	-aux. engines	1				2		200	diesel	30	5	15	24	50%	160	259	130	514.08	0.03
5	crew boat	1		70 x 30 x 15 (5)	2 waterjet engines 24"	2	transport crew	2000	diesel	90	20	15	14	50%	1400	1512	756	4498.2	0.39
	-aux. engines	1			or twin screw 3 ft	2		100	diesel	90	20	15	14	50%	80	76	38	257.04	0.02
6	work vessel a - main generator	1	2+3	300 x 80 x 25 (10)	4 thrusters 6 ft diam	1	build cofferdam Block Island	4000	diesel	40	5	20	24	50%	2700	5184	2592	8675.1	1.28
	-aux. engines	1				2	build cofferdam Narragansett	200	diesel	40	5	20	24	50%	160	259	130	514.08	0.03
	crawler crane	1				110	Pipeline crossings	250	diesel	40	5	20	24	50%	180	314	157	578.34	0.05
7	tug g - main engines	1		160 x 40 x 35 (18)	2 propellers 8 ft diam.	1	support work vessel a	4000	diesel	40	5	20	24	33%	2700	5184	1711	8675.1	0.85
	-aux. engines	1			1 bow thruster 3ft diam	2		80	diesel	40	5	20	24	33%	65	104	34	208.845	0.01
8	helicopter - main engines	1		54 x 15 x 17	4 blades 52 ft diam	helicopter	(emergency) crew transport	3700	aviation fuel	20	0	0	3	80%				0	0.07
9	support vessel - main engines	2		50 x 15 x 20 (6)	2 propellers 2 ft diam. 1 bow thruster 1ft diam	2	observation / crew transport	1000	diesel	20	2	5	24	33%	3350	1296	855	21527.1	0.09
																TOTAL	14,892	gal	5.78

BITS MARINE CONSTRUCTION

	Block Island Transmission System		al							Emissions - State Waters							
	vessels/equipment	number of units on site	NOx tons	CO tons	PM10 tons	SO2 tons	CO2 tons	CH4 tons	N2O tons	VOC tons	NOx tons	CO tons	PM10 tons	SO2 tons	CO2 tons	CH4 tons	N2O tons
1	material barge a -aux. engines	1	0.5	0.10	0.04	0.0004	38	0.0027	0.0009	0.01	0.4	0.07	0.03	0.0002	26	0.0019	0.0007
2	tug a - main engines	1	17.2	1.43	0.94	0.0093	990	0.0716	0.0249	0.46	12.0	1.00	0.66	0.0065	693	0.0501	0.0174
	-aux. engines	1	0.3	0.05	0.02	0.0002	20	0.0014	0.0005	0.00	0.2	0.04	0.02	0.0001	14	0.0010	0.0003
3	Cablelay barge - main engines	1	34.4	2.87	1.88	0.0187	1,981	0.1431	0.0498	0.91	24.1	2.01	1.31	0.0131	1,386	0.1002	0.0348
	-aux. engines	1	1.8	0.33	0.15	0.0012	124	0.0089	0.0031	0.03	1.3	0.23	0.10	0.0008	87	0.0063	0.0022
	turntable	1	3.3	0.59	0.27	0.0021	225	0.0163	0.0057	0.06	2.3	0.41	0.19	0.0015	158	0.0114	0.0040
	crawler crane	1	1.1	0.28	0.04	0.0013	147	0.0084	0.0037	0.04	0.8	0.19	0.03	0.0009	103	0.0059	0.0026
1	tug b - main engines	1	17.2	1.43	0.94	0.0093	990	0.0716	0.0249	0.46	12.0	1.00	0.66	0.0065	693	0.0501	0.0174
	-aux. engines	1	0.3	0.05	0.02	0.0002	20	0.0014	0.0005	0.00	0.2	0.04	0.02	0.0001	14	0.0010	0.0003
4	Material barge - jet waterpump	1	5.4	0.99	0.44	0.0035	375	0.0271	0.0094	0.09	3.8	0.69	0.31	0.0025	263	0.0190	0.0066
	-aux. engines	1	1.1	0.20	0.09	0.0007	75	0.0054	0.0019	0.02	0.8	0.14	0.06	0.0005	53	0.0038	0.0013
5	crew boat	1	15.8	2.88	1.30	0.0103	1,094	0.0791	0.0275	0.34	13.9	2.53	1.14	0.0091	963	0.0696	0.0242
	-aux. engines	1	0.8	0.14	0.06	0.0005	55	0.0040	0.0014	0.02	0.7	0.13	0.06	0.0005	48	0.0035	0.0012
6	work vessel a - main generator	1	33.9	2.82	1.85	0.0184	1,951	0.1410	0.0490	0.89	23.4	1.95	1.28	0.0127	1,350	0.0976	0.0339
	-aux. engines	1	1.4	0.26	0.12	0.0009	98	0.0070	0.0025	0.02	1.0	0.18	0.08	0.0006	68	0.0049	0.0017
	crawler crane	1	0.6	0.14	0.03	0.0010	114	0.0065	0.0029	0.03	0.4	0.09	0.02	0.0007	79	0.0045	0.0020
7	tug g - main engines	1	22.4	1.86	1.22	0.0121	1,287	0.0930	0.0324	0.59	15.5	1.29	0.84	0.0084	891	0.0644	0.0224
	-aux. engines	1	0.4	0.07	0.03	0.0002	26	0.0019	0.0006	0.01	0.3	0.05	0.02	0.0002	18	0.0013	0.0004
8	helicopter - main engines	1	0.1	0.64	0.01	0.0073	42	0.0012	0.0014	0.07	0.1	0.64	0.01	0.0073	42	0.0012	0.0014
9	support vessel - main engines	2	3.9	0.70	0.32	0.0025	267	0.0193	0.0067	0.08	3.2	0.57	0.26	0.0021	218	0.0157	0.0055
			161.8	17.8	9.76	0.100	9,918	0.71	0.25	4.13	116.2	13.3	7.09	0.074	7,166	0.51	0.18

OPERATIONAL EMISSIONS

no	Block Island Wind Farm O&M vessels/equipment	number of units on site	1. DP 2.Anch 3.Spud	dimensions (ft) length x width x depth (draft)	propulsion	Emission Factor Used (see EFs worksheet)	activity	hp	fuel	operating days within BIWF safety zone state waters	days outside BIWF safety zone state waters	days in federal waters	hrs/day	average load (%)	fuel use full load (gal/day) per unit	fuel use full load (gal/day) per unit	fuel use actual (gal/day) all units	fuel use full load (kg/day) all units	Emissions - tot VOC tons
1	crew boat	1		70 x 30 x 15 (5)	2 waterjet engines 24"	2	transport crew for O&M	2000	diesel	30	18	5	12	60%	1400	1296	778	4498.2	0.17
	-aux. engines	1			or twin screw 3 ft	2		100	diesel	30	18	5	12	60%	80	65	39	257.04	0.01
2	work vessel a - main generator	1	2+3	300 x 80 x 25 (10)	4 thrusters 6 ft diam	1	wind farm inspection and repair	200	diesel	5	2	2	12	50%	2700	130	65	8675.1	0.00
	-aux. engines	1				2		200	diesel	5	2	2	12	50%	160	130	65	514.08	0.00
	crawler crane	1				110		250	diesel	5	2	2	12	50%	180	157	78	578.34	0.00
3	tug a - main engines	1		160 x 40 x 35 (18)	2 propellers 8 ft diam.	1	support work vessel a	4000	diesel	12	2	2	12	33%	2700	2592	855	8675.1	0.10
	-aux. engines	1			1 bow thruster 3ft diam	2		80	diesel	12	2	2	12	33%	65	52	17	208.845	0.00
4	jack-up barge - main engines	1	1+3	500 x 140 x 50 (25)	2 propellers 9 ft diam.	1	repair turbines	8000	diesel	5	2	2	24	30%	5300	10368	3110	17028.9	0.21
	-aux. engines	1			1 bow thruster 4ft diam	2		500	diesel	5	2	2	24	30%	350	648	194	1124.55	0.01
	main crane	1				112		800	diesel	5	2	2	24	50%	560	1002	501	1799.28	0.04
	fork lift	1				110		300	diesel	5	2	2	24	50%	240	376	188	771.12	0.01
	crawler crane	1				111		500	diesel	5	2	2	24	50%	350	627	314	1124.55	0.01
5	tug h - main engines	1		160 x 40 x 35 (18)	2 propellers 8 ft diam.	1	support jack-up barge	5000	diesel	5	2	2	24	33%	3350	6480	2138	10763.55	0.15
	-aux. engines	1			1 bow thruster 3ft diam	2		80	diesel	5	2	2	24	50%	65	104	52	208.845	0.00
6	helicopter - main engines	1		54 x 15 x 17	4 blades 52 ft diam	helicopter	(emergency) crew transport	3700	aviation fuel	3	0	0	6	80%	400			1285.2	0.06
																TOTAL	8,395	gal	0.8

OPERATIONAL EMISSIONS

	Block Island Wind Farm O&M		al							Emissions - State Waters							
no	vessels/equipment	number of units on site	NOx tons	CO tons	PM10 tons	SO2 tons	CO2 tons	CH4 tons	N2O tons	VOC tons	NOx tons	CO tons	PM10 tons	SO2 tons	CO2 tons	CH4 tons	N2O tons
1	crew boat	1	6.9	1.26	0.56	0.0045	477	0.034	0.0120	0.15	6.3	1.14	0.51	0.0041	432	0.031	0.0109
	-aux. engines	1	0.3	0.06	0.03	0.0002	24	0.002	0.0006	0.01	0.31	0.06	0.03	0.0002	22	0.002	0.0005
2	work vessel a - main generator	1	0.1	0.01	0.01	0.0001	7	0.000	0.0002	0.00	0.09	0.01	0.00	0.0000	5	0.000	0.0001
	-aux. engines	1	0.1	0.02	0.01	0.0001	7	0.000	0.0002	0.002	0.08	0.01	0.01	0.0000	5	0.000	0.0001
	crawler crane	1	0.0	0.01	0.00	0.0001	8	0.000	0.0002	0.00	0.03	0.01	0.00	0.0001	6	0.000	0.0002
3	tug a - main engines	1	2.8	0.23	0.15	0.0015	158	0.011	0.0040	0.09	2.41	0.20	0.13	0.0013	139	0.010	0.0035
	-aux. engines	1	0.05	0.01	0.00	0.0000	3	0.000	0.0001	0.001	0.04	0.01	0.00	0.0000	3	0.000	0.0001
4	jack-up barge - main engines	1	5.6	0.47	0.31	0.0031	324	0.023	0.0081	0.17	4.38	0.36	0.24	0.0024	252	0.018	0.0063
	-aux. engines	1	0.3	0.05	0.02	0.0002	20	0.001	0.0005	0.01	0.23	0.04	0.02	0.0001	16	0.001	0.0004
	main crane	1	0.5	0.12	0.02	0.0004	50	0.003	0.0013	0.03	0.40	0.09	0.02	0.0003	39	0.002	0.0010
	fork lift	1	0.1	0.02	0.00	0.0002	19	0.001	0.0005	0.01	0.08	0.02	0.00	0.0001	15	0.001	0.0004
	crawler crane	1	0.2	0.06	0.01	0.0003	32	0.002	0.0008	0.01	0.18	0.05	0.01	0.0002	25	0.001	0.0006
5	tug h - main engines	1	3.9	0.32	0.21	0.0021	223	0.016	0.0056	0.11	3.01	0.25	0.16	0.0016	173	0.013	0.0044
	-aux. engines	1	0.1	0.01	0.01	0.0001	5	0.000	0.0001	0.001	0.06	0.01	0.00	0.0000	4	0.000	0.0001
6	helicopter - main engines	1	0.4	0.13	0.01	0.0019	202	0.001	0.0007	0.06	0.36	0.13	0.01	0.0019	202	0.0007	0.0007
			21.4	2.8	1.4	0.01	1,559	0.1	0.0	0.7	17.9	2.4	1.2	0.01	1,337	0.1	0.0

Parameters

Fuel specs

density =	3.3	kg/gal
suflur content =	0.0015%	(wt.)
carbon content =	86.8%	(wt.)

CMV fuel efficiency

	0.054	gal/hp-hr
=	0.072	gal/kWh

CO_2 and SO_2 emission factors

0.007	g SO_2/kWh
760	g CO_2/kWh

Other conversion factors

1 Btu =	1055	J
1 kg =	2.205	lb
1 m^3 =	35.315	ft^3
1 gal =	3.785	L
Ideal gas const R =	0.730245	ft^3-atm/lb-mol ^oR
=	0.008315	m^3-kPa/g-mol K
1 knot =	1.15	mph

Fuel specs for land-based equipment

	Density		kg CO_2/gal
Gasoline	6.2	lb/gal	8.81
Land-Based Diesel	7.11	lb/gal	10.15

Emission Factors

Commercial Marine Vessels (CMVs)

		Commercial Marine Vessel Emission Factors (g/hp-hr) a/								Fuel Cons.
		5	6	7	8	9	10	11	12	13
	Engine type	VOC	NO_x	CO	PM_{10}	SO_2 b/	CO_2	CH_4	N_2O	gal/hp-hr
1	CMV Category 2 engines	0.37	9.8	0.82	0.54	0.005	567	0.041	0.014	0.054
2	CMV Category 1 engines < 1000 kW	0.20	8.2	1.49	0.67	0.005	567	0.041	0.014	0.054

a/ Except as noted otherwise, emission factors are from US EPA's 2006 "Current Methodologies and Best Practices in Preparing Port Emissions Inventories" (converted from g/kW-hr to g/hp-hr by multiplying by 0.746 kW/hp). Category 1 engines have a range of emission factors depending on size; the highest values (for sizes < 1000 kW) were conservatively chosen.

b/ Emission factors for SO_2, CO_2, CH_4, and N_2O (and fuel consumption) are determined as identified in Attachment A.

Land-based Nonroad Engines and Other Equipment

	NONROAD Source Category			NONROAD Emission Factors (g/hp-hour)						Climate Leaders Factors			NONROAD
				Exhaust+ Crankcase	Exhaust	Exhaust	Exhaust	Exhaust	Exhaust	Exhaust	Exhaust	Consumption	Default
	SCC	Description	Engine Size (hp)	VOC	NO_x	CO	PM_{10} a/	SO_2	CO_2	CH_4	N_2O	gal/hp-hr c/	Load Factor
	Construction & Mining Subcategory (*002*)												
100	2270002003	Diesel Pavers	175 < HP <= 300	0.23	2.76	0.90	0.18	0.004	536	0.031	0.014	0.053	
101	2270002015	Diesel Rollers	175 < HP <= 300	0.24	2.89	0.93	0.18	0.005	536	0.031	0.014	0.053	
102	2270002027	Diesel Signal Boards/Light Plants	40 < HP <= 50	0.39	4.72	1.74	0.34	0.005	589	0.034	0.015	0.058	
103	2270002033	Diesel Bore/Drill Rigs	175 < HP <= 300	0.40	4.95	1.36	0.27	0.005	530	0.030	0.013	0.052	
104	2270002036	Diesel Excavators	75 < HP <= 100	0.27	3.21	2.99	0.40	0.005	595	0.034	0.015	0.059	
105	2270002036	Diesel Excavators	175 < HP <= 300	0.20	2.38	0.81	0.16	0.004	536	0.031	0.014	0.053	
106	2270002039	Diesel Concrete/Industrial Saws	75 < HP <= 100	0.41	4.06	3.45	0.50	0.005	595	0.034	0.015	0.059	
107	2270002039	Diesel Concrete/Industrial Saws	175 < HP <= 300	0.27	3.42	1.11	0.22	0.005	536	0.031	0.014	0.053	
108	2270002042	Diesel Cement & Mortar Mixers	75 < HP <= 100	0.61	5.38	2.78	0.49	0.005	589	0.034	0.015	0.058	
109	2270002045	Diesel Cranes	100 < HP <= 175	0.26	3.28	0.81	0.20	0.005	530	0.030	0.013	0.052	43%
110	2270002045	Diesel Cranes	175 < HP <= 300	0.23	3.02	0.63	0.13	0.004	530	0.030	0.013	0.052	43%
111	2270002045	Diesel Cranes	300 < HP <= 600	0.23	3.92	1.00	0.16	0.005	530	0.030	0.013	0.052	43%
112	2270002045	Diesel Cranes	750 < HP <= 1000	0.37	5.41	1.27	0.22	0.005	530	0.030	0.013	0.052	43%
113	2270002051	Diesel Off-highway Trucks	100 < HP <= 175	0.19	2.23	0.97	0.24	0.004	536	0.031	0.014	0.053	
114	2270002051	Diesel Off-highway Trucks	175 < HP <= 300	0.17	1.98	0.63	0.12	0.004	536	0.031	0.014	0.053	59%
115	2270002066	Diesel Tractors/Loaders/Backhoes	75 < HP <= 100	1.19	5.41	6.57	0.98	0.006	692	0.040	0.018	0.068	
116	2270002081	Diesel Other Construction Equipmen	75 < HP <= 100	0.40	4.00	3.42	0.49	0.005	595	0.034	0.015	0.059	
	Industrial Equipment Subcategory (*003*)												
117	2270003020	Diesel Forklifts	50 < HP <= 75	0.20	3.16	2.27	0.23	0.005	596	0.034	0.015	0.059	59%
118	2270003020	Diesel Forklifts	175 < HP <= 300	0.17	1.96	0.61	0.12	0.004	536	0.031	0.014	0.053	59%
119	2270003040	Diesel Other General Industrial Eqp	75 < HP <= 100	0.37	4.02	2.20	0.36	0.005	589	0.034	0.015	0.058	
120	2270003040	Diesel Other General Industrial Eqp	300 < HP <= 600	0.26	4.28	1.12	0.19	0.005	530	0.030	0.013	0.052	
	Commercial Equipment Subcategory (*006*)												
121	2270006005	Diesel Generator Sets	75 < HP <= 100	0.61	5.09	2.78	0.50	0.005	589	0.034	0.015	0.058	43%
122	2270006005	Diesel Generator Sets	100 < HP <= 175	0.45	5.05	1.58	0.31	0.005	530	0.030	0.013	0.052	43%
123	2270006005	Diesel Generator Sets	175 < HP <= 300	0.41	4.81	1.40	0.26	0.005	530	0.030	0.013	0.052	43%
124	2270006005	Diesel Generator Sets	300 < HP <= 600	0.36	4.80	1.51	0.23	0.005	530	0.030	0.013	0.052	43%
125	2270006010	Diesel Pumps	75 < HP <= 100	0.61	5.10	2.81	0.52	0.005	589	0.034	0.015	0.058	43%
126	2270006010	Diesel Pumps	300 < HP <= 600	0.36	4.81	1.52	0.23	0.005	530	0.030	0.013	0.052	43%
127	2270006015	Diesel Air Compressors	50 < HP <= 75	0.39	4.34	2.41	0.35	0.005	589	0.034	0.015	0.058	43%
128	2270006015	Diesel Air Compressors	75 < HP <= 100	0.38	4.11	2.23	0.37	0.005	589	0.034	0.015	0.058	43%
129	2270006025	Diesel Welders	50 < HP <= 75	1.33	5.68	6.50	0.96	0.006	692	0.040	0.018	0.068	21%

a/ NONROAD only outputs emission factors as PM_{10}; as per EPA guidance ("Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression-Ignition," EPA420-P-04-009/NR-009c, April 2004; "Exhaust Emission Factors for Nonroad Engine Modeling: Spark-Ignition," EPA420-R-05-019/NR-010e, December 2005), $PM_{2.5}$ factors gas diesel and gasoline engines are 97% and 92% of PM_{10} factors, respectively.

	Emission factors in g/mi								
	VOC	NO_x	CO	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O	mi/gal
Light-Duty Gasoline Vehicles (LDGV)	0.483	0.419	5.24	0.0248	0.0067	368	0.40	0.17	24.1
Light-Duty Gasoline Trucks (< 3 ton)	0.754	0.754	7.47	0.0249	0.0088	478	0.40	0.17	18.6
Light-Duty Gasoline Trucks (> 3 ton)	0.628	0.760	6.70	0.0249	0.0115	623	0.40	0.17	14.2
Light-Duty Diesel Trucks (LDDT)	0.15	0.205	1.006	0.0497	0.0056	314	0.005	0.005	32.4
Heavy-Duty Diesel Vehicles (HDDV)	0.405	2.525	0.922	0.1031	0.0131	1411	0.005	0.005	7.2
	g/gal								
Light-Duty Gasoline Vehicles (LDGV)	11.6403	10.0979	126.284	0.59768	0.161	8869	9.6	4.1	
Light-Duty Gasoline Trucks (< 3 ton)	14.0244	14.0244	138.942	0.46314	0.164	8883	7.4	3.2	
Light-Duty Gasoline Trucks (> 3 ton)	8.9176	10.792	95.14	0.35358	0.163	8845	5.7	2.4	
Light-Duty Diesel Trucks (LDDT)	4.86	6.64	32.59	1.61	0.181	10170	0.16	0.16	
Heavy-Duty Diesel Vehicles (HDDV)	2.92	18.18	6.64	0.74	0.094	10157	0.04	0.04	

On-road Vehicles

		MOBILE6 emission factors (g/hp-hr)								
		VOC	NO_x	CO	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O	gal/hp-hr
150	Light-Duty Gasoline Vehicles (LDGV)	0.70	0.61	7.6	0.036	0.010	532	0.58	0.25	0.06
151	Light-Duty Gasoline Trucks (< 3 ton)	0.84	0.84	8.3	0.028	0.010	533	0.45	0.19	0.06
152	Light-Duty Gasoline Trucks (> 3 ton)	0.54	0.65	5.7	0.021	0.010	531	0.34	0.14	0.06
153	Light-Duty Diesel Trucks (LDDT)	0.29	0.4	2.0	0.097	0.011	610	0.010	0.010	0.06
154	Heavy-Duty Diesel Vehicles (HDDV)	0.17	1.1	0.4	0.045	0.006	609	0.002	0.002	0.06

Emission factors (g/mi) for VOC, NO_x, CO, PM, SO_2, CO_2, and fuel economy values were based on RI DEM's latest information (MOBILE6.2 model and inputs for 2009, run for a summer 2013 run; 20 mph speed Arterial run; emission factors shown are conservatively for PM_{10} rather than $PM_{2.5}$). Conversions to g/gal were calculated based on average fuel economy (mi/gal). Conversions to g/hp-hr were based on an estimated brake-specific fuel consumption of 0.06 gal/hp-hr.

Helicopters

	Helicopter emissions in g/kg fuel									
	VOC	NO_x	CO	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O	gal/hr	kg/hr
Helicopters	5.2	6.6	47.2	0.66	0.54	3107	0.087	0.100	67	205
	kg/hr									
	1.07	1.36	9.7	0.136	0.111	638	0.018	0.021		

Emission factors for VOC, NO_x, CO, and SO_2 are from the FAA's EDMS model (Bell 206 helicopter data from AP-42 Volume II); factors are worst-case with respect to takeoff, climb-out, and approach modes. Emission factors for PM are 10% of those for NO_x, conservatively based on data showing PM emissions no higher than 10% of NOx emissions for all shaft horsepower (from "Guidance on the Determination of Helicopter Emissions," Edition 1, 0 / 3/33/33-05-020, March 2009, Swiss Confederation Federal Office of Civil Aviation (FOCA), CH-3003). Gal/hr based on client estimate of 400 gal per 6 hour day. kg/hr based on a helicopter turbine fuel density of 3.08 kg/gal; this density, along with emission factors for CO_2, CH_4 and N_2O are from EPA (2008) "Direct Emissions from Mobile Combustion Sources." Climate Leaders: Greenhouse Gas Inventory Protocol, Core Module Guidance. EPA430-K-08-004. May.

CH_4 and N_2O From Combustion

Marine Diesels Fueled With Oil

Reference	Sources	CH_4	N_2O
EPA (2008), Table A-6	Marine diesels fueled with oil	0.230 g/kg	0.080 g/kg

Other Offroad/Nonroad Engines

EPA (2008), Table A-6 and TCR (2008), Table 13.6	Construction Equipment	0.180 g/kg	0.080 g/kg

Boilers, Turbines, and Stationary Engines

TCR (2008), Table 12.7	Industrial Gas-Fired Boilers	0.9 g/MMBtu (HHV)	0.9 g/MMBtu (HHV)
TCR (2008), Table 12.7	Industrial Distillate Oil-Fired Boilers	0.2 g/MMBtu (HHV)	0.4 g/MMBtu (HHV)
TCR (2008), Table 12.7	Industrial Residual Oil-Fired Boilers	3.0 g/MMBtu (HHV)	0.3 g/MMBtu (HHV)
TCR (2008), Table 12.7	Gas-Fired Combustion Turbines	3.8 g/MMBtu (HHV)	0.9 g/MMBtu (HHV)
TCR (2008), Table 12.9	Oil-Fired Combustion Turbines	3.0 g/MMBtu (HHV)	0.6 g/MMBtu (HHV)
TCR (2008), Table 12.5, 12.9	Large Dual-Fueled Engines	245 g/MMBtu (HHV)	0.1 g/MMBtu (HHV)
TCR (2008), Table 12.7, 12.9	Gas-fired recip engines, 2-stroke lean-burn	658.0 g/MMBtu (HHV)	0.1 g/MMBtu (HHV)
TCR (2008), Table 12.7, 12.9	Gas-fired recip engines, 4-stroke lean-burn	566.9 g/MMBtu (HHV)	0.1 g/MMBtu (HHV)
TCR (2008), Table 12.7, 12.9	Gas-fired recip engines, 4-stroke rich-burn	104.5 g/MMBtu (HHV)	0.1 g/MMBtu (HHV)
TCR (2008), Table 12.7, 12.9	Oil-fired recip engines	4.0 g/MMBtu (HHV)	0.6 g/MMBtu (HHV)

On-road vehicles

TCR (2008), Table 13.4 and EPA (2008), Table 3	On-road gasoline vehicles (highest values in ranges given)	0.4 g/mi	0.17 g/mi
TCR (2008), Table 13.4 and EPA (2008), Table 3	On-road diesel vehicles (highest values in ranges given)	0.005 g/mi	0.005 g/mi

EPA (2008) “Direct Emissions from Mobile Combustion Sources.” Climate Leaders: Greenhouse Gas Inventory Protocol, Core Module Guidance. EPA430-K-08-004. May.

TCR (2008) The Climate Registry General Reporting Protocol. Version 1.1. May.

APPENDIX E

Digital Appendix

Electronic Copy of General Activities Plan Shapefiles

Marine Site Characterization Study Digital Appendix

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