Volume II

Aguirre Offshore GasPort Project
Final Environmental Impact Statement

FERC/EIS-0253F

Docket Nos.
CP13-193-000
and PF12-4-000

February
2015

Federal Energy Regulatory Commission
Office of Energy Projects
Washington, DC 20426

Aguirre Offshore GasPort Project
Final Environmental Impact Statement

Aguirre Offshore GasPort, LLC
Volume II

Docket Nos. CP13-193-000 and PF12-4-000
FERC/EIS-0253F

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U.S. Coast Guard
Puerto Rico Permits Management Office
U.S. Department of Energy
U.S. Department of Transportation
Puerto Rico Environmental Quality Board
Puerto Rico Planning Board
Puerto Rico Department of Natural and Environmental Resources
Puerto Rico Department of Health
U.S. Department of Agriculture

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FINAL ENVIRONMENTAL IMPACT STATEMENT

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U.S. COAST GUARD LETTER OF RECOMMENDATION AND ANALYSIS

U.S. Department of Homeland Security
United States Coast Guard

Commander
U.S. Coast Guard Sector San Juan

5 Calle La Puntilla
San Juan, PR 00901-1819
Phone: (787) 729-2300

16610
P 071-14
May 02, 2014

Director of Gas Environment and Engineering, PJ11
Attn: Ms. Lauren O'Donnell
Federal Energy Regulatory Commission
888 1St NE
Washington, DC 20426-002

Dear Ms. O'Donnell:

This Letter of Recommendation (LOR) is issued pursuant to 33 CFR 127.009 in response to the Letter of Intent (LOI) submitted by Excelerate Energy L.P. on December 20, 2011 proposing to transport Liquefied Natural Gas (LNG) by ship to the Aguirre Offshore GasPort Project proposed for operation in Salinas, along the southern shore of Puerto Rico in Commonwealth waters. This LOR conveys the Coast Guard's recommendation on the suitability of the waterway for LNG marine traffic as it relates to safety and security. In addition to meeting the requirements of 33 CFR 127.009, this letter also fulfills the Coast Guard's commitment for providing information to your agency under the Interagency Agreement signed in February 2004.

After reviewing the information in the applicant's LOI and the Waterway Suitability Assessment (WSA) and completing an evaluation of the waterway in consultation with a variety of Commonwealth and local port stakeholders, I recommend that the waterway surrounding the Jobos Bay be considered suitable for accommodating the type and frequency of LNG marine traffic associated with this project. My recommendation is based on review of the factors listed in 33 Code of Federal Regulations (CFR) 127.007 and 33 CFR 127.009. The reasons supporting my recommendation are outlined more thoroughly in the enclosed LOR Analysis, which contains a detailed summary of the WSA review.

On April 21, 2014, I completed a review of the WSA for the Aguirre Offshore GasPort Project, submitted by Excelerate Energy L.P. on January 10, 2014. This review was conducted following the guidance provided in U.S. Coast Guard Navigation and Vessel Inspection Circular (NVIC) 01-2011. The review focused on the navigation safety and maritime security aspects of LNG vessel transits along the affected waterway. My analysis included an assessment of the risks posed by these transits and possible management measures that should be imposed to mitigate these risks. During the review, I consulted with members from the South Coast Harbor Safety Committees, Area Maritime Security Committee, Commonwealth government and industry partners, and collected their expert input and recommendations relating to the future operations and potential impacts to the waterway surrounding the Jobos Bay. Following the formal consultation and validation of the WSA, my staff developed the enclosed LOR Analysis (LORA), which contains a detailed summary of the WSA review process that has guided this recommendation. Since certain sections of the LORA contain security-related data that is "Sensitive Security Information" (SSI), two versions are enclosed. The first contains SSI. The second has all SSI redacted and is maked as such. This is done to a redacted copy that is releasable to the general public.

16610
P 071-14
May 02, 2014

My recommendation of the suitability of this waterway is provided to assist you in your determination of whether the proposed facility should be commissioned. As with all issues related to waterway safety and security, I will assess each transit on a case by case basis to identify what, if any, safety and security measures are necessary to safeguard the public health and welfare, critical marine infrastructure and key resources, the port, the marine environment, and the vessel.

If you have questions regarding this recommendation, my point of contact is LCDR Jose Perez and can be reached at 787-729-2374 and at jose.a.perez3@uscg.mil.

Sincerely,

D. W. PEARSON
Captain, U. S. Coast Guard
Captain of the Port

Enclosures: (1) Letter of Recommendation Analysis (SSI)
(2) Letter of Recommendation Analysis (Redacted)

Copy: Commander Coast Guard District 7 (dp)
Commander Atlantic Area (ap)
Excelerate Energy L.P.

ANALYSIS SUPPORTING THE LETTER OF RECOMMENDATION ISSUED BY COTP SECTOR SAN JUAN ON MAY 02, 2014

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1. INTRODUCTION

A. This analysis supplements the Letter of Recommendation (LOR) dated May 02, 2014, which conveys the San Juan Captain of the Port (COTP) recommendation on the suitability of the Aguirre Offshore GasPort Project for liquefied natural gas (LNG) marine traffic associated with the Aguirre Offshore GasPort, LLC (AOGP), an entirely owned subsidiary of Excelerate Energy L.P. (Excelerate Energy). AOGP is proposing to develop, construct, and operate the Aguirre Offshore GasPort Project (Project) to be located in Salinas, along the southern shore of the Commonwealth of Puerto Rico in Commonwealth waters. The Project is being developed in cooperation with the Puerto Rico Electric Power Authority (PREPA) for the purpose of receiving and storing liquefied natural gas (LNG) to be acquired by PREPA, regasifying the LNG, and delivering natural gas to PREPA's existing Aguirre Power Complex (Aguirre Plant). The Project will include an LNG terminal and facilities that will be sited, constructed and operated pursuant to Section 3 of the Natural Gas Act (NGA), 15 U.S.C. § 717b. It documents the processes followed in analyzing the AOGP's Waterway Suitability Assessment (WSA) completed on January 10, 2014, and the Coast Guard's assessment of the suitability of the waterway for LNG marine traffic identified above.

For the purposes of this analysis, the following assumptions were made:

1. The applicant is fully capable of, and would fully implement, any and all risk mitigation measures identified in their WSA and measures referenced in this LOR Analysis.

2. The conditions of the port area identified in the WSA fully and accurately describe the actual conditions of the GasPort area at the time of the WSA submission.

3. The conditions of the port area have not changed substantially during the analysis process.

4. The applicant will fully meet all regulatory requirements including the development and submission of an Emergency Manual and Operations Manual.

2. BACKGROUND

A. The data and information regarding the proposed LNG berthing and regasification platform (BRP) detailed in this Letter of Recommendation Analysis (LORA) were derived from Aguirre Offshore GasPort Project's Letter of Intent (LOI) and WSA provided directly to the COTP. The WSA is an applicant-prepared risk-based assessment, designed to document and address all safety concerns related to the marine transportation of LNG for a U.S. port or waterway. The scope of the Aguirre Offshore GasPort Project (AOGP) WSA was based on U.S. Code of

Federal Regulations (CFR) Part 127, and U.S. Coast Guard (USCG) policy guidance (in part) contained in Navigation and Vessel Inspection Circular (NVIC or Circular) 01-2011, *Guidance Related to Waterfront Liquefied Natural Gas (LNG) Facilities*, dated January 24, 2011.

B. The Aguirre Offshore GasPort Project's WSA considered the entire approach to the LNG BRP, with particular attention focused on all safety aspects of the waterway within 25 kilometers (15.5 miles) of the proposed platform location, as outlined in 33 CFR 127.007 and 127.009. Included in this evaluation were the hydrodynamics of the waterway (tides, currents etc.), density of deep-draft vessel traffic, recreational boating, commercial fishing, aids to navigation (ATON), climatic weather (winds and heavy seas), identification of environmentally sensitive areas, detection of hazards to navigation (shoaling, ledges etc.), and the available response capabilities along the transit route.

C. The lead federal agency responsible for the permitting of this LNG BRP is Federal Energy Regulatory Commission (FERC). Information contained in the AOGP's LOI and WSA enables the COTP to provide specific input, via this Letter of Recommendation (LOR) to FERC as to the suitability of the waterway to support LNG marine traffic associated with the AOGP LNG project. It should be noted that the LOR is based upon the Coast Guard's expertise in navigation safety and neither the LOR nor this LORA impose conditions on the FERC permit.

D. Regional stakeholders were invited to form an LNG working group. The LNG working group contributed to the information contained in this LOR Analysis. None of the participants were asked to "vote" or otherwise indicate whether the AOGP project proposal should be approved. Rather, members from the LNG working group were relied upon to provide valid input based on their expertise and regional familiarity in order to conduct a thorough review of the WSA. The input gathered from the LNG working group helped identify potential risks to navigational safety associated with the proposed project. Additionally, this input assisted with the development of operational parameters significant to the transit, and assisted in the identification of potential mitigation measures.

E. The LNG working group included participation of members from Harbor Safety Committee and other port stakeholders. On August 14, 2013 the LNG working group met in U.S. Coast Guard Resident Inspection Office in Ponce for the initial LNG working group meeting. Representatives from the following agencies and port stakeholders participated in this working group: South Coast Pilots, American Tugs Incorporated, Luis Ayala Vessel Agents, Gulf Harbor Shipping Agents, South Puerto Rico Towing, and CORCO. In addition to the member's from the LNG working group, the Puerto Rico's Departamento Recursos Naturales y Ambientes (DRNA) was also consulted during the review and validation of the WSA.

F. The LNG working group was provided electronic copies of the WSA; they then reviewed and commented on subject areas commensurate with their vocation, expertise, or regional familiarity. After the initial review, specified issues, concerns, and/or risks relating to the proposed project were reviewed by individual members and *ad hoc*, informal groups, for further consideration and recommended resolution.

3. RESOLUTION PRECISION

A. The following sections summarize the myriad specifics considered and reasoning behind the COTP's determination. This summary is not all inclusive; background information and amplifying data are contained in the applicant's WSA, to include vessel traffic studies, casualty analysis, port characterization appraisals, and risk-based safety assessments, among others.

B. COTP has confirmed that the hydrographic characteristics of the waterway as described in the WSA will sustain deep draft vessel movement confirming that the transit and maneuvers are comparatively feasible for the design range of LNG carriers anticipated. Identified safety risk mitigation measures, and/or implementation strategies from the WSA are discussed in the following paragraphs, where applicable.

C. COTP comments pertinent to a particular WSA recommendation, and/or the identification of additional risk management measures recommended by the COTP, are also provided where relevant.

4. PROJECT OVERVIEW

A. AOGP, a wholly owned subsidiary of Excelerate Energy is proposing to develop, construct, and operate the Aguirre Offshore GasPort Project to be located in Salinas, along the southern shore of the Commonwealth of Puerto Rico in Commonwealth waters. The Project is being developed in cooperation with the Puerto Rico Electric Power Authority (PREPA) for the purpose of receiving and storing LNG to be acquired by PREPA, regasifying the LNG, and delivering natural gas to PREPA's existing Aguirre Plant.

B. The purpose of the project is to provide up to 3.2 Bcf of LNG storage capacity and sustained deliverability of 500 MMscf/d, with a peaking deliverability of up to 600 MMscf/d of natural gas directly to the 1,492 MW Aguirre Plant. The project will allow PREPA to effectuate its long planned conversion of the Aguirre plant from fuel oil only to dual-fuel generation facility, capable of burning diesel and/or natural gas for the combined cycle units and fuel oil and natural gas for the thermoelectric plant. A diversified fuel supply at the Aguirre Plant will present an environmentally acceptable alternative to oil in meeting the project demand.

C. In order to deliver natural gas to the Aguirre Plant, PREPA is working with AOGP who will develop, construct and operate an LNG terminal off the coast of Aguirre. As part of this process, on December 20, 2011 Excelerate Energy submitted to the USCG Captain of the Port at San Juan, Puerto Rico, and an LOI to construct and operate an offshore LNG import terminal off the southern coast of Puerto Rico.

D. The project requires authorization from the FERC and be subject to a full public environmental review and analysis under the National Environmental Policy Act (NEPA). The Aguirre Offshore GasPort will be located approximately 3 miles from shore and approximately 0.6 miles from the barrier islands outside Bahía de Jobos, near the towns of Salinas and Guayama. The location is in waters approximately 60 ft deep and well clear of shipping lanes, established navigation channels, and other marine infrastructure.

E. The project will consist of three main components: 1) an offshore berthing platform; 2) an offshore LNG receiving facility (Offshore GasPort) consisting of a Floating Storage and Regasification Unit (FSRU) moored at the offshore berthing platform; and 3) a subsea pipeline connecting the Offshore GasPort to the Aguirre plant. The facility will consist of a fixed offshore berthing platform carrying all the topside facilities that will incorporate a berth for one of Excelerate Energy's eight existing Energy Bridge Regasification Vessels (EBRV) that will serve as the FSRU and a berth for LNG carriers (LNGC) with capacities ranging from 125,000 cubic meters (m3) up to 210,100 m3. Cargo will be transferred from the LNGC via the topside conventional LNG loading arms and cryogenic piping to the FSRU for storage.

F. The FSRU will remain moored at the facility continuously unless anticipated extreme weather conditions or maintenance needs dictate otherwise. The FSRU will be capable of storing up to a nominal 150,900m3 of LNG, the equivalent of approximately 3.2 billion cubic feet (Bcf) of natural gas in liquid form, and processing and transferring 500 million cubic ft per day (mmscfd) with peaking rates of up to 600 mmscfd to the Aguirre Plant via subsea pipeline. LNGCs will dock and offload at the facility on a regular basis except when extreme weather conditions are anticipated.

G. Along with the LOI, Excelerate Energy submitted a Preliminary Waterway Suitability Assessment (PWSA) for the project, in accordance with the requirements of 33 CFR 127.007 administered by the USCG and 18 CFR 157.21 administered by the FERC.

H. The Follow-On Waterway Suitability Assessment (WSA) was prepared to provide additional information on the project, including maritime safety assessments.

Figure 4A: Project Site Map

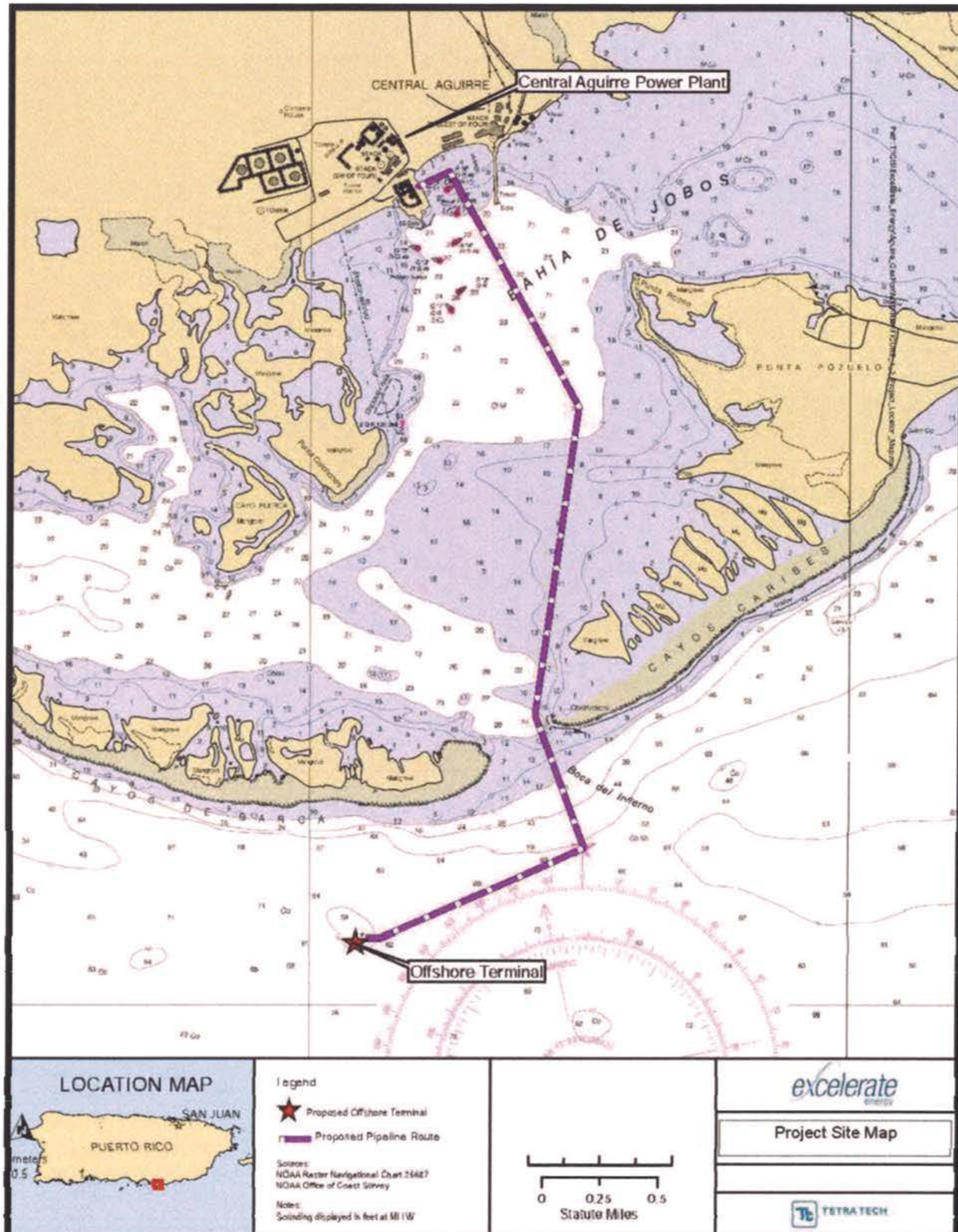

Figure 4B: Aguirre Offshore GasPort LNG Terminal

Figure 4C: Aguirre Offshore GasPort with FSRU

Figure 4D: Aguirre Offshore GasPort with FSRU and LNGC

5. MARINE TRANSPORTATION OF LIQUEFIED NATURAL GAS (LNG)

A. LNG consists almost entirely of methane (CH4), the simplest hydrocarbon compound. Typically, LNG is 85 to 95-plus percent methane, along with a few percent ethanes, even less propane and butane, and trace amounts of nitrogen. The exact composition of natural gas (and the LNG formed from it) varies according to its source and processing history. And, like methane, LNG is odorless, colorless, noncorrosive, and nontoxic. In general, deep draft or ocean-going "gas carriers" are categorized by the hazard potential of the cargo or cargoes they carry and are divided into (1) those that carry LHG cargoes and (2) those that carry LNG. As per the International Maritime Organization (IMO) Gas Carrier Code, they are further broken down into three types: IG, IIG, or IIIG, depending on vessel size, cargo tank design/placement, and level of protective measures intended to prevent the escape of cargo. Type IG is used for chlorine, ethylene oxide, methyl bromide, and sulfur dioxide cargoes; type IIG is used for LHG or LNG and applies to vessels over 150 meters (492 feet) in length, and type IIIG is intended for cargoes of nitrogen and refrigerant gases. LNG carriers calling on the AOGP will predominately be type IIG ships, built with independent cargo tanks, usually of prismatic shape, that are completely self-supporting, *i.e.,* they do not form part of the vessel's hull.

B. Cargoes carried in this type of cargo tank arrangement are fully refrigerated, and maintained at or near atmospheric pressure. For added safety and efficiency, modern LNG carriers of the above design have a secondary containment system, known as a "secondary barrier", surrounding each tank that is capable of containing the entire contents of the cargo tank. This is accomplished by building a second "skin" around the cargo tank itself, or building the hull out of special steels to accomplish the same. In either case, the space between the primary barrier and secondary barrier is filled with inert gas, which will not support combustion. Below is the Department of Energy's Liquefied Natural Gas Understand the Basic Facts.

Department of Energy; Liquefied Natural Gas: Understanding the Basic Facts

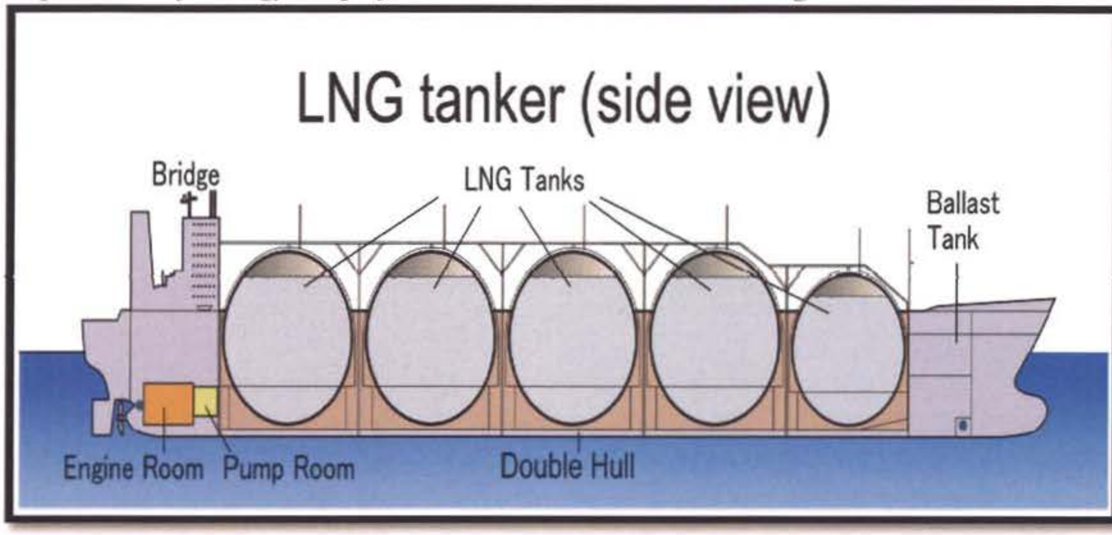

Figure 5A: LNG tanker side view

Figure 5B: Typical LNG carrier anticipated for the AOGP

While the marine transportation of liquefied gases incurs its own special hazards, some of the features are less hazardous than those of the heavier petroleum cargoes. Hazards peculiar to the carriage of LHG cargoes include:

- Cold from leaks and spillages can affect the strength and ductility of a vessel's structural steel. Likewise, skin contact with the liquids or escaping gases can produce frostbite and inhalation of the cold vapor can permanently damage certain organs, such as the lungs.

- Rupture of a pressure system containing LNG could release a massive evolution of vapor, termed a vapor cloud.

LHG transportation hazards that are reduced, as compared with "normal" petroleum tanker operations, include:

- Loading or ballasting does not eject gases to the atmosphere in the vicinity of decks and superstructures. Gas freeing is rarely performed and does not usually produce gas on deck.
- Liquefied gas compartments are never within flammable limits throughout the cargo cycle. Within a cargo tank the vapor space above the liquid cargo is virtually 100% rich with cargo vapor and thus far above the upper flammable limit. Static electricity and other in-tank ignition sources are, therefore, no hazard.
- There is no requirement for tank cleaning; therefore, the hazards associated with that operation are eliminated.
- Gas carriers are fitted with fixed water spray systems for added fire protection. The spray nozzles cover cargo tank domes, above-deck cargo tank areas, manifolds, and provide a curtain of spray over the front of accommodation spaces, cargo control rooms, etc.

6. WATERWAY TRANSIT CONSIDERATIONS.

6.1. TRANSIT ROUTE

A. The intended transit route for the deep-draft LNGCs, from sea to project site, excludes the Bahía de Jobos. Only smaller tug and barges delivering oil to the Aguirre Terminal will be continuing the use of the Bahia de Jobos. This area is located in Central Aguirre on the south coast of the Commonwealth of Puerto Rico at latitude 17 56'23" North and longitude 66 13'07" West between the towns of Salinas (population approximately 31,000) and Guayama (population approximately 45,500). Bahía de Jobos is an elliptical body of water, about 4 NM long in an east-west direction and about 2.5 nm wide at its widest points, with general depths ranging from 11 ft (3.4 m) to 30 ft (9.1 m). All aspects of the transit route to and from the proposed terminal and storage facility were evaluated, including tides and currents, prevailing weather, density and character of marine traffic, deep draft vessel management, recreational boating and commercial fishing, navigational aids, regional waterway events, surrounding community/port impacts, and relevant environmental/iconic considerations.

B. Applicable navigation charts are National Oceanic and Atmospheric Administration (NOAA) #'s 25677 *Guanica Light to Punta Tuna Light* and 25687 *Bahía de Jobos*. General information on the region is available from the U.S. Coast Pilot Volume 5 *Gulf of Mexico, Puerto Rico & the Virgin Islands, Chapter 13: Puerto Rico*. Figure 6A provides an overview of the Bahía de Jobos Waterway and the primary oil cargo delivery to the Aguirre Plant.

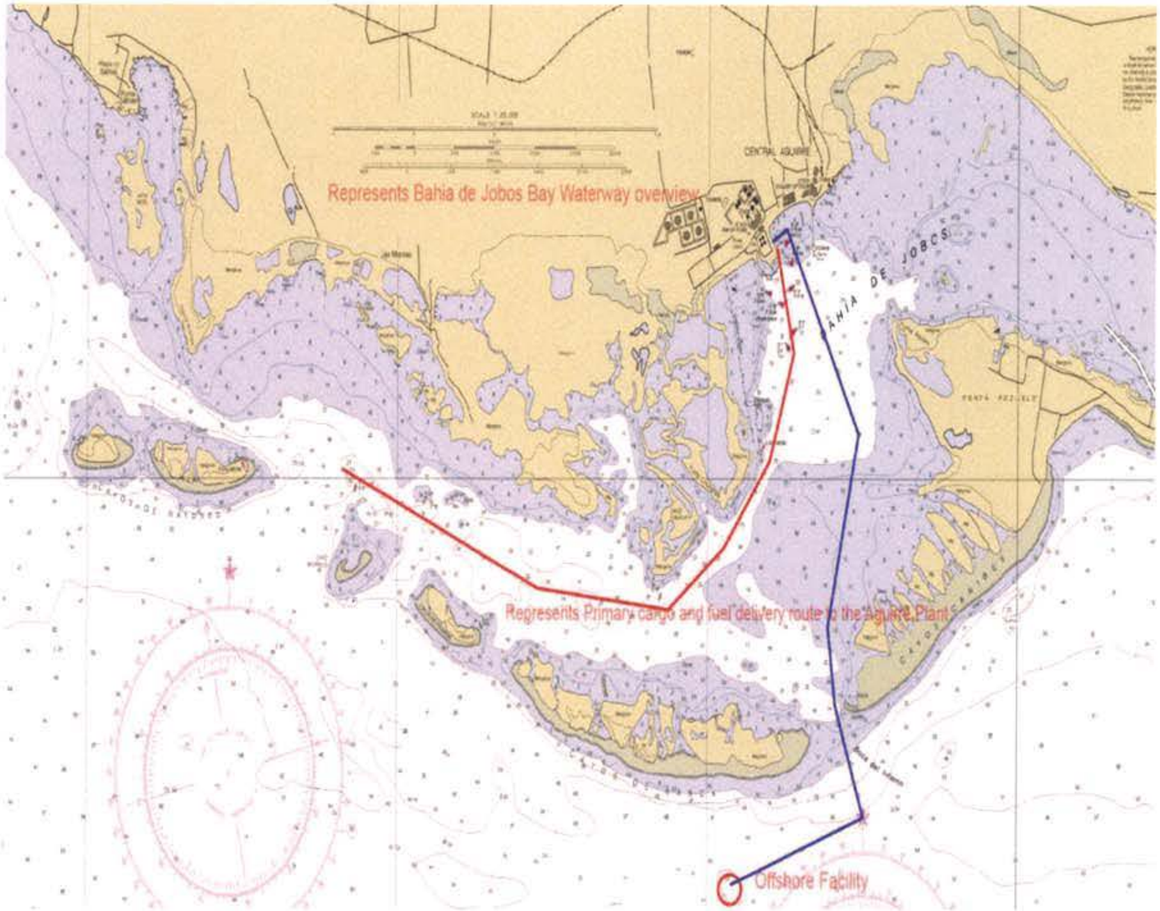

Figure 6A: Waterway overview

6.2. DEPTHS OF WATER & TIDAL RANGE

A. LNG carrier routes that will be used are open water deep transits. Depths at the LNG offshore facility will be approximately 60 feet with the further seaward the greater the depth and can be navigated throughout the tidal range. As per the recommendations made by the LNG working group (which included input from the South Coast Pilots), it was decided that the best location for the pilot boarding area would be two nautical miles due South of the LNG offshore facility. The identified pilot boarding area will be in depths greater than 80 feet, which does not pose a risk of grounding, see Figure 6B. Additionally, the LNG working group determined that the prevailing sea states at this location allow for the safe boarding of the pilots. NOAA tidal range prediction for the area in 2013 is a 1FT maximum high tide and a -0.3 maximum low tide. A typical monthly tide table is in Figure 6C shows that currents also have been steady from 2008 to 2012 with a Flood at 250 degrees True and Ebb at 055 degrees True.

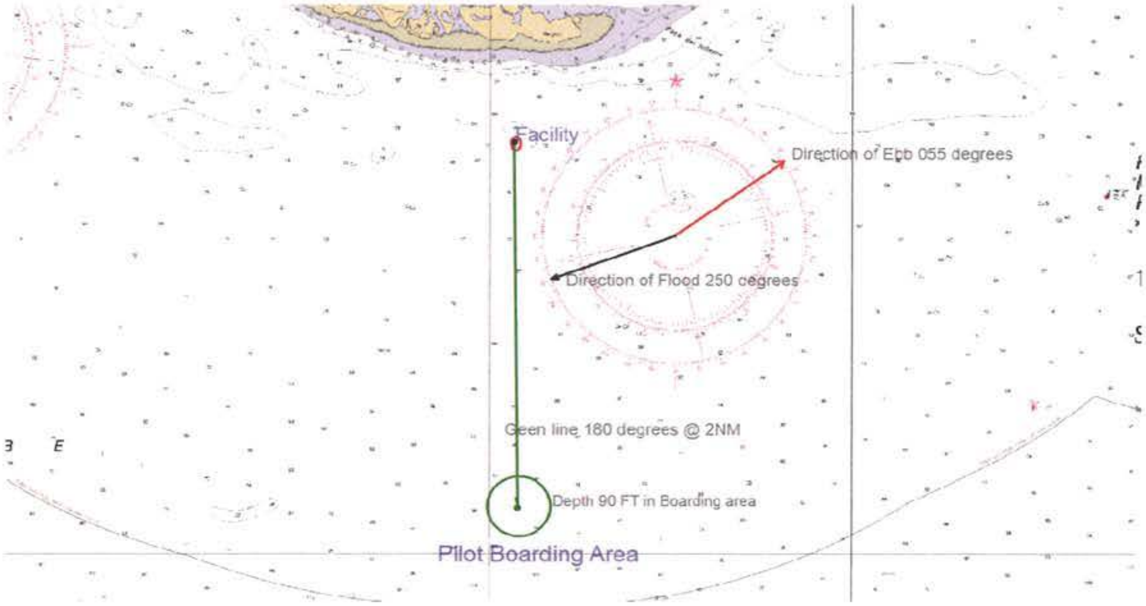

Figure 6B: Pilot Boarding Area, Facility location and current direction.

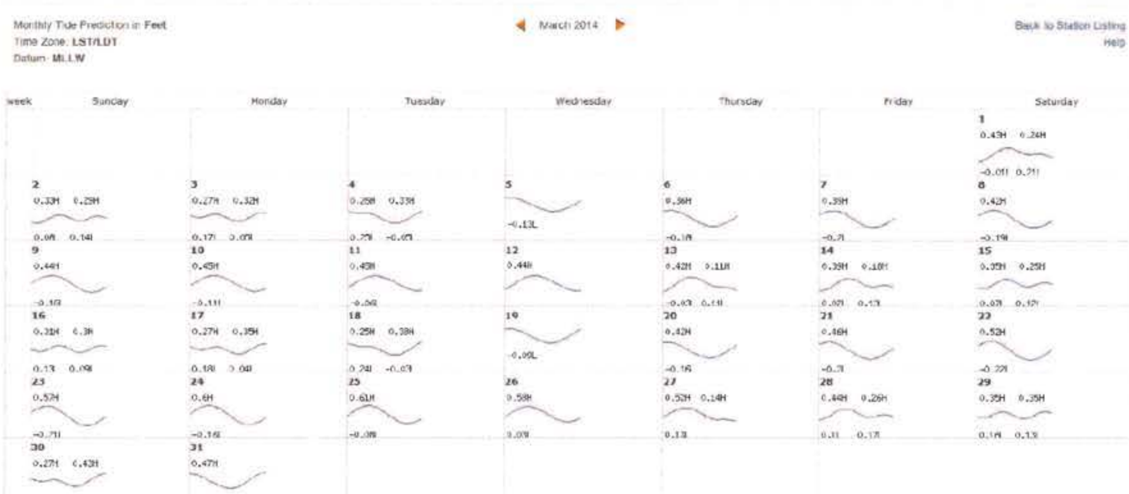

Figure 6C: Typical monthly tide table.

B. The submerged pipeline will be laid from the offshore gas port through the east side of Boca del Infierno and then continue north through Bahía de Jobos towards the Aguirre power plant. The submerged pipeline will be anchored on the bottom at depths between nine to 60 feet. The pipeline will extend 24 inches off the bottom and may pose a risk to vessels depending on their draft. Vessels with a deep draft should avoid the area along the pipeline due to the pipeline protruding 24 inches off the sea floor.

C. Anchoring and dredging should be avoided along the route of the pipeline. The route of the pipeline begins in an approximate position of 17 54'15"N, 066

13'50"W thence north-east to approximate position 17 54'17"N, 066 13'42"W thence north-west to approximate position 17 54'35"N, 066 12'59"W thence north to approximate position 17 55'03"N, 066 13'10"W thence north-west to approximate position 17 56'11N, 066 13'01"W and end at the Aguirre power plant, again all positions are approximate. The purpose of this pipeline is to transfer LNG from the Aguirre Offshore GasPort to the Aguirre power plant located approximately 3 miles from the offshore facility. It is recommended that an entry be made into the U.S. Coast Pilot Volume 5 *Gulf of Mexico, Puerto Rico & the Virgin Islands, Chapter 13: Puerto Rico.* This information will be available to all vessels transiting the area and inform mariners of the dangers associated with the pipeline. It is also recommended that the pipeline, facility and note be charted on NOAA charts informing mariners of the dangers of a submerged pipeline in the area. Examples of the notes to be added to NOAA Charts are listed in Figure 6C and Figure 6D.

NOTE C

The PRECAUTIONARY AREA/LOOP SAFETY ZONE is a regulated area. Clearance procedures for entry and conduct of operations within this zone are found in 33 CFR 150, SUBPART C. These regulations should be reviewed prior to attempting a transit of this area.

Figure 6C: Note Example for Chart

CAUTION

SUBMARINE PIPELINES AND CABLES

Charted submarine pipelines and submarine cables and submarine pipeline and cable areas are shown as:

Pipeline Area

Cable Area

Additional uncharted submarine pipelines and submarine cables may exist within the area of this chart. Not all submarine pipelines and submarine cables are required to be buried, and those that were originally buried may have become exposed. Mariners should use extreme caution when operating vessels in depths of water comparable to their draft in areas where pipelines and cables may exist, and when anchoring, dragging, or trawling.

Figure 6D: Example of Caution note for Chart

6.3. HYDROGRAPHIC & WEATHER CHARACTERISTICS

A. The vessel master and port facility operator shall monitor weather conditions and forecasts by official weather advisories to ensure cargo unloading and regasification operations occur within the safe operating parameters of the port facility. Should existing conditions or forecasts exceed normal safe operating parameters established for the port facility, the vessel master and port facility operator shall follow a Severe Weather Action Plan, published in the Operations Manual, in accordance with 33 CFR 127.019. The Severe Weather Action Plan shall be developed and in place before the port facility is placed into operation and shall include the following basic provisions:

1. While an LNG carrier is moored and discharging cargo at the port facility, weather shall be monitored by the port facility operator and vessel master. Any significant weather disturbances within a 500-mile radius of the port facility shall warrant special attention. Additional weather information shall be made available through several sources, including commercial weather services, the NOAA Tropical Prediction Center, the National Data Buoy Center, and local weather broadcasts;

2. As stated within the WSA, and as per the normal operating procedures that the Aguirre GasPort will implement, LNGCs and the FSRU moored to the port facility will make initial preparations to depart the port facility when a weather disturbance is forecasted to generate wave heights in excess of 3 meters and is projected to approach the port facility within 24-hours;

3. LNG carriers moored at the port facility shall secure LNG transfer operations, disconnect from the port facility, and depart whenever a weather disturbance forecasted to generate wave heights in excess of 3 meters is projected at the port facility within 12-hours, or at any time the port facility operator or LNG master determine there is an unsafe condition or other occurrence that requires the need for the LNG carrier to depart the port facility;

4. The FSRU moored at the port facility shall make initial preparations to depart the port facility when a weather disturbance forecasted to generate wave heights in excess of 3 meters is projected to approach the port facility within 24-hours;

5. The FSRU vessel shall secure regasification operations, disconnect from the port facility and depart whenever a weather disturbance forecasted to generate wave heights in excess of 3 meters is projected at the port facility within 12-hours, or anytime the port facility operator or vessel master determine there is an unsafe condition or other occurrence that requires the need for the vessel to depart the port facility; and

6. For all situations where a LNG carrier or FSRU departs the port facility due to weather or unsafe conditions, permission to return to the port facility shall not

be granted by the port facility operator until the weather disturbance is well clear of the area, sea and swell have subsided, and the port facility is prepared to return to normal operation in accordance with the established safe operating parameters and permission from the COTP has been granted to resume operations. The platform may be inspected by COTP to ensure is safe to return to operations.

B. In an emergency situation, the LNG carrier and / or FSRU can activate the Emergency Shut-Down (ESD) System immediately suspending all cargo transfer and regasification operations and isolate the cargo system and other safety devices in a prescribed sequence. The port facility operator shall be able to activate the ESD System independently of either vessel, isolate and disconnect the HPMLA or cargo transfer arms and standby to activate the quick-release mooring hooks thereby releasing the vessel to depart the port facility under her own power in approximately 20-minutes.

C. The average wind speeds in Puerto Rico vary by season and by month. In summer the island is windier in comparison to winter. The prevailing winds of the island under normal conditions come from the northeast trade winds. Due to the close proximity to shore the facility shouldn't be affected by wind driven waves. The barrier islands to the north and Cayos Caribes to the northeast of the facility should create a lee and provide protection against the winds. During hurricane season the facility may be affected depending on the course of the storm. Due to the location of the offshore facility there is a possibility for wind and wave damage during a storm since there is no protection from the southeast to southwest of the offshore facility. There are five port conditions implemented by COTP. Condition 4 is to be set by all vessels and waterfront facilities from 1 June through 30 November. All remaining conditions shall be set when gale force winds (34KTS/39 MPH) are expected: Port Condition Whiskey 72 hrs, X-ray 48 hrs, Yankee 24 hrs, and Zulu 12 hrs. All ocean going commercial vessels greater than 500 GT are required to depart port or the designated representative must request permission in writing, for the COTP prior to setting Port Condition X-Ray and all ocean going commercial vessels over 500 GT not having written permission to remain in port must be at open sea when Port Condition Yankee is set in the COTP zone. It is recommended that the offshore facility implement the five port conditions as per the COTP requirements.

7. PORT LEVEL CONSIDERATIONS

7.1. MARITIME COMMERCE

A. The Aguirre GasPort will be constructed within the land and waters of Bahía de Jobos and the areas surrounding the Boca del Inferno leading to the contiguous Caribbean Sea. Currently, there are no federally regulated shipping lanes in the vicinity of the terminal site and traffic along the coast is mainly recreational and smaller size fishing boats. Furthermore, the proposed pipeline that extends from the location of the platform to the landside Aguirre Power plant will remain outside the privately maintained navigational channel.

B. No other deep draft vessel traffic passes or is expected near the offshore platform site. Fuel oil is delivered to the Aguirre Plant by a tug and barge. The tugs run inside the barrier islands then follow the non-federally regulated channel across Bahía de Jobos to the PREPA terminal, thus directly avoiding any proximity to the proposed pipeline.

C. The majority of the marine traffic in the area consists of commercial, recreational fishing and sport diving vessels. A summary of the findings include:

1. The Bahía de Jobos and surrounding keys plays host to a significant and diverse range of motor, sail, and manually-propelled boaters

2. The geographical setting promotes boating and ecotourism activities because of multiple mangrove canals, some of which form tunnels that local resident refer to as, "Los Placeres" (The Pleasures).

3. Over 50 small commercial vessels and 75 recreational fishermen utilize the water surrounding Bay the Jobos and the keys adjacent to the offshore platform.

4. There are no oil transfer anchorage areas, which alleviate the necessity or requirements for commercial vessels to anchor or to conduct fuel/oil transfer operations.

5. The amount of recreational boating traffic remains constant throughout the year.

6. The waterway is relatively wide and there is no established population along the route that the LNG carriers or in the vicinity of the offshore platform. If a casualty occurred involving an underway LNG carrier and resulted in a breach and release of cargo, potentially the platform staff, local recreational and fishing vessels transiting near or outside the safety zone will be affected. Population densities (persons per square mile) for the nearby areas located along the intended vessel route and the Aguirre GasPort are considered "low" e.g., less than 1,000.

7.2. REGIONAL IMPACT

A. An accidental spill or release of LNG consequent to a marine casualty could pose serious harm and multiple hazards to the general population, the navigable waterway, and surrounding environment. The nature and severity of the spill, climatic and sea conditions are all factors that must be taken into consideration in order to mount a rapid and effective response.

B. Safety zone parameters have been determined taking in consideration the worst case impact originated from a spill and the areas of concerns listed within the WSA. A fixed safety zone around a moored LNG carrier will be established, and will minimally impact the public's ability to access this particular area. Most significantly, the vessel traffic will not be able to access the water surrounding the Aguirre GasPort without permission from the COTP.

7.3. CULTURAL/ECONOMIC IMPACT

A. This region has a maritime footprint and few commercial operations that include: commercial and sport fishing, ecotourism industry and oil barge supply trade. Tourism and sport diving operations supplements the local economy, with much of the tourist pull centered on boating, canoeing/kayaking, recreational fishing, and day excursions to the cays in the vicinity of the offshore platform. The local municipalities along the shoreline depend on tourist-related and commercial fishing businesses to increase local capital and bolster employment opportunities. The residents of the municipality of Salinas have depended heavily on the coastal resources of Bahía de Jobos and the Caribbean Sea. Access to the Bay is an important means of subsisting.

B. Additionally, Salinas and Guayama have extensive shoreline resources including the second largest mangrove forest in Puerto Rico; beach facilities are located on the offshore islands and cays that ring the southern boundary of Bahía de Jobos. The geographical setting promotes boating and ecotourism activities because of multiple mangrove canals within the Bay, some of which form tunnels that local residents refer to as, "Los Placeres" (The Pleasures).

C. According to some residents and local businesses who are concerned with the Aguirre GasPort, the establishment of restricted zones and limitation of access to Bahía de Jobos and the Caribbean Sea via the cays in proximity to the project is a critical issue to the fishing community. Establishing restriction beyond the proposed safety zone of 500 yards could prevent the local fishermen from gaining access their fishing grounds. Additionally, the siting of the project in the midst of the cays threatens to severely hamper the ecotourism and recreational activities and might well tip the balance of the Bay towards further industrial activities.

D. The COTP appreciates the above-stated concerns and considered each throughout the WSA review and validation process. While this project does represent an increase in deep-draft vessel traffic and the enforcement of a regulated navigable area, it is taking into consideration not to expand restrictions that impact the nearby coastal resources beyond the proposed 500 yard safety zone.

8. OPERATIONAL CONSIDERATIONS

8.1. SHORE-SIDE EMERGENCY RESPONSE.

A. COTP comment: It's logical for one to expect that, in general, shore-based fire departments, emergency response units, and emergency management organizations located in close proximity would have the appropriate training and equipment necessary to launch an initial response capability to an LNG fire and/or related medical emergency. Unfortunately, in keeping with the rural nature of the area, that capability does not currently exist in the Bahia de Jobos. In all LNG project evaluations where the Federal Energy Regulatory Commission (FERC) is the lead federal jurisdictional agency and ultimately authorizes the sitting of the LNG terminal, the Commission Order will dictate that emergency response needs and related planning strategies must be addressed as per Section 311(d) of the Energy Policy Act of 2005, and the Natural Gas Act, 15 U.S.C § 717b-1. In addition, the Energy Policy Act of 2005 and ultimately, the FERC commission, require a cost sharing plan within the Emergency Response Plan (ERP), again applicable to LNG, that identifies the funding mechanism for all project-specific safety/emergency management costs that would be borne by state and local agencies to include:

1. Direct reimbursement (overtime for police and fire, *etc.*)
2. Capital costs associated with emergency management equipment (patrol boats, firefighting equipment, *etc.*); and
3. Annual costs associated with specialized training for fire departments, mutual aid, *etc.*

B. Accordingly, the need for offshore emergency plan development, resource identification, response training, and a public education program on emergency response management were acknowledged in the safety risk assessment portions of the WSA. Risk reduction measures such as these will need to be further considered by the FERC as the lead federal agency with siting authority for this project, in joint collaboration with the Commonwealth of Puerto Rico.

8.2. MARINE FIREFIGHTING CAPABILITIES

A. Fire is one of the most dangerous emergency conditions onboard a LNG ship. Therefore, LNGC onboard firefighting capabilities must be in compliance with rigorous requirements established by the International Gas Carrier (IGC) Code under the International Convention for the Safety of Life at Sea (SOLAS) 1974. In that firefighting resources aboard a vessel are physically limited, prevention is significantly important. The Fire Safety System (FSS) Code provides specific standards of engineering for fire safety systems onboard these vessels, to include fixed gas, foam, water pressure and spray extinguishing systems, personal protection equipment, and detection and alarm systems, just to name a few.

B. Due to the nature of LNG cargoes, and the potential for severe consequence subsequent to a major casualty, most LNG escort and assist tug boats are equipped with firefighting equipment that meet the International Association of Classification Societies (IACS) "FiFi 1" notation; *i.e.,* vessels are equipped with at least ***one monitor*** that, in total, have a discharge rate of 2400 m^3/hr, and are able to spray water to a height of 45 meters and to a minimum distance of 120 meters and capable of conducting sustained firefighting operations for at least 24 hours. In addition to the water stream requirements, at all levels of FiFi categories (1, 2, and 3) the vessels must have a deluge system, comprised of piping and associated sprinkler heads and nozzles along the deck and pilot house, which will provide a protective curtain of water and protect the tug/response vessel and crew from the effects of radiant heat. This would allow the tug to escape the scene of a fire in order to reach an area of refuge, or it might enable the tug to enter an area of high heat to affect a rescue. The National Fire Protection Academy, as outlined in its publication NFPA 1915 – *Standard on Marine Fire-Fighting Vessels,* also requires similar criteria for towing vessels in order that they maintain Class 1 certification. While there is no federal requirement that specifies that tugs in the service of escorting or assisting LHG vessels meet the FiFi 1 criteria; it has widely become the industry standard. Therefore, the COTP will require at least one tug in service to any LNGC or the FSRU to have FiFi 1 capability at all times.

C. The tug service for the Bahía de Jobos area is provided by South Puerto Rico Towing Company located in Guayanilla, PR. South Puerto Rico Towing is the principal towing company operating in the South and West coast of Puerto Rico serving EcoElectrica for more than 12 years moving more than 28 LNG tank vessels per year. The 03 tugs available to assist the LNG transit and mooring of LNG carriers are the:

1. 4,500 HP M/V MR FRANKIE P, which is powered by two GM diesel engines married to Ulstein "z-drives", has a 40 short-ton bollard pull and one FiFi fire pump monitor 850 hp hydraulic motor 5,300 gallons per minute (GPM) PSI 1400 RPM;

2. 4,300 HP twin-propellers M/V AZIMUTH TRACTOR TUG HECTOR P, which has a one monitor fitted with one FiFi fire pump and two other fire pumps firefighting system rated at 5,280 GPM; and

3. 3,800 HP twin-propellers powered M/V TUG DON HIRAM P, which has a 27 short-ton bollard pull and is equipped with a firefighting system capable of supplying 2,500 GPM. Currently, this vessel's system does not meet the FiFi 1 criteria.

D. Currently, two of the listed tugs are equipped with firefighting capabilities that meet the criteria specified for a FiFi 1 category. However, the South Puerto Rico Towing Tractor Tug Company, has examined the feasibility of retrofitting the

M/V TUG DON HIRAM P with the necessary drives, pumps, and associated piping etc. in order to produce water stream capacities that will meet the Fifi 1 criteria.

E. The COTP concurs on the need and significance of adequate firefighting capabilities for the port area and appreciates the tug company intentions to improve the capabilities of the M/V TUG DON HIRAM P. Enhanced firefighting capabilities will not only serve the LNG proposal, it will increase the margin of safety for all deep draft freighters and petroleum tankers servicing the south coast area.

8.3. APPLICATION OF ZONES OF CONCERN

A. An important consideration in assessing the suitability of the proposed transit route and approaches to support LNG marine traffic, is establishing the zones of concern, associated with a large release of LNG. The criterion used to define the outer limits of Zone 1 and 2 is incident flux, i.e., thermal radiation that would be expected from an intense LNG vapor fire over a specified time period.

Zone 1: The area within 500 meters (0.3 statute mile; 0.25 nm) of an LNG carrier where a LNG spill could pose a severe public safety and property hazard and could damage or significantly disrupt key assets located within that area.

Zone 2: Is the area from 500 meters (0.3 statute mile; 0.25 nm) to 1,600 meters (1 statute mile; 0.9 nm) of an LNG carrier where an LNG spill would have less severe consequences for public safety, property, and key assets.

Zone 3: The area from 1,600 meters (1 statute mile; 0.9 nm) to 3,500 meters (2.2 statute miles; 1.9 nm)from an LNG carrier where an LNG spill would have the least likelihood of severe consequences in the event that three cargo tanks are breached and a vapor cloud disperses with initial ignition at the source. The Sandia Report defines Zone 3 further: "This zone covers LNG shipments and deliveries that occur more than approximately 750 meters from major infrastructures, population/commercial centers, or in large bays or open water, where the risks and consequences to people and property of an accidental LNG spill over water are minimal. Thermal radiation poses minimal risks to public safety and property". This definition characterizes the Aguirre Near shore GasPort location.

9. RISK ASSESSMENT AND MANAGEMENT STRATEGIES

9.1. ASSESMENT METHODOLOGY

A. The **safety** risk assessment portion of the WSA evaluated the risks of an *accidental* release of LNG from a carrier, where events may be triggered by incidents such as collisions, groundings, or spill during cargo transfer/handling, etc. Potential problems that could lead to an accidental release were considered and the likelihood and consequences of these events further evaluated. Successful mitigation measures generally fall into one of two categories: prevention and consequence management. Whereas prevention seeks to avoid an accident, consequence management seeks to reduce the negative impacts should an accident or incident occur.

B. Tetra Tech, Inc., Protective Services Group, performed and documented the risk assessments for the Aguirre Terminal. The risk assessment summarizes the risks associated with those changes and identifies current mitigation strategies.

These included:

1. The COTP's jurisdictional authority under 33 CFR Part 127, as defined in 33 CFR 127.005, is that part of a waterfront facility located between the vessel, or where the vessel moors, and the first shutoff valve on the pipeline immediately inland of the terminal manifold or loading arm.

2. The Aguirre GasPort and associated LNG carriers that serve them will comply with all applicable international treaty requirements and federal laws and regulations regarding the implementation of safety measures, and other specifically mandated requirements.

3. Only a single LNGC will be transiting to and from the Aguirre GasPort at any one time; i.e., there will be no opposing LNG traffic.

4. There will be no routine bunkering operations conducted at the terminal or anywhere along the transit route involving LNGCs.

C. The safety analysis also took into consideration historical data and informational exchanges with area stakeholders. The safety measures currently in place at the Eco-Electrica Terminal (existing LNG facility) were utilized to analyze and help mitigate the risks associated with the marine transportation of LNG. Specific questions that the safety assessments were structured to answer included:

1. What potential incidents involving an LNG carrier transiting through the proposed route would threaten members of the public, commerce, or the environment?

2. What is the likelihood and consequence of such events?

3. What additional safety measures are needed to reduce the identified risks?

D. **The Aguirre GasPort's risk-based assessment methodology suggests that the likelihood of accidental releases and/or threats of intentional interference are relatively low.** This assessment was based on the current and previous deep-draft vessel activity, the remoteness of the terminal, the substantial width and relative depth of the transit route, and population densities.

E. In consideration of the risk factors acknowledged in the Aguirre GasPort WSA, substantiated in part with the findings of the LNG working group, it's clearly apparent that it will be a sound recommendation to implement the mitigation measures stated in the WSA to effectively manage the identified navigation, safety and environmental risks associated with the project.

9.2. SAFETY RISK ASSESMENT AND SCENARIOS

A. Consistent with the guidelines contained in NVIC 01-2011, the Aguirre GasPort applied the Coast Guard's *Risk-Based Decision-Making Guidelines* to develop a comprehensive assessment strategy that adequately analyzes the safety risks that arise with the potential introduction of LNG operations into the waterway surrounding Bahía de Jobos.

B. In turn the Safety Risk Assessment was performed with the base assumption that the Offshore Gas Port will be located approximately 3 miles offshore, and LNGCs will approach the Offshore Gas Port from open water only. There is no defined waterway that will be used by LNGCs en route or departing from the Offshore GasPort, and there are no shoreline areas adjacent to the approach that will be used by LNGCs.

C. WSA's Tables 6-4 through 6-16 document the qualitative analysis of the safety related scenarios applied to each phase. For each risk based scenario, the corresponding tables provided:

1. A description of the scenario examined (*Event*, e.g., collision, allision, spill while transferring cargo, etc.);

2. The causes that would result in a scenario occurring *(Causes*, e.g., severe weather, mechanical failure, human error, breakage of mooring lines, poor communications, etc.);

9.3. PROPOSED MITIGATION MEASURES

A. To counter or reduce risks and consequences associated with the LNG operations of the Aguirre GasPort the following mitigation measures provide the most realistic and viable alternatives:

1. There are international protocols, design standards, and operational measures that promote the safe marine transportation of LNG. These include:

    a. Enhanced crew competency linked to the internationally required "Standards of Training, Certification and Watch keeping" (STCW);

    b. Higher classification society standards regarding carrier design, construction, and Flag State Control

    c. Employment of Automatic Identification System (AIS);

    d. USCG Port State Control safety-related boarding's and testing of operational and cargo systems.

2. Additionally, the WSA provided the following list of potential risks and mitigation measures:

Risk 1: Normal marine risks associated with transit inside the 9 nm Territorial Sea
Level of risk: Minimal
Mitigated by:
1. Open, deep water transit all the way to the facility;
2. No natural hazards along the route;
3. Low levels of marine traffic overall; and
4. Sea condition data readily available to LNGCs and pilots from the Caribbean Regional Association (CaRA) Integrated Coastal Ocean Observing System (ICOOS).
5. Additional needs: None.

Risk 2: Increased level of deep draft vessel traffic
Level of risk: Minimal
Mitigated by:
1. Low volume of traffic, ranging from one or two ships monthly to a peak volume of one ship per week;
2. Offshore platform location well clear of traditional Bahía de Jobos shipping paths; and
3. Pilots do not anticipate problems due to traffic volume or vessels size.
4. Additional needs: None.

Risk 3: Potential for LNGC to run aground
Level of risk: Minimal
Mitigated by:

1. Water depth approaching and around the facility is approximately 60 ft, 1.5 times the maximum draft of a LNGC;
2. No submerged hazards in the region; and
3. Redundant controls and safety features minimize the potential for a LNGC to lose all propulsion and steering control and drift ashore.
4. Additional needs: None.

Risk 4: Maneuvering to and from the offshore facility
Level of risk: Minimal.
Mitigated by:

1. Maneuvering simulation study results confirm that the waterways and maneuvering area are adequate for all vessels expected to use the terminal.
2. Additional needs: None.

Risk 5: Navigation challenges presented by other traffic
Level of risk: Minimal.
Mitigated by:

1. Relatively low volumes of traffic overall;
2. Low volume of LNGC traffic; and
3. 500 yards Safety zone around FSRUs and LNGCs while underway and moored
4. Additional needs: USCG Safety zone regulation.

Risk 6: Risk of collision and potential for collision damage
Level of risk: Minimal.
Mitigated by:

1. Overall low levels of traffic;
2. Clear navigation area;
3. Safety zone around FSRUs and LNGCs while underway and moored; and
4. LNG carrier design minimizes potential for damage if a collision did occur.
5. Additional needs: None.

Risk 7: LNG carrier allision
Level of risk: Minor.
Mitigated by:

1. Redundant operating systems and pre-arrival systems checks minimize the risk of vessel control system failure; and
2. Tugs in attendance.
3. Additional needs:
   a. Pilot familiarity with FSRUs, LNGCs, and offshore facility; and
   b. Maneuvering training for pilots for tug operations at the terminal.

Risk 8: Risk of a passing vessel alliding with a moored FSRU, LNGC, or offshore berthing platform
Level of risk: Minimal.
Mitigated by:
1. Low level of traffic overall; few large vessels operate in the region;
2. Offshore berthing platform structure will be well marked;
3. FSRU and LNGCs will be highly visible; and
4. 500 yards Safety zone around FSRUs and LNGCs while underway and moored.
5. Additional needs: None.

Risk 9: Weather and sea conditions could make port entry impracticable
Level of risk: Minor.
Mitigated by:
1. Moderate wind effects can be overcome with tug assistance as demonstrated in simulation studies;
2. Pilots will determine safe operating parameters based on individual vessel handling characteristics and other factors; and
3. Risks and hazards associated with tropical storms and hurricanes will be addressed in facility operating plans and terminal and vessel emergency plans.
4. Additional needs: None.

Risk 10: Environmental risks
Level of risk: Minimal.
Mitigated by:
1. The potential for a casualty that could result in a release of a harmful pollutant (i.e. fuel oil) is very low;
2. LNGC design minimizes the potential for damage that could result in a release;
3. No environmental risks associated with LNG cargo, as the liquid is non-polluting and would evaporate quickly; and
4. Sensitive environmental areas along the LNG carrier route are primarily wetlands, sea grasses and fish habitat that are not likely to be affected by a spill of LNG onto the surface of the water.
5. Additional needs: None.

10. EMERGENCY RESPONSE PLANNING

A. As per 33 CFR 127.1307, the Aguirre GasPort owner and operator must submit the Emergency Manual to the COTP.

B. Additionally, the owner and operator are also required to submit an *Operations Manual* to the COTP as per 33 CFR 127.019.

11. RECOMMENDED RISK MITIGATION MEASURES

A. Based on the Aguirre GasPort WSA, LNG workgroup effort, and comprehensive assessment conducted of the waterway surrounding Bahía de Jobos, the COTP has determined that the following mitigation measures shall be established and maintained:

1. Inbound, loaded or partially loaded LNG carriers shall only transit the waterway during daylight hours, with daylight being interpreted, in practical terms, as being able to clearly see the horizon, shoreline and receiving berths clearly under conditions of natural light.

2. A minimum of two miles of clear visibility shall be required for the movement of LNG carrier. In marginal weather conditions visibility can vary significantly along the route; the decision as to whether sufficient visibility exists, and is likely to continue to exist for the full transit, is a judgment call that will need to be made jointly between the attending pilot(s) in consultation with, and the concurrence of, the COTP.

3. Thirty knots shall be the maximum sustained true wind speed, as measured on the LNG carrier, at which an inbound or outbound transit should be allowed to commence, and 25 knots gusting, during docking/undocking evolutions. As with visibility, significant variation in wind conditions can exist along the route, and the decision as to whether wind conditions permit a safe transit will be made by the attending pilot(s) in consultation with, and concurrence by, the COTP.

4. The Aguirre GasPort should plan and successfully conduct full mission bridge simulator training for those pilots providing services to LNG carriers. The training should take into account the full spectrum of vessel design and length, cargo carrying capacity, method of propulsion, steering and rudder configuration, thruster arrangements, and maneuvering characteristics for those carriers being considered for charter. In addition, expanded simulator training incorporating the number and design of tug boats having the minimum performance and operating criteria should be conducted.

5. The Aguirre GasPort must prepare and submit an Operations Manual, as required by 33 C.F.R. § 127.305, and an Emergency Manual, as required by 33 C.F.R. § 127.307, to the COTP for review and approval. The Operations and Emergency Manuals must be submitted at least 30 days before any transfer of LNG can take place. Comprehensive and coordinated response planning should consider:

   a. In-transit and dockside emergency procedures in the event of fire, mechanical malfunction, allision, grounding, and/or need of safe anchorage or refuge.

b. The potential environmental impact of an LNG release and the identification and acquisition of joint resource needs to respond to the potential release.
c. A contingency response plan specific to LNG and focusing on a layered response approach.
d. Coordinated marine firefighting training and emergency response, with an emphasis on containing and extinguishing LNG fires.
e. An incident management training and collaborative exercise program.

6. As per the enclosure (10) of NVIC 1-11, and prior to commencement of LNG operations, the Aguirre GasPort must provide the COTP with the following information pertaining to vessels that are reasonably anticipated to be servicing Aguirre GasPort: a) Intended LNGCs nation of registry; b) The nationality or citizenship of the officers serving on board the intended LNGCs; and c) The nationality or citizenship of the crew members serving on board the intended LNGCs.

7. Until the facility goes into operation, the Aguirre GasPort must conduct an annual review of their WSA and provide the COTP with an update that accurately reflects all changes (actual and planned), to include changes of planned LNG carrier size or load frequency, port characterization modifications, facility-related design alternations, and conditions potentially affecting cumulative considerations. The annual review cycle should coincide with the anniversary date of the LOR.

8. The Aguirre GasPort should consider providing an education program directed at personnel residing or working near the proposed operation that outlines the steps the Aguirre GasPort operators and local emergency response organizations may take in the event of an emergency, and what the public can do to contribute to their own safety if an LNG release should occur.

9. Aguirre GasPort shall provide necessary data pertaining to the depth and keel clearance of the underwater pipeline. Most significantly at any area that the pipeline approaches the vicinity of the keys, entrance to the Boca del Infierno or any other shoal areas. These areas are frequently used by local fishermen and recreational boaters. To mitigate the risk of an unintentionally grounding or anchoring, the pipeline shall be mark and updated with NOAA so that is updated with the appropriate nautical charts. Areas where the keel clearance is less than 10 feet shall also be properly marked to warn any vessel transiting in close proximity of the pipeline.

10. The USCG proposes to establish a moving 100 yards safety zone for all LNG carriers entering the surrounding areas of Bahía de Jobos while on approach and departure to the offshore terminal. The Aguirre GasPort will have a fixed 500 yards safety zone at all times. Once the LNG vessel is moored, the vessel will be part of the 500 yards safety zone regulation.

11. As described in the WSA, marine firefighting capabilities are limited in this region. In order to improve firefighting capabilities able to respond to the Aguirre GasPort and LNGC, it is highly recommended to retrofit another commercial tug boat with FiFi 1 equipment, which will provide a third viable resource to combat at sea fire emergencies. As stated in Section 8.2.B., the COTP will require at least one tug in service to any LNGC, or the FSRU, to have FiFi 1 capability at all times. Additionally, the Commonwealth should assess the availability of marine firefighting resources in this region and develop a strategic plan in cooperation with the Aguirre GasPort that addresses all potential resource shortfalls.

12. CONCLUSIONS

Based on a review and validation of the information contained in the Aguirre Offshore Gas Port WSA as per 33 CFR 127.007 and 33 CFR 127.009 respectively, and evaluation of the waterway in consultation with a variety of port stakeholders, the COTP has determined that the Bahía de Jobos transit route is suitable for the type and frequency of marine traffic associated with this proposed project.

The U. S. Coast Guard's evaluation focused on the navigation safety aspects of LNG vessel transits along the intended waterway and included analyses of safety risk methodologies and corresponding risk mitigation measures. These port management plans and risk mitigation measures are *recommended* tools intended to enhance maritime safety and effectively manage waterway priorities and mitigate safety resource shortfalls.

If the conditions of the waterway change and/or situational awareness dictate the need, the COTP may reconsider this determination. Pursuant to his authority under the Ports and Waterways Safety Act of 1972 (33 U.S.C.§1221 et.seq.), among other authorities, the COTP will continue to assess the Bahía de Jobos waterway to determine and implement controls and safeguards as necessary for the protection of the public's health, welfare and marine environment. Any orders to this effect may well be separate and apart from this LOR process.

APPENDIX C

SEDIMENT DISPERSION MODELING FOR PIPELINE INSTALLATION, AGUIRRE OFFSHORE GASPORT, PUERTO RICO

Sediment Dispersion Modeling for Pipeline Installation, Aguirre Offshore GasPort, Puerto Rico

ASA Team: Nathan Vinhateiro, Tatsu Isaji, Jill Rowe

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1. Project Background

Applied Science Associates, Inc. (dba RPS-ASA) has used numerical models to predict the concentration and subsequent seabed deposition of suspended sediment introduced to the water column from hand jetting, dredging, and disposal activities related to the Aguirre Offshore GasPort Project. The excavation activities include the routing and installation of a subsea pipeline between an offshore terminal and the Central Aguirre Power Plant, and excavation of entry/exit holes for sections of the pipeline that may require Horizontal Directional Drilling (HDD) across the Boca del Infierno to avoid impacts to coral reef habitat. This report briefly describes the environmental inputs and modeling approach, and presents the results of the SSFATE (Suspended Sediment FATE) model and its application to the proposed construction activities.

The study area is located in Jobos Bay, between the municipalities of Salinas and Guayama on the south coast of Puerto Rico. Figure 1 shows the location of the various construction activities that were considered for modeling. An 18-inch outside diameter natural gas pipeline with concrete coating (to 24”) will be installed to connect the offshore terminal to the existing Aguirre Plant. The proposed pipeline route extends approximately 4.1 miles from the proposed GasPort located outside of Jobos Bay, through the Boca del Inferno inlet and across the basin of Jobos Bay to the Aguirre Plant property where it will interconnect with the Central Aguirre Power Plant.

Figure 1. Location of the proposed construction areas, Jobos Bay, Puerto Rico.

RPS-ASA is using the SSFATE (Suspended Sediment FATE) model to predict the excess suspended sediment concentration and the transport of sediment from jetting, dredging, and disposal activities related to the pipeline installation. SSFATE addresses the short-term movement of sediments during both the dredging and disposal processes where sediment is introduced into the water column and predicts the path and fate of the sediment particles using the local currents. In addition, SSFATE calculates the resulting deposition thickness of resuspended sediments that have settled back on the bottom.

Based on plans filed by the applicant, seabed disturbance in Jobos Bay is expected from two (2) construction activities: (i) hand jetting for subsea pipeline installation, and (ii) mechanical dredging at the entry and exit holes of a water-to-water HDD installation.

A total of two scenarios were modeled using SSFATE.

1. Installation of the subsea pipeline, including:
    a. Hand jetting to a depth of 60” (36” of cover) for water depths < 12 ft;
    b. Hand jetting to a depth of 24” (at grade) for water depths > 12 ft; and
    c. Direct lay of the pipeline for segments of the route that traverse coral reef areas.

2. Excavation of the HDD entry and exit hole by mechanical dredging.

2. Hydrodynamic Modeling (HYDROMAP)

The SSFATE model requires a representation of the current field in the study domain for sediment transport calculations. For this study, HYDROMAP, a hydrodynamic model developed by RPS-ASA, was used to reproduce the local circulation in Jobos Bay due to wind and tides. HYDROMAP is a globally re-locatable three-dimensional hydrodynamic model (Isaji, et al., 2001) capable of simulating complex circulation patterns due to tidal forcing, wind stress and fresh water flows. HYDROMAP employs a novel step-wise-continuous-variable-rectangular (SCVR) gridding strategy with up to six levels of resolution. Boundaries between successively smaller and larger grids are managed in a consistent integer step. The advantage of this approach is that large areas of widely differing spatial scales can be addressed with one consistent model application. Grids constructed by the SCVR are still “structured,” so that arbitrary locations can be easily located to corresponding computational cells. This mapping facility is particularly advantageous when outputs of the hydrodynamics model propagate to subsequent application programs (e.g. Lagrangian particle transport models such as SSFATE) that use another grid or grid structure.

The hydrodynamic model solves the time dependent, three-dimensional conservation equations for water mass, density, and momentum in spherical coordinates with the Boussinesq and hydrostatic assumptions applied. Model output consists of surface elevation and the three-dimensional field of horizontal current velocities. The numerical solution methodology follows that of Davies (1977) and Owen (1980). Isaji, et al. (2001), and Isaji and Spaulding (1984) provide a detailed description of the model.

2.1. Application of HYDROMAP to Jobos Bay

Model Grid and Bathymetry

The model grid was developed to cover the entire Jobos Bay and extends southward into the Caribbean in order to capture basin characteristics that influence the propagation of tides into the region. The large domain necessitated the use of the stepwise grid refinement feature with grid cell resolution of approximately 200 m in the offshore region, and refinement down to approximately 50 m within Jobos Bay and 25 m resolution near coastal features. The fully nested hydrodynamic grid is shown in Figure 2.

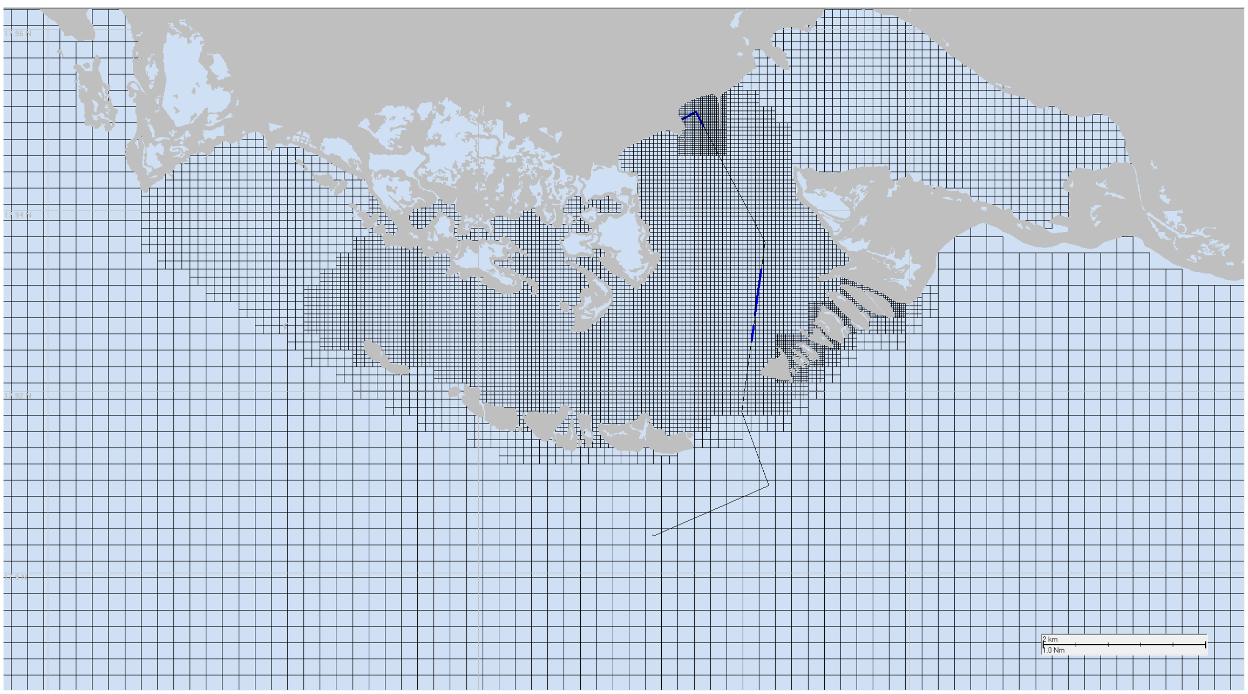

Figure 2. HYDROMAP model domain grid showing step-wise refinement within the project area. The pipeline route between the offshore terminal and power station is shown for reference.

Grid cells were assigned depths based on data obtained from a combination of multibeam bathymetry (collected by C&C Technologies in 2012), digitized soundings from NOAA navigational charts, and SRTM_PLUS30 global bathymetry database (Becker et al., 2009). Figure 3 illustrates the model grid bathymetry in the study area. Depths inside of Jobos Bay are relatively shallow, typically less than 10 m. The seabed has a generally moderate slope inside of the bay which steepens at the reef edge, south of the Boca del Infierno inlet. A comprehensive discussion of small-scale bathymetric features along the pipeline route is included in Resource Report 6 (Geological Resources).

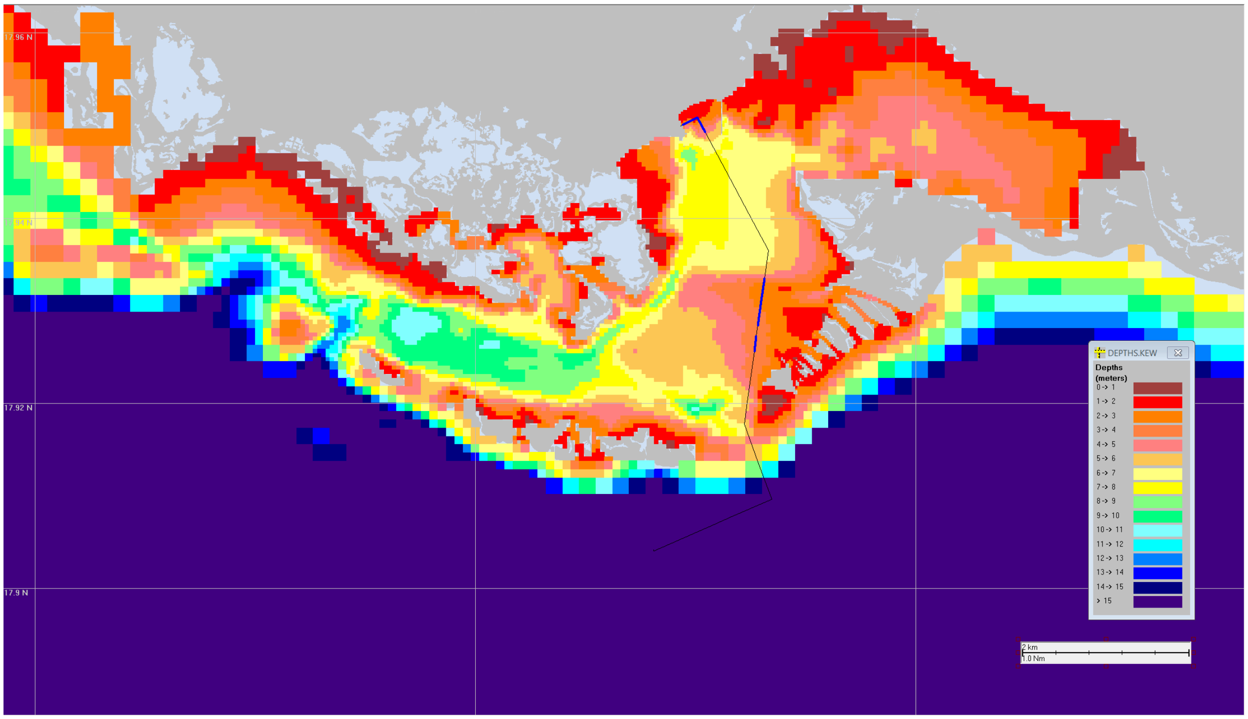

Figure 3. HYDROMAP grid bathymetry focused on project area.

Model Boundary Conditions

The hydrodynamic model simulations were forced with tides and winds. Tidal open boundary specification was based on the global tide data obtained from Oregon State University Inverse Tidal model TPXO8. TPXO8 is a data assimilation model constrained by the satellite altimetry data, TOPEX/Poseidon (Egbert, Bennett, and Foreman 1994). Eight astronomical constituents (M2, S2, N2, K2, O1, K1, P1, Q1) were simulated and their harmonic constants are stored to construct actual circulation for any given date and time.

A constant wind field reflecting the average wind speed and direction was used to generate a wind driven current component for use in the SSFATE scenarios. The wind field was based on a continuous wind and wave hindcast provided by the applicant (Resource Report 1), which covers a 26 year period (1980-2005). The data is from the GROW-FINE Caribbean Project, which is a comprehensive metocean study of the Caribbean Sea. The hindcast data includes both individual tropical storms and a continuous hindcast. Figure 4 shows a wind rose presenting the distribution of hindcast wind speeds and directions near the site for 'full year' data. Winds are predominantly out of the east, following the general trade wind pattern observed in the area (Daly *et al.* 2003). Wind speeds are moderate and generally range between 6 m/sec and 12 m/sec (13-27 miles per hour). The strongest winds are observed during the winter months, with only a slight decrease seen during the summer months. There is little directional variability, with a slight shift to the northeast during the winter and a slight shift to the southeast during the summer. A steady-state eastward wind at 10 m/s was therefore applied to the HYDROMAP field.

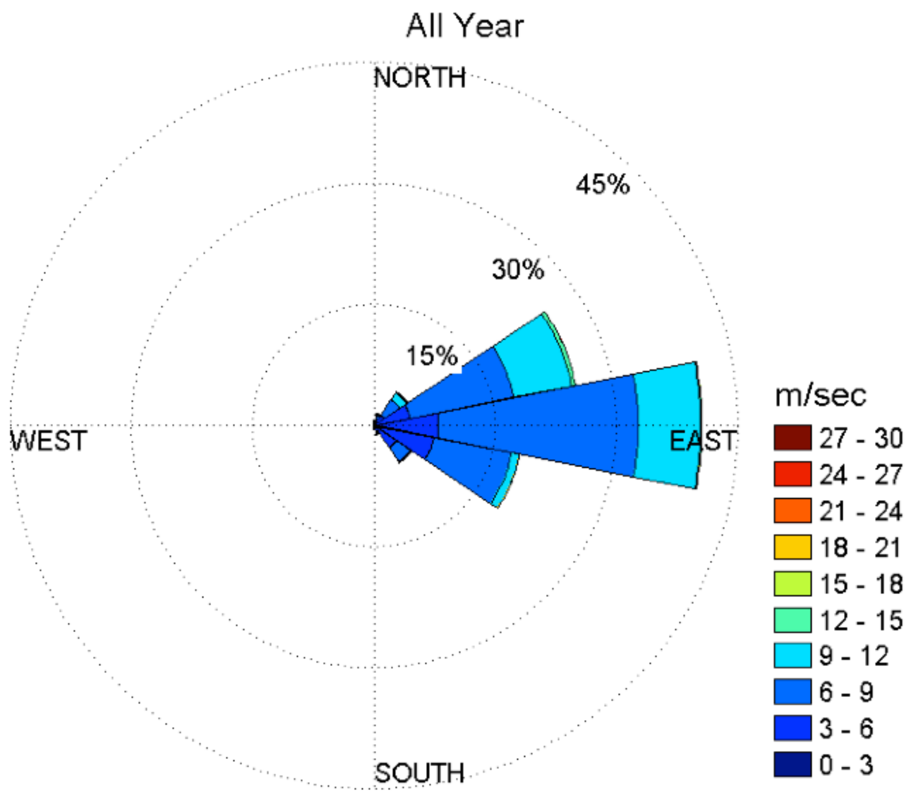

Figure 4. Distribution of full year wind speed and direction, based on applicant-provided hindcast wind data (data shown in meteorological convention, i.e., the direction the wind is coming from).

2.2. HYDROMAP Model Results

The cyclical tidal and constant wind driven current components were packaged into one file for use in the hydrodynamic simulations, combined together to represent a spatial and temporally varying current field. Flow from individual tidal constituents is far less significant when compared with the flow velocities from the sustained easterly tradewinds. As an example, Figure 5 and Figure 6 show samples of model-predicted flood and ebb current patterns (respectively) from the K1 (diurnal) tidal constituent. By comparison, Figure 7 shows wind driven flow velocities in the surface water, which are an order of magnitude larger. Current intensities decrease with depth and local flow reversals are noted, particularly in shallow regions of the central Jobos Basin (Figure 8).

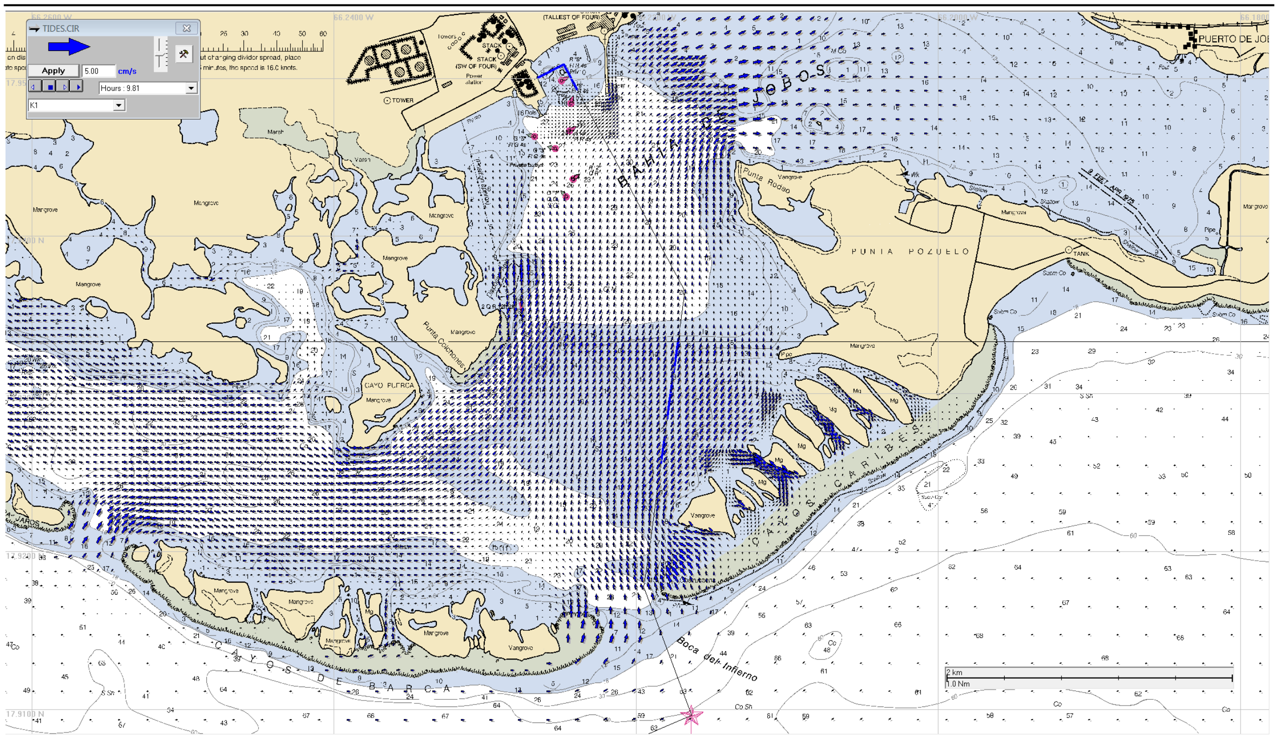

Figure 5. K1 flood tidal vectors near Jobos Bay. Scale of vectors shown in the upper left corner is 5 cm/s. Outlines of the proposed pipeline excavation areas within Jobos Bay are shown for reference.

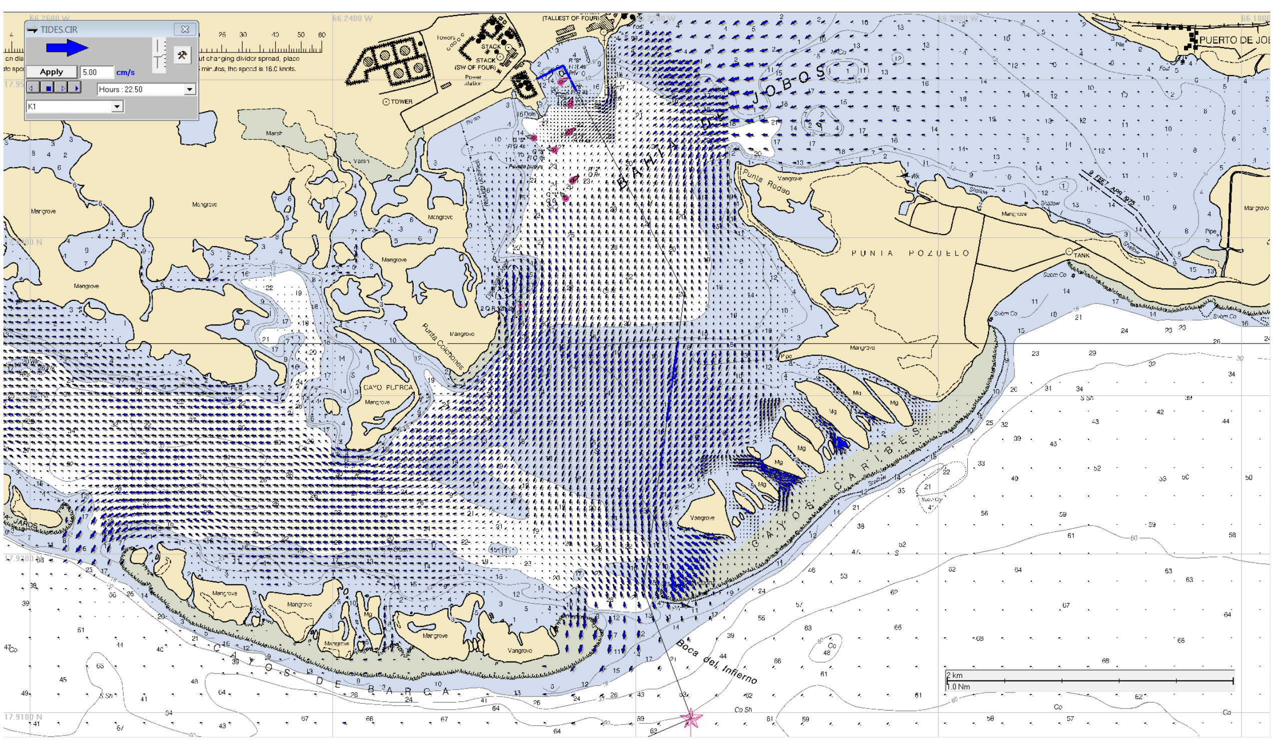

Figure 6. K1 ebb tidal vectors near Jobos Bay. Scale of vectors shown in the upper left corner is 5 cm/s. Outlines of the proposed pipeline excavation areas within Jobos Bay are shown for reference.

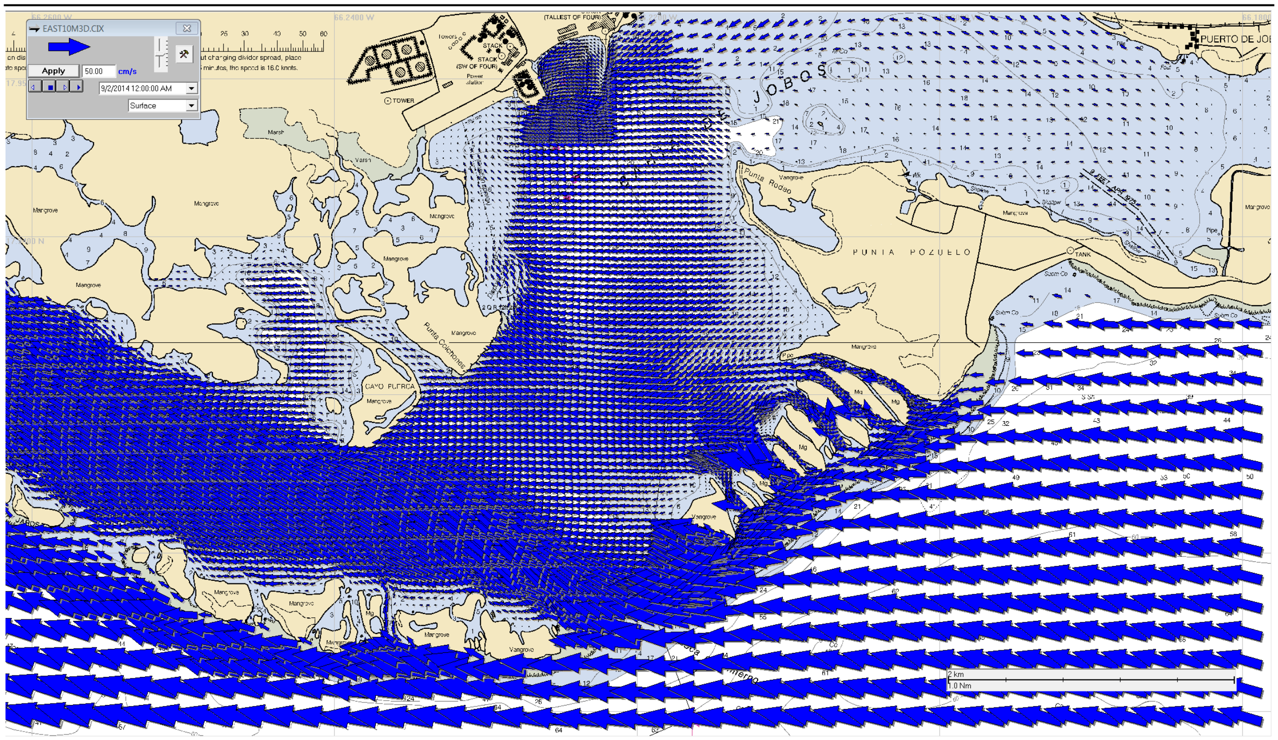

Figure 7. Wind-driven current vectors (surface layer). Scale of vectors shown in the upper left corner is 50 cm/s. Outlines of the proposed pipeline excavation areas within Jobos Bay are shown for reference.

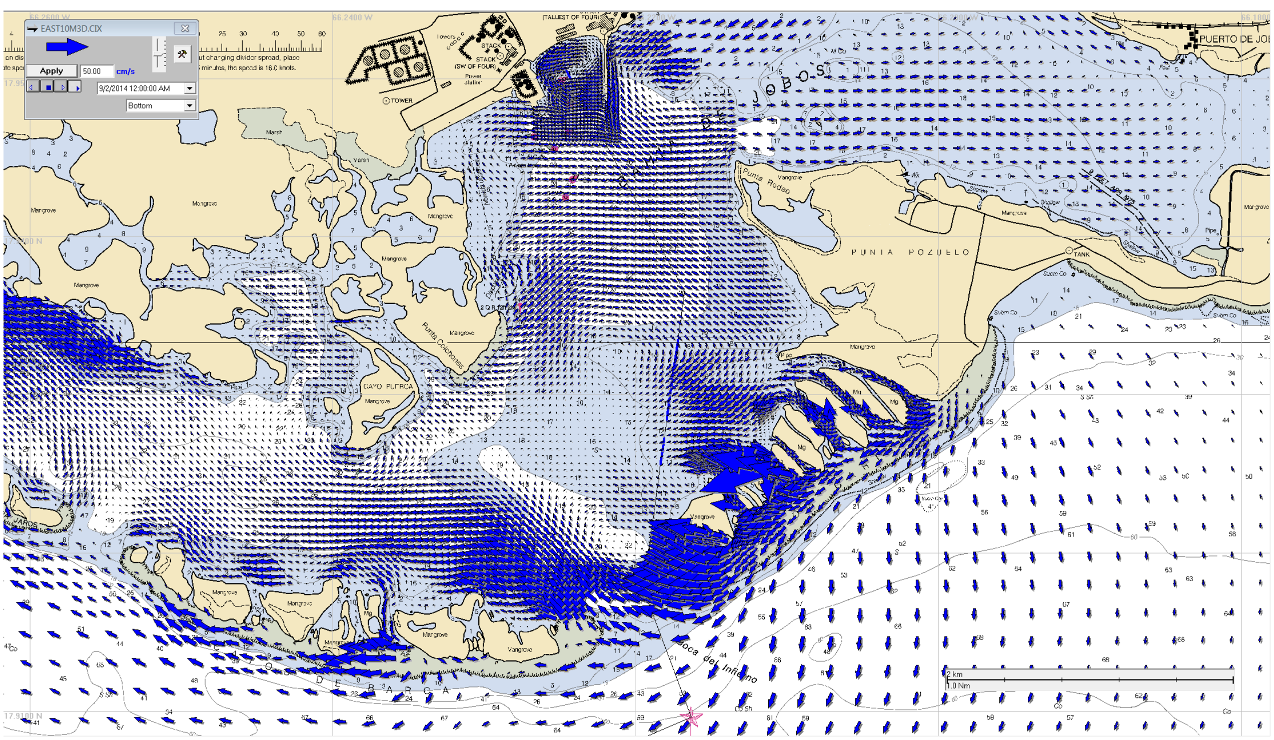

Figure 8. Wind-driven current vectors (bottom layer). Scale of vectors shown in the upper left corner is 50 cm/s. Outlines of the proposed pipeline excavation areas within Jobos Bay are shown for reference.

3. Sediment Dispersion Modeling (SSFATE)

3.1. Model Description

The SSFATE (Suspended Sediment FATE) model was used to predict suspended sediment concentrations and the transport and deposition of sediment released during subsea construction activities. SSFATE addresses the short term movement of sediments that are disturbed during mechanical plowing, hydraulic jetting, dredging and other processes where sediment is introduced into the water column and predicts the path and fate of the sediment particles using three-dimensional currents in estuaries and oceans.

SSFATE was jointly developed by ASA and the U.S. Army Corps of Engineers (USACE) Environmental Research and Development Center (ERDC), to simulate sediment suspension and deposition from dredging operations. The model has been documented in a series of USACE Dredging Operations and Environmental Research (DOER) Program technical notes (Johnson et al., 2000; Swanson et al., 2000); at a previous World Dredging Conference (Anderson et al., 2001) and a series of Western Dredging Association Conferences (Swanson et al., 2004; Swanson and Isaji, 2006). Many ASA technical reports have been prepared that demonstrate successful application to dredging. In addition SSFATE has been extended to include the simulation of cable and pipeline burial operations using water jet trenchers (Swanson et al., 2006), and mechanical plows.

3.2. Model Application

SSFATE was used to simulate the suspended sediment concentration and subsequent deposition resulting from hand jetting and mechanical (backhoe) dredging in the Jobos Bay region. The project is expected to utilize a diver-operated hand held jet pump for sections of pipeline requiring trenching, and a backhoe dredge to excavate the HDD entry/exit pits. In total, two scenarios were run using SSFATE

- Scenario 1: Direct lay of pipeline on the seabed followed by (i) hand jetting to a depth of 60” (36” of cover) for water depths < 12 ft, (ii) hand jetting to a depth of 24” (at grade) for water depths > 12 ft, and (iii) direct lay of pipeline for segments of the route that traverse coral reef areas at the Boca del Inferno inlet.
- Scenario 2: Excavation of the HDD entry hole (outside of the bay) and exit hole (inside the bay) by mechanical dredging.

Locations of the various construction activities are shown in Figure 1. The dates of the pipeline installation and burial activity are still unknown, and therefore the modeling was performed using an arbitrary start date of January 1, 2015. The burial/dredging specifications used for modeling are described further in Table 1. The model duration was based on information provided by the applicant specifying that the jetting/burial process for shallow water sections would require 18-24 days. A production rate of 641.5 m^3/day was calculated based on the assumption that the construction schedule would require 3 days of mobilization/demobilization (no active hand jetting) and a daily 12-hour work schedule. The same production rate was then used to estimate the duration of hand jetting for sections buried at grade. The duration of dredging for the HDD pits was estimated using the parameters in Table 2, based on review of standard mechanical dredges by Adair (2003) and IDR (2003) and a constant cycle time of 60 seconds (Bergeron, 2000; Hayes, 2000). Simulations were conducted with the assumption that the HDD dredging activities will be occurring at the same time as pipe laying (utilizing separate crews).

Table 1. Dimensions and rate of advance for simulated trenching/dredging activities.

Scenario	Installation	Feature length (m)	Trench Cross-section (m^2)	Total excavation volume (m^3)	Duration (day)	Start date
1	Direct lay and burial of pipeline	6,057.19	4.18 (<12 ft.) 1.11 (>12ft)	10,281	16.02	1-Jan-15
2	Mechanical dredging of HDD entry and exit pits (concurrent)	n/a	n/a	4,248	0.64	1-Jan-15

Table 2. Dredge operation parameters used for modeling.

Dredge bucket volume (m^3)	Cycle time (s)	Production rate (m^3/d)
3	60	3,302.88

During each dredge cycle (60 s), the backhoe pulls the bucket to the dredger, raises the bucket to the water surface and side casts sediments either to a barge or to the adjacent seabed. Within the SSFATE model, the sediment load released to the water column is a fraction of the sediment volume that is lost from the bucket due to leakage during excavation and turbulence as the bucket moves through the water column. The sediment release is simulated as a line source, with sediment vertically distributed within 5 equal bins of the water column. Typically, sediment loss rates vary due to factors such as the size and type of the bucket, seabed lithology, presence of debris, current speed, water depth, and the dredging approach of the operator (Anchor Environmental, 2003). However, for this application, a sediment loss rate of 100% of the excavated volume was used because material is expected to be side cast directly to the seabed in the vicinity of the excavation pit. Sediment loss from the bucket is insignificant by comparison.

Sediment Characteristics

Six boreholes and four sediment vibracores were recovered from the project area as part of a preliminary geotechnical and soils characterization (see Resource Reports 6 and 7). Sample material (at or near the seabed) was recovered from seven of these locations and analyzed for grain size by sieving and hydrometer techniques. Figure 9 presents a graph of the representative grain size distribution for each sample location. The arrangement of the grain size data (south to north, along the pipeline route), illustrates the general shift in lithology between construction areas outside and inside of Jobos Bay. Mean grain size increases south of the Boca del Infierno, where sediments are predominantly sand. Samples collected along the northern pipeline route range from silty sand to silty clay. Only two of the samples analyzed (AGT-CS0098, AGT-CS010) contain less than 50% sand.

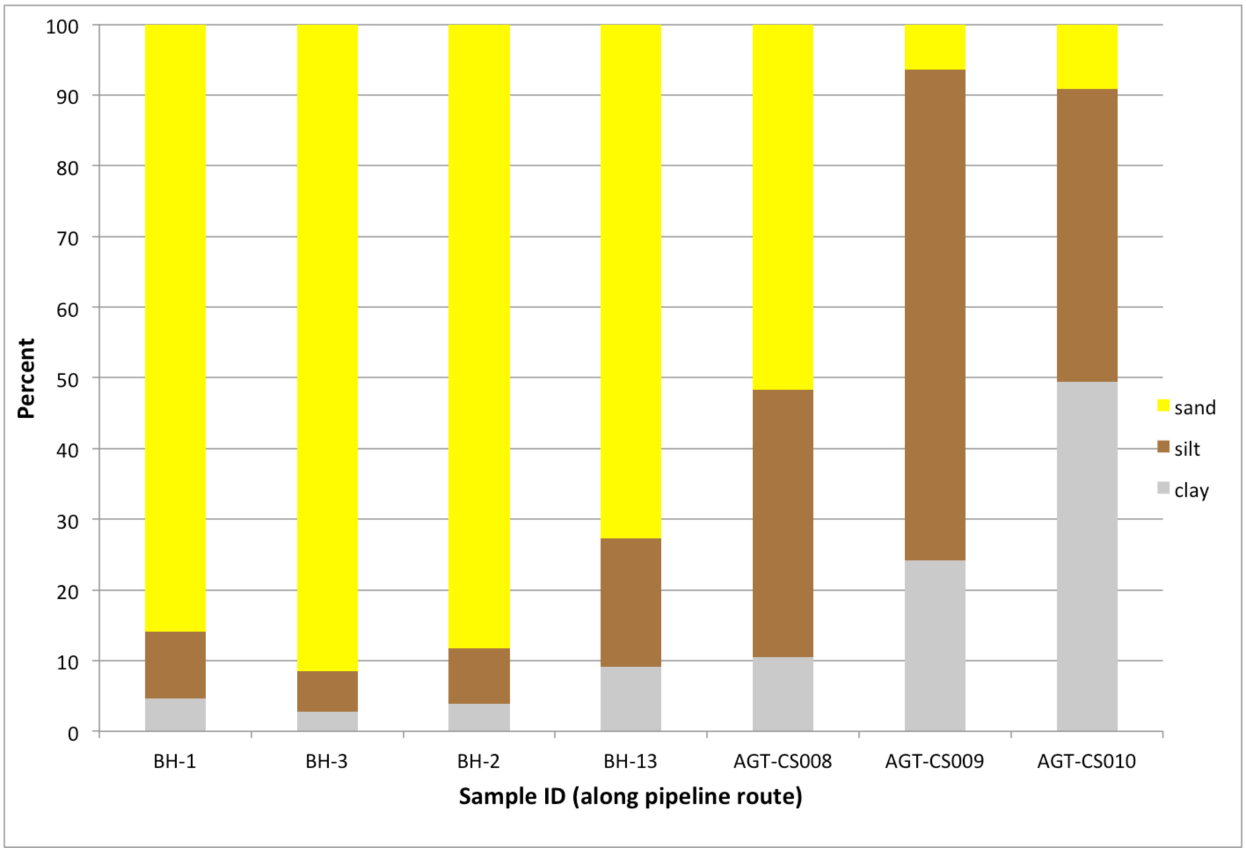

Figure 9. Grain size distribution data for each sediment sample location.

Figure 10 shows the location and classification of sediment samples with respect to the proposed excavation zones. Table 3 lists the sediment grain size distributions used as input to the model at each sample location. The solid fraction was calculated from the reported specific gravity and moisture content of each sample.

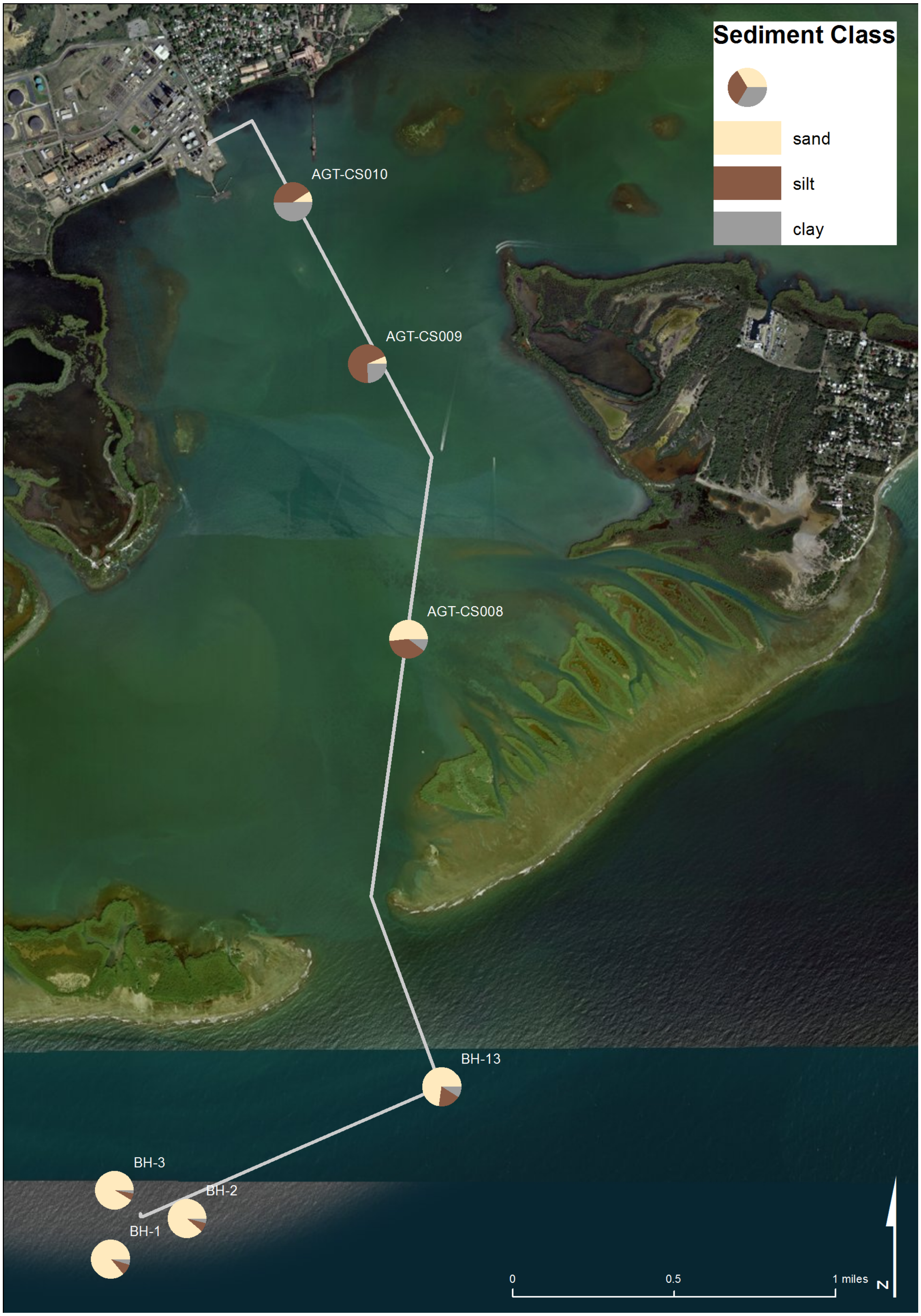

Figure 10. Location and classification of offshore sediment samples.

Table 3. Sediment size distribution (class types in percentages) used for modeling based on information provided by the applicant.

Sample ID	% Coarse Sand	% Fine Sand	% Coarse Silt	% Fine Silt	% Clay	%Solid
BH-1	65.3	20.7	4.7	4.7	4.7	58.2
BH-3	52.9	38.7	2.8	2.8	2.8	58.2
BH-2	48.6	39.8	3.9	3.9	3.9	58.2
BH-13	47.1	25.7	9.1	9.1	9.1	58.2
AGT-CS008	6.0	45.7	31.2	6.7	10.5	51.2
AGT-CS009	1.0	5.4	53.1	16.4	24.1	35.1
AGT-CS010	1.6	7.5	21.6	19.8	49.5	25.3

3.3. SSFATE Model Results

Individual SSFATE simulations were performed corresponding to construction activities listed in Table 1. Each simulation was run assuming a continuous operation until excavation of that particular construction leg was completed. The results from the model runs are presented below on maps showing the predicted jetting/dredging-induced total suspended sediment (TSS) concentration and subsequent deposition resulting from each activity. Tables below list the area covered by suspended sediment plumes and sediment deposition at selected concentrations and mass accumulation rates. Concentrations reported here are those that are predicted above the background/ambient concentration (i.e., a concentration of 0 mg/L equals the ambient concentration in the Jobos Bay region).

Suspended Sediment Concentrations

Suspended sediment concentrations presented in the figures below show the maximum concentration the model predicts at any time during the jetting/dredging process and at any depth in the water for each simulation. The maximum concentrations predicted are a composite in both space and time; they do not represent any instantaneous snapshot of water column concentrations, but instead show the maximum, time-integrated suspended sediment within the study domain during each scheduled release. The predictive results presented are therefore inherently conservative.

For each simulation, the shape of the plume generally reflects the local circulation and bathymetric features along the pipeline route. Suspended sediment concentrations are predicted to be larger for construction activities that occur inside of the bay, where sediments are generally finer and currents (which act to disperse TSS) have lower flow velocities. The maximum TSS concentrations are predicted to occur during dredging of the HDD entry pit, north of the Boca del Infierno inlet, where currents are generally weak and where large volumes of sediment will be continuously released to the seabed. By contrast, plumes generated as a result of exit pit dredging outside of the bay are quickly dispersed by the local current system. Excess TSS concentrations are therefore more limited in space and time.

Table 4. Areas of total suspended sediment concentration exceeding certain thresholds for each model scenario.

Plume concentration (mg/L)	Cumulative area exceeding (km^2)	
	1	2
	Pipeline Burial	HDD Excavation
> 5	1.812	3.225
> 10	0.987	1.139
> 20	0.672	0.441
> 50	0.384	0.127
> 100	0.295	0.052
> 500	0.138	0.010
> 1000	0.021	0.005

SSFATE model results were analyzed to determine how suspended sediment concentrations decrease with distance away from the operating dredge. Findings are shown in the accompanying plots for each jetting/dredging scenario, which displays the maximum concentration of suspended sediment predicted by the model at a range of distances from the jet/dredge as it traverses the excavation route. For each plot, the maximum concentration found at any water depth are extracted from the model output at distances of 20, 50, 100, 200, etc. meters from the dredge location. Because the model was run using a 60-minute output time step, these locations correspond to the dredge position every 60 minutes along the route. For each scenario (construction activity) the extracted concentration values are plotted on a graph with distance from the dredge on the x-axis and suspended sediment concentration on the y-axis.

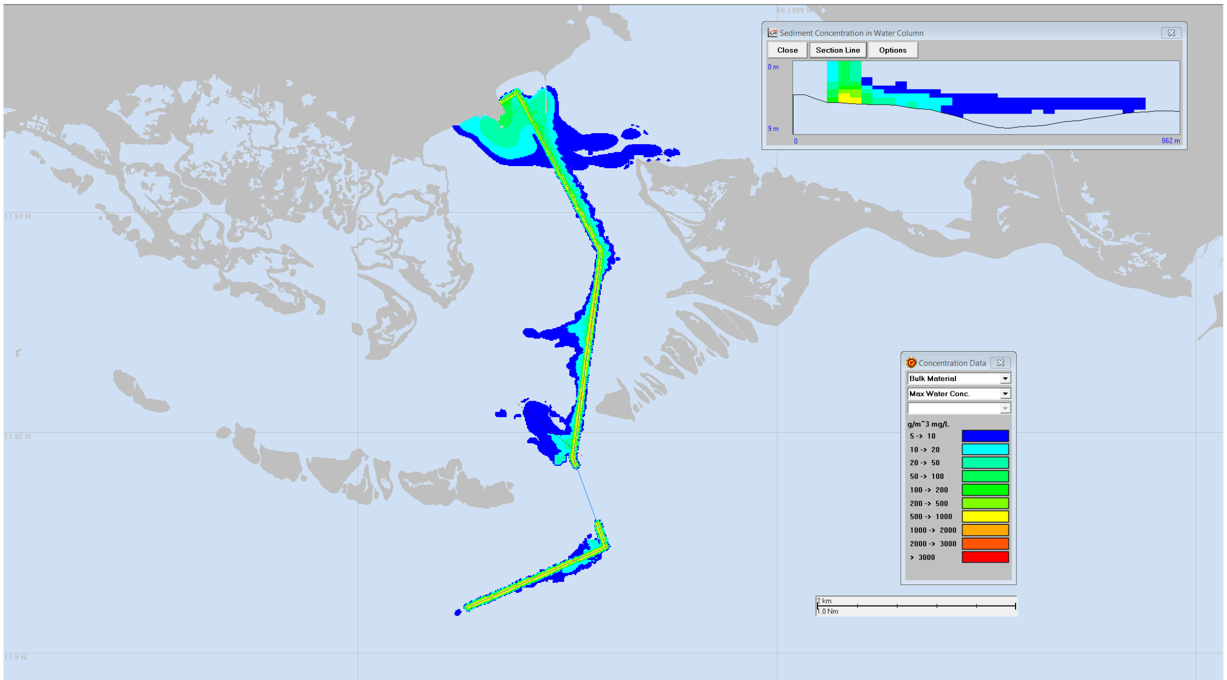

Figure 11. Maximum suspended sediment concentration resulting from the installation and burial of the 18" pipeline (Scenario 1). Vertical cross-section corresponds to the location of the bold line.

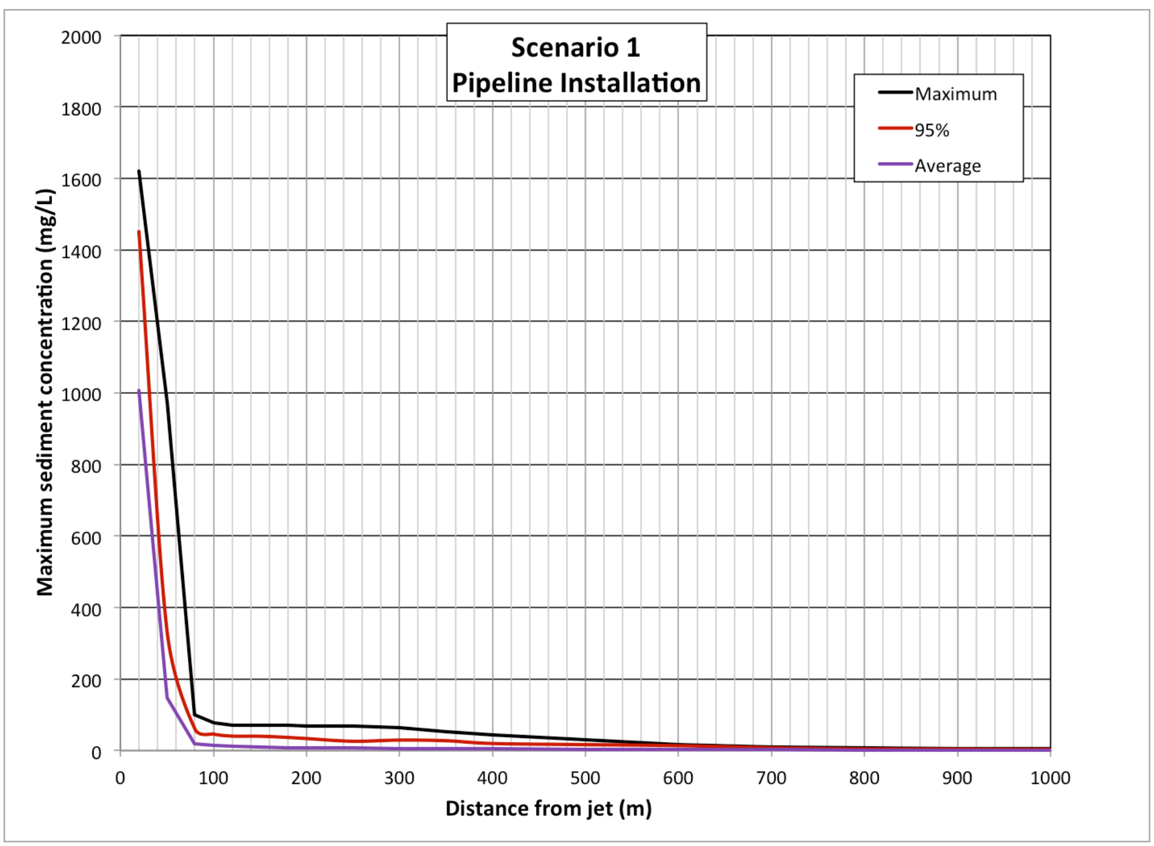

Figure 12. Suspended sediment concentrations with distance from the hand jet. Scenario 1: burial of 18" pipeline. Maximum (black), 95 percentile (red), and average (blue) concentrations.

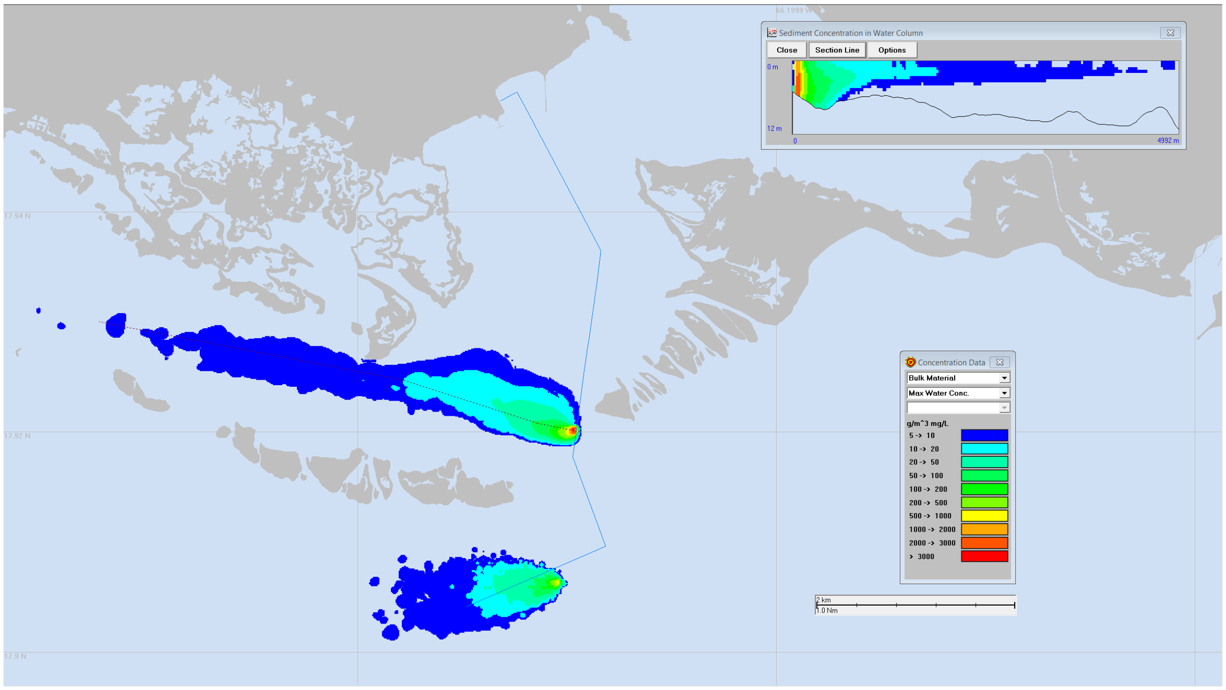

Figure 13. Maximum suspended sediment concentration resulting from mechanical dredging and disposal at the HDD entry and exit pits (Scenario 2). Vertical cross-section corresponds to the location of the bold line.

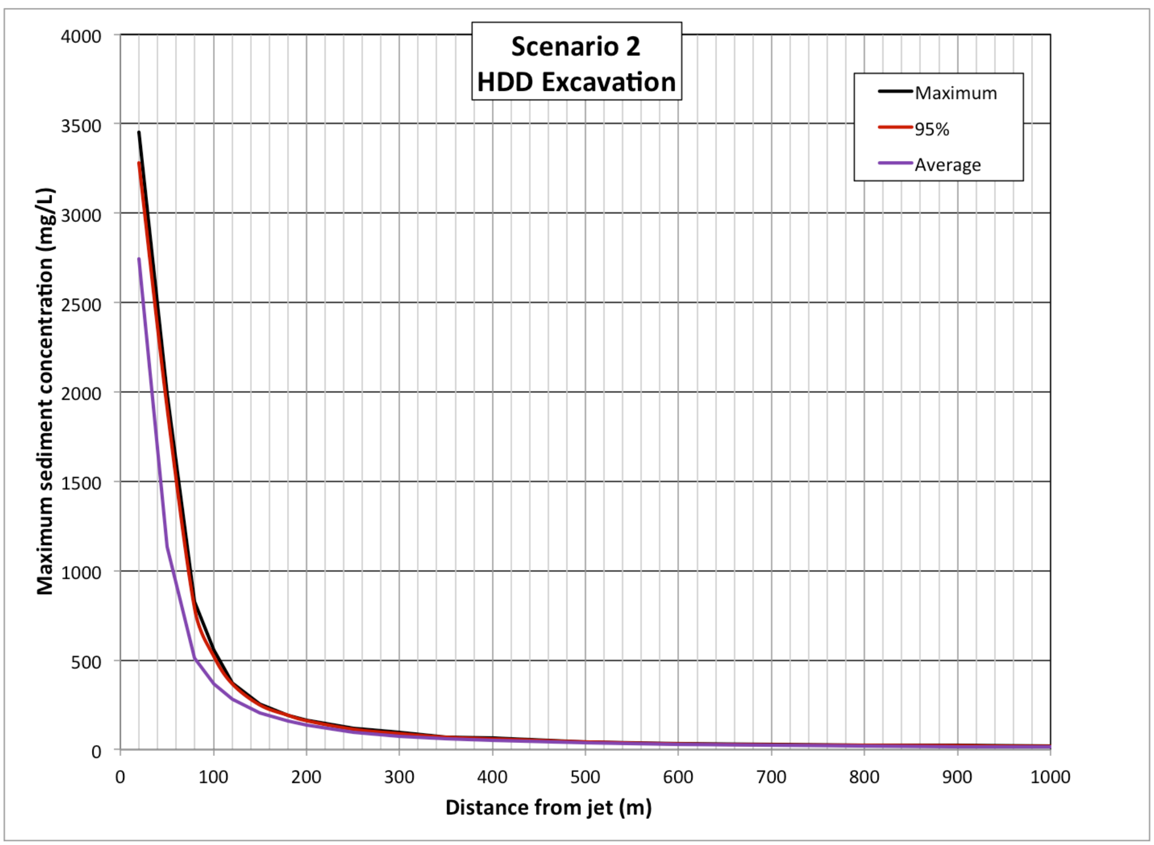

Figure 14. Suspended sediment concentration with distance from the dredge. Scenario 2: Excavation of HDD entry and exit pits. Maximum (black), 95 percentile (red), and average (blue) concentrations.

Sediment Deposition

Deposition of sediment released during jetting/dredging occurs over time as the particles settle through the water column to the seabed. The figures presented below show the model predicted deposition from each construction activity using the tidal conditions starting on January 1, 2015 and continuing until the trenching/dredging operations are complete, approximately 16 days later. Deposition is presented as a mass accumulation on the seabed in units of g/m^2. Table 5 summarizes the areal impact of deposition for each model scenario. The same data are presented graphically in Figure 15. Neglecting a void ratio (ratio of water to solid in a given volume) and assuming a sediment bulk density of 2,500 kg/m^3, the 10,000 g/m^2 sediment load corresponds to a thickness of 4 mm on the seabed.

Table 5. Areal extent of seabed accumulation for each scenario.

Mass accumulation rate (g/m^2)	Cumulative area exceeding (km^2)	
	1	2
	Pipeline Burial	HDD Excavation
500	0.657	0.519
1000	0.493	0.360
10,000	0.087	0.048
100,000	0.000	0.012
200,000	0.000	0.007

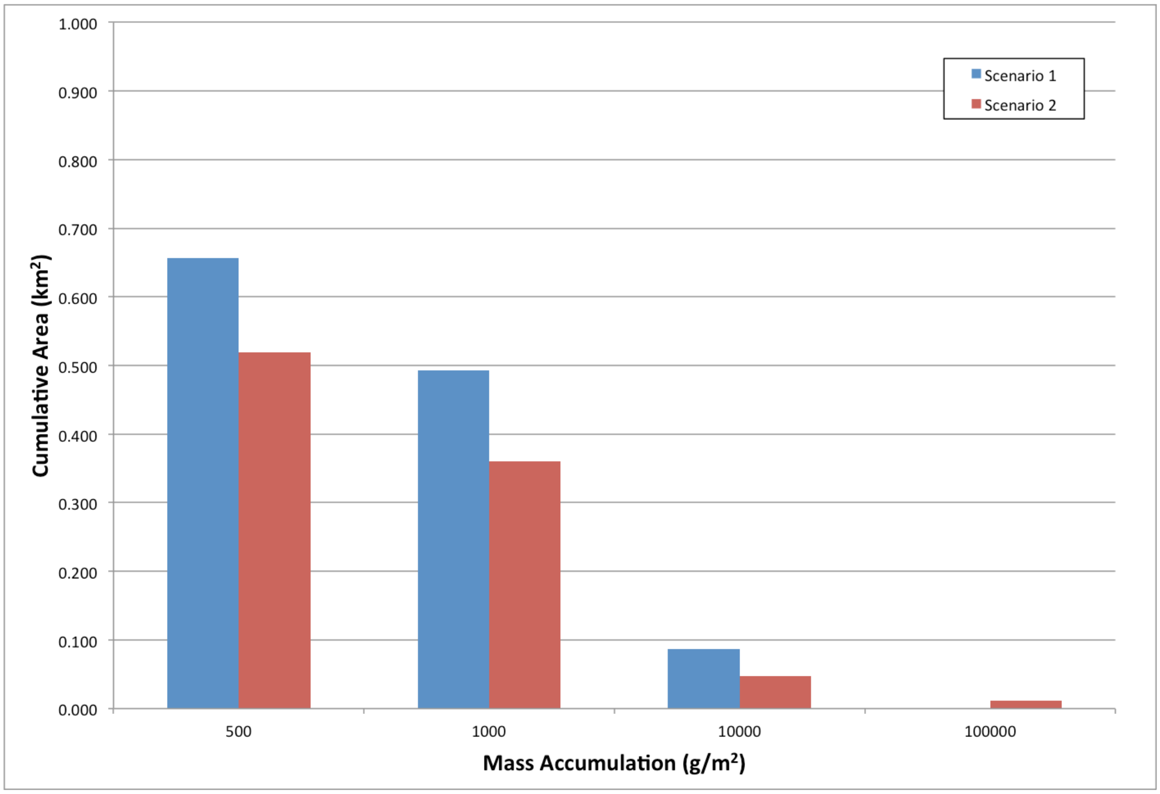

Figure 15. Comparison of the areal extent of seabed deposition resulting from jetting/dredging scenarios.

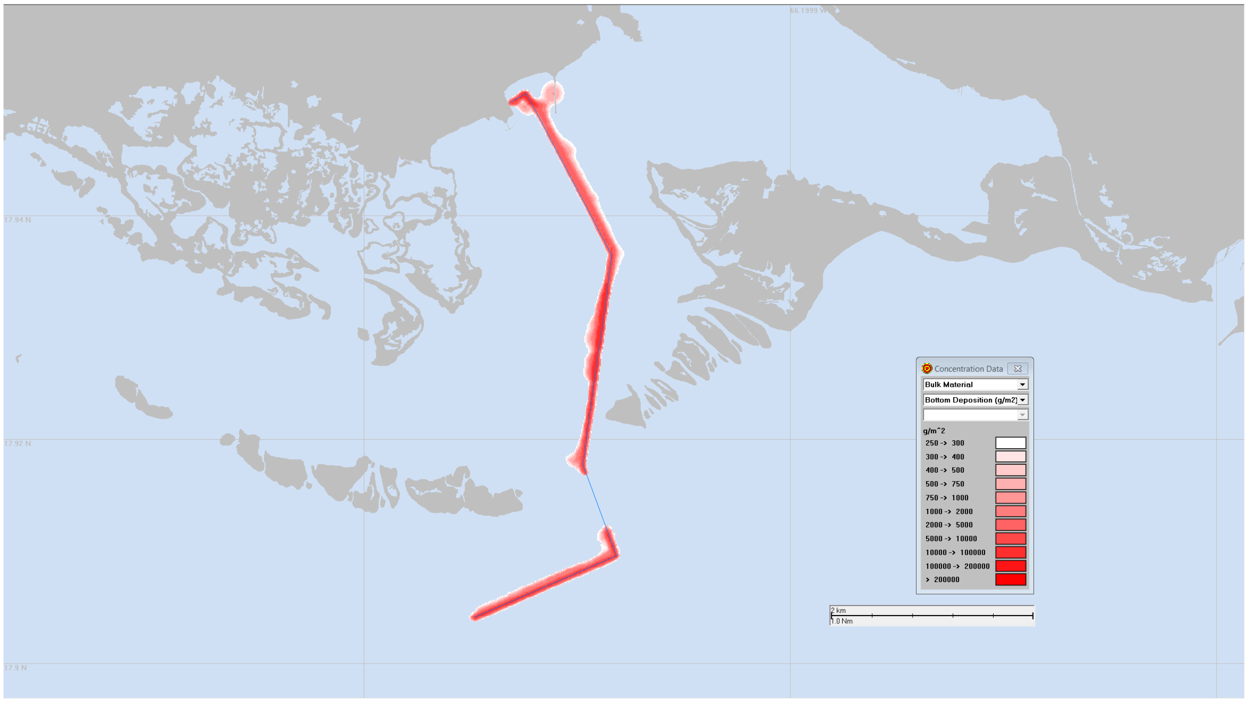

Figure 16. Cumulative mass accumulation (g/m2) of sediment resulting from Scenario 1: pipeline burial.

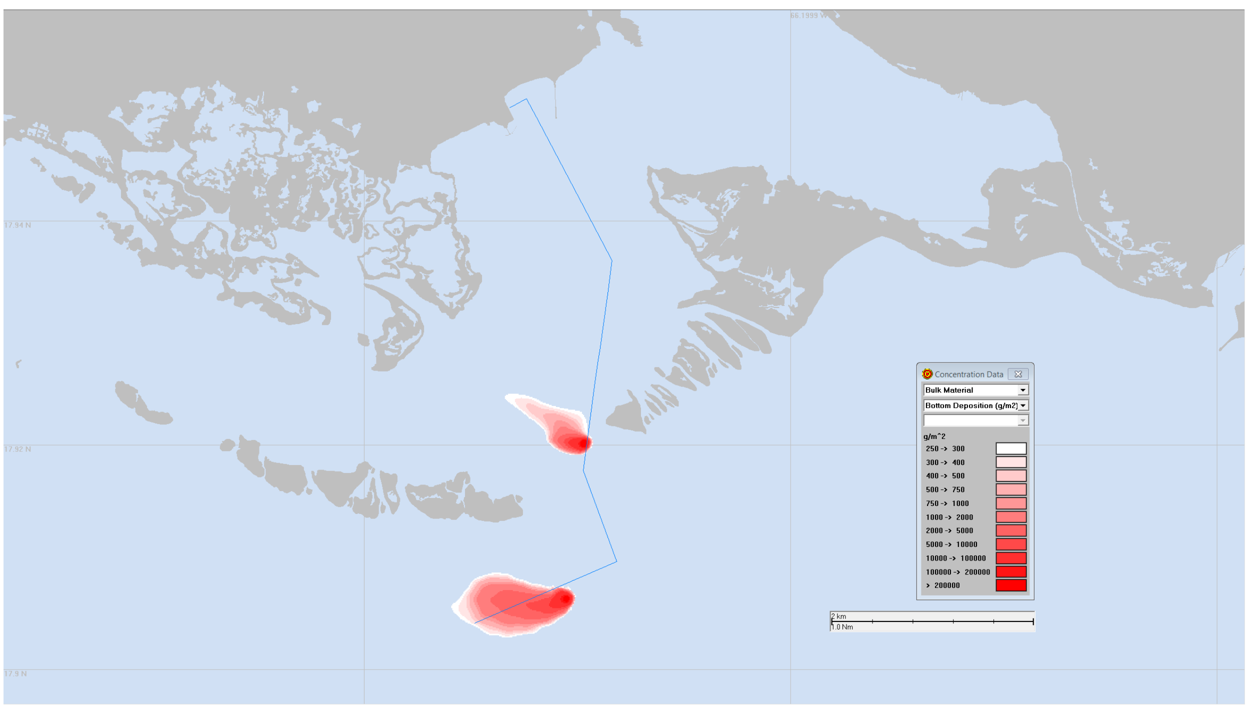

Figure 17. Cumulative mass accumulation (g/m2) of sediment resulting from Scenario 2: dredging and disposal of the HDD entry and exit pits.

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APPENDIX D

BENTHIC RESOURCES MITIGATION PLAN

Attachment 19B

Aguirre Offshore GasPort Project

Benthic Resources Mitigation Plan

Draft

Prepared for:

excelerate energy
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The Woodlands, TX 77380

Prepared by:

Tetra Tech, Inc.

September 2014

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LIST OF ACRONYMS AND ABBREVIATIONS

ANOSIM	Analysis of similarity test
BRR/RS	Back Reef Rubble/Reef Shallow stratum
CCA	Crustose coralline algae
cm	Centimeter
CS	Coarse Sand stratum
CS-IS	Coarse Sand-Inshore stratum
CEQ	Council on Environmental Quality
DGPS	Differential Global Positioning System
DSD	Dark spot disease
ESA	Endangered Species Act
EFH	Essential fish habitat
°F	Fahrenheit
FERC	Federal Energy Regulatory Commission
FSRU	floating storage and regasification unit
ft.	foot/feet
FWS	U.S. Fish and Wildlife Service
GPS	Global Positioning System
HB	Hard Bottom strata
HDOP	Horizontal Dilution of Precision
in.	inch/inches
JBNERR	Jobos Bay National Estuarine Research Reserve
Km	Kilometers
LNG	liquefied natural gas
LNGC	liquefied natural gas carrier
$m\ s^{-1}$	Meters per second
m^2	square meter
m	meter/meters
MDS	multidimensional scaling ordination
MMO	Marine Mammal Observer
MMscf/d	million standard cubic feet per day
NAD 83	North American Datum of 1983
NEPA	National Environmental Policy Act

NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
PI	points of inflection
PP	Power plant strata
PREPA	Puerto Rico Electric Power Authority
SGCN	Species of Greatest Conservation Need
SIMPROF	Similarity profile test
Std. dev	Standard deviation
StRS	stratified random sampling
sp.	Species
spp.	Species (plural)
USCG	United States Coast Guard
VSP	Visual Sample Plan
WGS84	World Geodetic System 1984

1 INTRODUCTION

Aguirre Offshore GasPort, LLC (AOGP), a wholly owned subsidiary of Excelerate Energy L.P. (Excelerate Energy) is proposing to construct an offshore Gasport in the waters off the coast of Aguirre, Puerto Rico. The Aguirre Offshore GasPort Project (AOGP Project or Project) and the associated approximately 4 mile subsea pipeline that will run along the seafloor will connect to the existing Aguirre Power Plant. The pipeline will transect the Jobos Bay National Estuary Research Reserve, (JBNERR), pass through the Boca del Infierno, between two mangrove cayes, and will terminate in the offshore waters at the proposed permanent GasPort location. AOGP has performed numerous studies including a site location study, alternatives analysis, archeological surveys, geotechnical evaluations, water quality and thermodynamic modeling, benthic habitat mapping, and marine mammal and sea turtle monitoring to evaluate the effects of the project on the surrounding area. The project will be affecting benthic communities including coral reef colonies, seagrass communities, and essential fish habitat. The purpose of this Mitigation Plan is to provide details regarding avoidance and minimization measures, as well as outline a regulatory Mitigation Plan for unavoidable impacts to coral reef, seagrass and essential fish habitat.

The Project will be subject to Section 3 of the Natural Gas Act (NGA), Section 10 of the Rivers and Harbors Appropriation Act, the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA) and the Magnuson-Stevens Fishery Management and Conservation Act (MSA). The project will be constructed within the jurisdiction of the U.S. Army Corps of Engineers (USACE), and will be coordinated with National Oceanographic and Atmospheric Administration (NOAA Fisheries) and U.S. Fish and Wildlife Service (USFWS). Additionally, local permitting requirements will be applied by the Puerto Rico Department of Natural Resources.

Compensatory mitigation involves actions taken to offset unavoidable impacts to aquatic resources. Compensatory mitigation is not considered until all appropriate and practicable steps have been taken to avoid and minimize adverse impacts to the environment. Mitigation may include restoration of an aquatic site's functions, creation of a new aquatic site, or preservation of a site.

The MSA provides for the conservation and management of the nation's fishery resources through the preparation and implementation of fishery management plans (FMPs). The MSA calls for NOAA Fisheries to work with regional Fishery Management Councils to develop FMPs for each fishery under their jurisdiction. One of the required provisions of FMPs specifies that essential fish habitat (EFH) be identified and described for the fishery, adverse fishing impacts on EFH be minimized to the extent practicable, and other actions to conserve and enhance EFH be identified. The MSA also mandates that NOAA Fisheries coordinate with and provide information to federal agencies to further the conservation and enhancement of EFH. Federal agencies must consult with NOAA Fisheries on any action that might adversely affect EFH. When NOAA Fisheries finds that a federal or state action would adversely affect EFH, it is required to provide conservation recommendations. AOGP has prepared an EFH Report which was submitted as part of the Federal Energy Regulation Commission (FERC) application.

Section 7 of the ESA outlines the procedures for Federal interagency cooperation to conserve federally listed species and designated critical habitats. Because the project will affect listed and proposed listed species of coral as well as critical habitat, Section 7 consultation will be required. The proposed Mitigation Plan will outline proposed measures to minimize and mitigate for impacts to protected species and critical habitat.

1.1 PROJECT DESCRIPTION

The AOGP Project is being developed in cooperation with the request of the Puerto Rico Electric Power Authority (PREPA) for the purpose of receiving and storing liquefied natural gas (LNG), regasifying the LNG, and delivering natural gas to PREPA's existing Aguirre Power Complex (Aguirre Plant). The Project will include an LNG terminal and facilities and will be sited, constructed, and operated pursuant to Section 3 of the NGA 15 U.S.C. § 717b under the jurisdiction of the FERC. The FERC is the Lead Agency in preparing an Environmental Impact Statement (EIS) in compliance with the Council on Environmental Quality (CEQ) regulations for implementing NEPA, and the FERC's implementing regulations under Chapter I, Title 18, Code of Federal Regulations, Part 380. As the federal Lead Agency, the FERC must also comply with Section 7 of the ESA.

AOGP is proposing to develop, construct, and operate the Project to be located in Salinas, along the southern shore of the Commonwealth of Puerto Rico in Commonwealth waters (Figure 1-1). The Project will utilize Excelerate Energy's proven Energy Bridge™ technology to receive, store and vaporize LNG for delivery as natural gas utilizing one of Excelerate Energy's existing Energy Bridge Regasification Vessels (EBRVs) functioning as a floating storage and regasification unit (FSRU). The FSRU will have a storage capacity of approximately 150,900 m3 of LNG. PREPA will contract for 100% of the available capacity (storage and delivery throughput) from the FSRU. The FSRU will operate in the closed-loop regasification mode[1] and will have the capability of sustained delivery up to approximately 500 MMscf/d of natural gas and peak delivery up to approximately 600 MMscf/d. LNG will be delivered to the Project via LNG carriers (LNGCs), unloaded and stored within an FSRU[2], regasified on the FSRU, and delivered directly to the Aguirre Plant by a subsea pipeline. LNGCs are qualitatively little-different than any other large vessel with respect to the stressors associated with their normal operations. Indeed, LNGCs are somewhat larger and slower than many other vessels operating in the area meaning that they present a less-intense strike risk.

The AOGP Project will consist of three main components: 1) an offshore berthing platform; 2) an offshore marine LNG receiving facility (Offshore GasPort) consisting of an FSRU moored at the offshore berthing platform; and 3) a subsea pipeline connecting the Offshore GasPort to the Aguirre Plant. The offshore berthing platform and the connecting subsea pipeline will comprise the LNG terminal facilities to be certificated in this proceeding pursuant to Section 3 of the NGA. Figure 1-2 provides the project location and the proposed pipeline and offshore terminal location.

The FERC Notice of Schedule for Environmental Review (dated May 2, 2014) indicates issuance of the Notice of Availability of the final EIS by December 19, 2014 with the 90-day Federal Authorization Decision Deadline set for March 19, 2015. AOGP anticipates requesting authorization to commence construction approximately one month after FERC authorization. Construction is anticipated to require approximately 12 months with the Project in service by 2nd Q 2016.

[1] The closed-loop regasification mode does not utilize sea water in the regasification process.
[2] The facility will be designed for long-term, continuous operations. As explained below, the FSRU will be capable of maneuvering on its own away from the offshore berthing platform when necessary and will not be permanently attached to the offshore berthing platform.

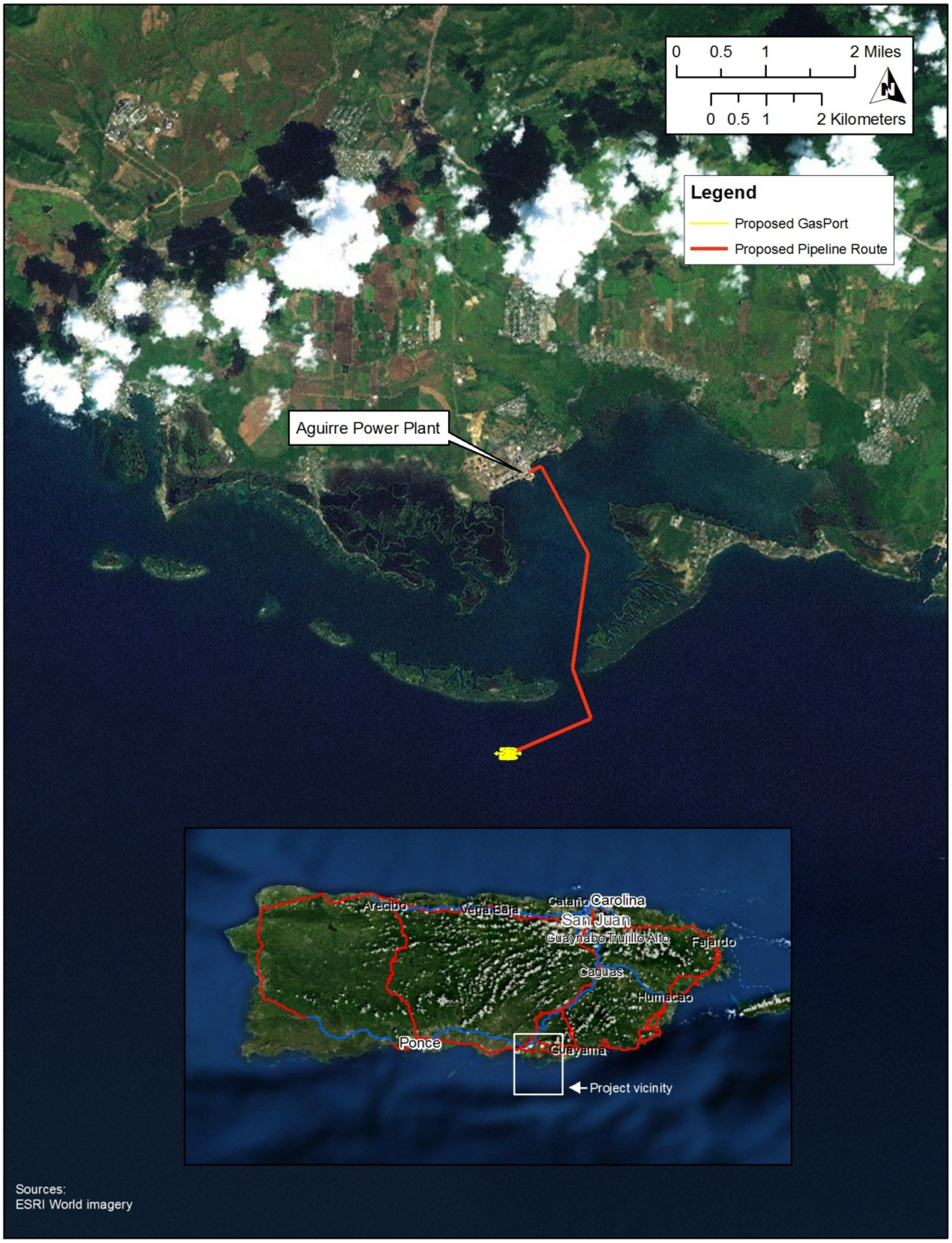

Figure 1-1. Vicinity of Proposed Pipeline Route and Terminal Locations

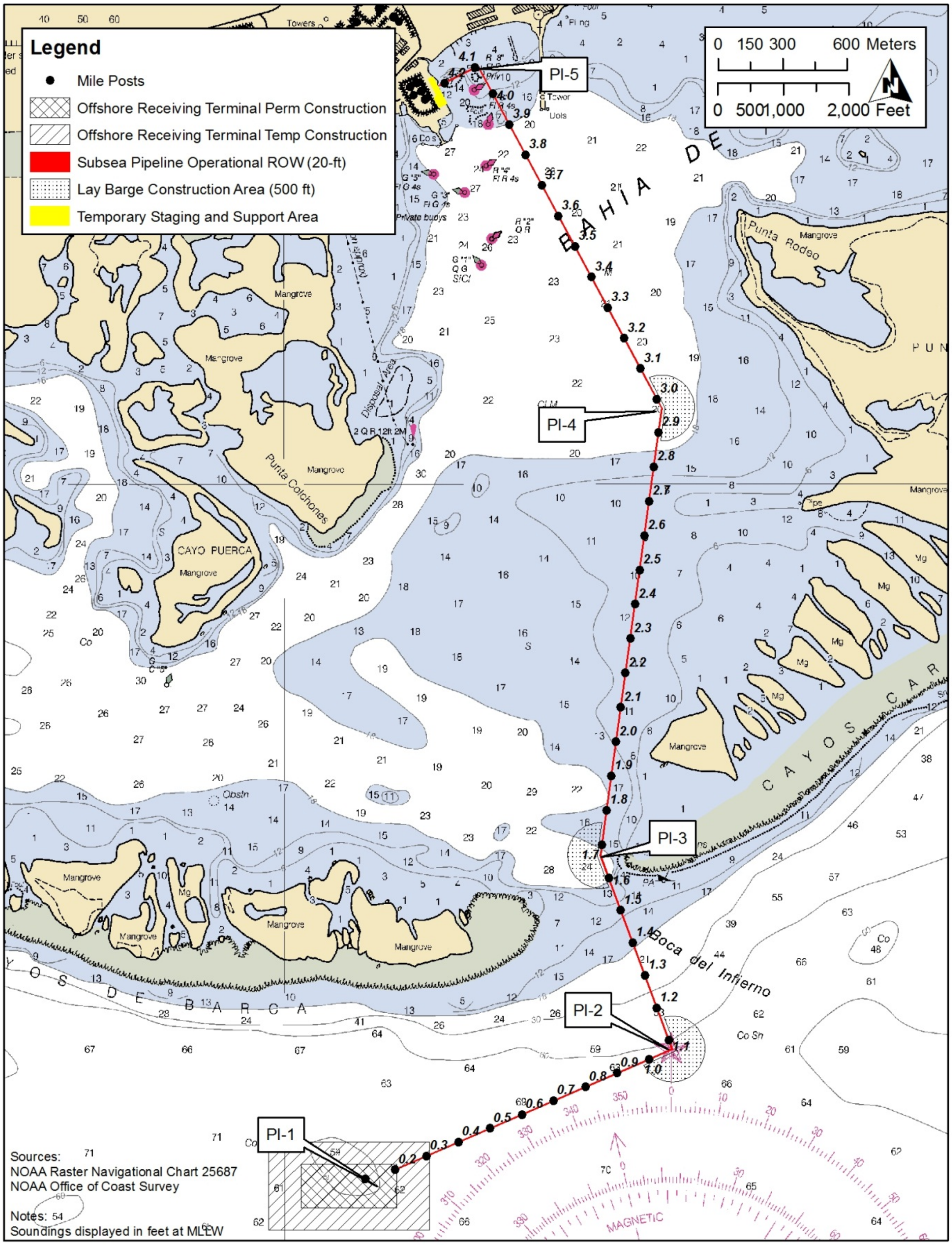

Figure 1-2. Detail of Proposed Pipeline Route and Terminal Location

1.2 AVOIDANCE AND MINIMIZATION MEASURES

AOGP considered many factors in the site selection for the offshore GasPort and the placement of the pipeline connecting the GasPort to the existing Aguirre Power Plant. Numerous studies were performed to ensure the subsea conditions are suitable for construction of the GasPort including geotechnical investigations, hydrographic surveys, archeological studies as well as current and wind studies. Additionally, the placement of the offshore GasPort considered onshore local communities that might be affected by the construction and operation of the facility. Further considerations were made for biological and environmental resources including coral reef, seagrass, threatened and endangered species, critical habitat and essential fish habitat.

An alternatives analysis was included in Resource Report 10 of the FERC application. This report reviewed four (4) alternative offshore locations for the GasPort as well as alternate routes for the proposed pipeline to the onshore power plant. The site selected through the alternatives analysis for the Offshore GasPort is located in open water approximately 3,000 feet south of Cayos de Barca (Figure 1-2). The proposed site is located between alternative sites 1 and 3. Water depth is approximately 60 feet. The proposed site would require a 4.1-mile-long pipeline to reach the Aguirre Plant. The nearest populated areas are the communities of Punta Pozuelo approximately 3 miles northeast of the site, and Central Aguirre approximately 3.5 miles north of the site.

Existing vessel traffic in the area of the proposed site consists of small recreational boats, recreational and commercial sport fishing, and subsistence fishing. The proposed site would not interfere with established shipping lanes or large commercial vessel traffic.

1.2.1 ALTERNATIVE PIPELINE ROUTES

AOGP evaluated several alternative sites for the Offshore GasPort, each of which by design would require a different pipeline route to deliver regasified LNG to the Aguirre Plant. The pipeline route required for each alternative site was a factor in AOGP's evaluation of each site, and eventually in selecting the proposed site for the Offshore GasPort.

The proposed pipeline route has been sited according to the following criteria:

- Shortest reasonable route between the proposed location of the Offshore GasPort and the Aguirre Plant;
- Avoid mangrove barrier islands;
- Avoid sensitive bottom habitats;
- Minimal bends, or points of inflection (PI), to facilitate offshore installation methods with least bottom impacts;
- Avoid crossing of existing barge channel in Jobos Bay;
- Avoid crossing of existing Aguirre Plant cooling water outfall pipe; and
- Direct landfall within the Aguirre Plant to avoid private properties.

With these routing criteria in mind, there are limited options for significant pipeline route alternatives. However, AOGP evaluated possible pipeline route variations between the proposed Offshore GasPort location and the Aguirre Plant. As additional information regarding the benthic communities and protected coral species within the project area were identified, additional alternatives were evaluated to ensure that impacts to benthic resources are avoided and minimized to the greatest extent possible. Based on feedback and concerns from regulatory agencies, AOGP performed additional towed diver surveys to map benthic habitat for alternative passes for the pipeline routes (Figure 1-3) (Alternative Pass Baseline Benthic Characterization Report, Tetra Tech 2014). Ultimately, the alternative pass analysis showed that the route through the Boca del Infierno will cause the least impacts to coral reef, seagrass and protected species. See Table 1-1 Summary of Total Cumulative Habitat Impacts for All Pipeline Alignments.

Table 1-1 Summary of Total Cumulative Habitat Impacts for All Pipeline Routes (Acres)

Habitat Type	Pipeline Alignment 1		Pipeline Alignment 2		Proposed Alignment	
	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary
Consolidated reef	2.15	18.15	0.39	10.48	0.24	0.55
Unconsolidated reef	3.22	38.26	0.76	8.14	0.02	0.35
Seagrass	1.54	45.25	1.59	44.97	0.74	6.97
Macroalgae	10.07	82.72	5.81	48.56	0.85	17.17
Soft-bottom	33.31	281.02	32.03	268.83	0.88	2.69
Total	**50.29**	**465.4**	**40.58**	**380.98**	**2.73**	**27.73**

[1] Value calculated using a combination of the field data and NOAA Jobos Bay Shallow Water Benthic Habitats GIS data layer

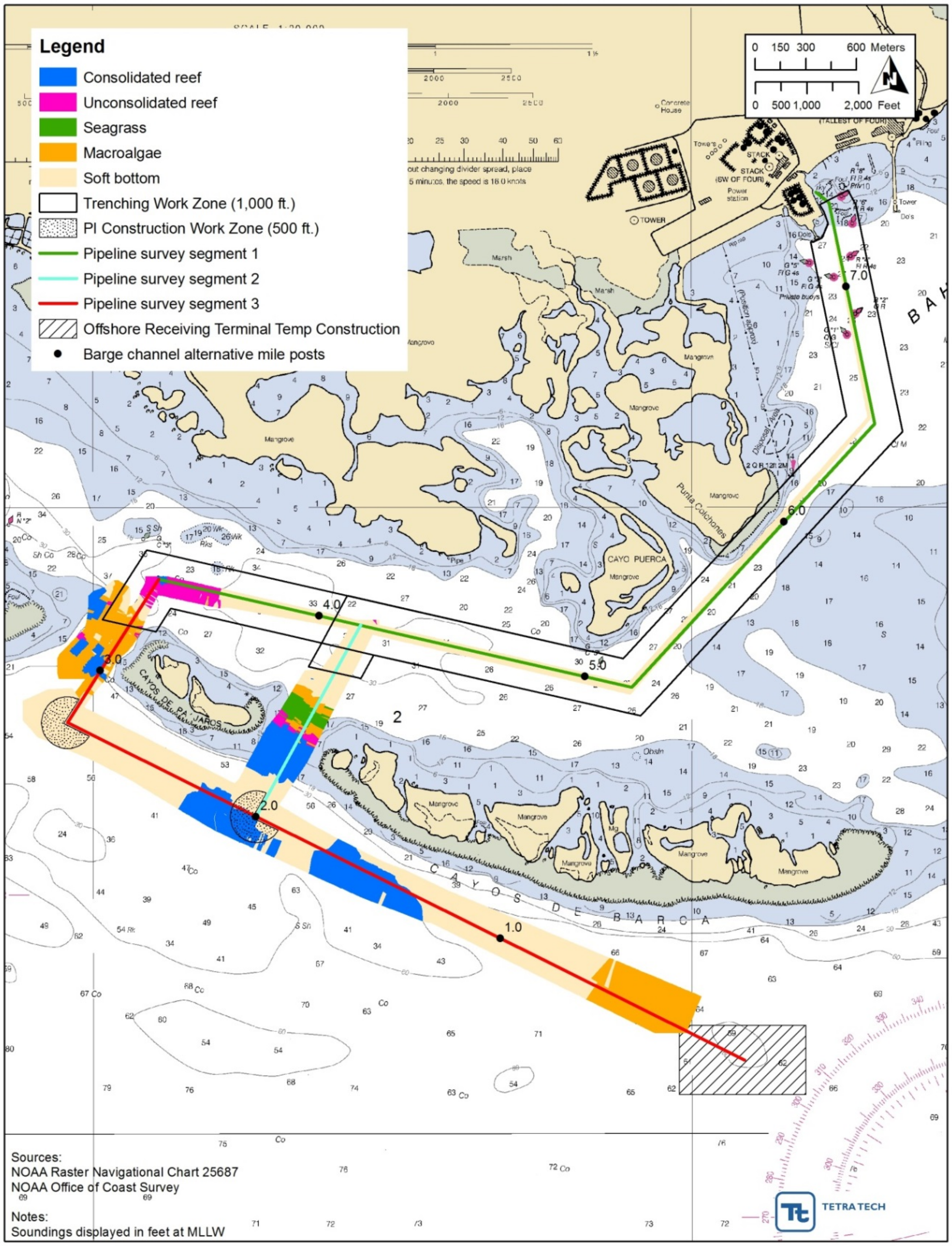

Figure 1-3. Benthic Cover by Habitat Type - Pipeline Alternatives

1.2.2 CONSTRUCTION METHODS TO MINIMIZE IMPACTS

In order to minimize impacts to the marine environment the pipeline will be constructed using a push-pull method, rather than trenching or directional drilling installation methods. The push-pull method also minimizes construction related vessels necessary to perform the work. The barges will be utilized in the areas at the points of inflection (P/I's) (Figure 1-2). The push-pull method allows for long segments of the pipeline to be fabricated on barges and then pulled into position along the pipeline route using cables along an anchor point on the alignment. This method minimizes the potential construction impacts to just a few feet on either side of the pipeline during installation. The construction equipment utilized for installation of the pipeline will be a lay barge anchored to the seafloor with temporary piles or "spuds". This barge will be stationary during construction activities minimizing the impacts to the benthic habitat. [To be reviewed and updated by Excelerate Energy as necessary]

The pipeline segment crossing the coral reef habitat (mile posts 1.0-1.6) will be constructed at the lay barge location, floated to a location outside of the reef habitat. Subsequent flooding of the pipeline segment will slowly and deliberately place the pipeline segment onto the seafloor. Once in place the pipeline will be secured to the consolidated substrate with a series of anchoring devices. This would result in direct impacts to coral located directly underneath the pipeline. However, this technique would eliminate direct impacts to coral reef habitat immediately adjacent to the pipeline that would result from traditional pipeline installation techniques due to side-casting of spoil, and possible indirect impacts that could occur from movement of a non-anchored pipeline during natural high energy events while in operation.

2 OBJECTIVES

The Mitigation Plan identifies the proposed mitigation efforts including restoration and enhancement of appropriate habitat types and the functional gain to be achieved by the plan in order to address the needs of the area. The plan includes the mitigation work plan, success criteria, maintenance and monitoring requirements and reporting timeframes.

2.1 PURPOSE OF MITIGATION PROPOSAL

The purpose of the Mitigation Plan (Plan) is the establishment (creation) of benthic resources for the purposes of offsetting unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization has been achieved. The overall goal of the Plan is to create and/or restore existing degraded habitat that supports a variety of marine fauna, submerged aquatic vegetation (SAV) and sessile reef inhabitants within the vicinity of the project. The actions presented in this Plan will successfully replace lost functions and services within the same marine ecological system that are incurred as a result of the project. The Plan also addresses minimization of impacts to coral species protected under the ESA.

The objectives of the Plan are as follows:

a. Further avoid and minimize impacts to epibenthic flora and fauna by transplanting seagrass and relocating coral colonies from within the construction footprint of the proposed pipeline prior to the start of construction.
b. Provide compensatory mitigation for unavoidable impacts to resources resulting from construction and operation of the AOGP Project unavoidable impacts to aquatic resources.
c. Relocate ESA listed stony coral species to avoid potential for "take" of these species

d. Provide compensatory mitigation for loss of critical habitat for *Acropora* spp.
e. Provide compensatory mitigation for impacts to seagrass, foraging habitat for the green sea turtle and the Antillean manatee.
f. Offset impacts to Essential Fish Habitat (EFH)

2.2 TRANSPLANTING OF SEAGRASS AND STONY CORALS

Transplanting of seagrass and marine plants SAV has been a practice in restoration and mitigation efforts for many decades as a result of the decline in seagrass habitat in developing coastal areas. Methodologies for transplanting seagrass vary depending on the species and substrate of the donor and recipient sites. Numerous methods have been tested including bare root, peat pots, sods, individual plugs, mechanical transplanting etc. Additional considerations are made regarding environmental conditions, distance from planting resources, time of year, etc. (Fonseca et al, 1994). There are many factors that influence the success of transplanting various seagrass species including water quality, bioturbation, herbivory, tidal and wind driven current energy, appropriate sedimentation and other factors. This Plan has been developed to consider local environmental factors in an effort to ensure transplanting success for the AOGP Project.

Coral relocation has been a concept of avoidance and minimization and in the coral recovery efforts since the 1970's in Hawaii and has become common throughout Florida and the Caribbean. Recent efforts in coral recovery strategies also include coral propagation and outplanting programs. The intent of relocating corals is to avoid impacts to stony corals by relocating viable specimens from the project impact area to an adjacent recipient area where impacts will not occur.

Corals must be relocated to a habitat similar to that into which they will be transplanted, especially with respect to the degree of water movement, depth and turbidity. For example, coral from shallow clear turbulent reef fronts will not do well in turbid sheltered bays (Maragos, 01974; Plucer-Resario and Randall, 1987). Attachment methods include cement, marine epoxy, plastic coated wire, metal frames, and plastic cable ties (Harriott and Fisk, 1988). Methodologies for coral relocation for the AOGP Mitigation Plan are described in Section 5.0.

3 BASELINE INFORMATION

In May 2012, AOGP performed a Baseline Benthic Characterization in order to identify and map the existing marine habitats within the project area in Jobos Bay. Towed–diver survey operations were conducted over a five-day period using scientific divers, Trimble® DGPS, diver to top-side communications, and HYPACK® 2011 marine surveying, positioning, and navigation software. The towed–diver survey allowed divers to visually ground truth geophysical data layers and catalog habitat types and sensitive benthic resources (e.g. *Acropora* spp., *Strombus gigas*, *Panulirus argus* aggregations) within the study area.

The inshore survey area is a 149-acre linear corridor (500-600 ft. wide) that stretches from the Aguirre Power Plant out to the Boca del Infierno. The inshore survey area was split in to 2 distinct survey areas (Area1 and Area 2). Area 1 includes the north leg of the pipeline corridor which runs southeast from the Aguirre Power Plant to the point of inflection (PI) and Area 2 continues in a southerly direction from the PI to Boca del Infierno (Figure 3-1).

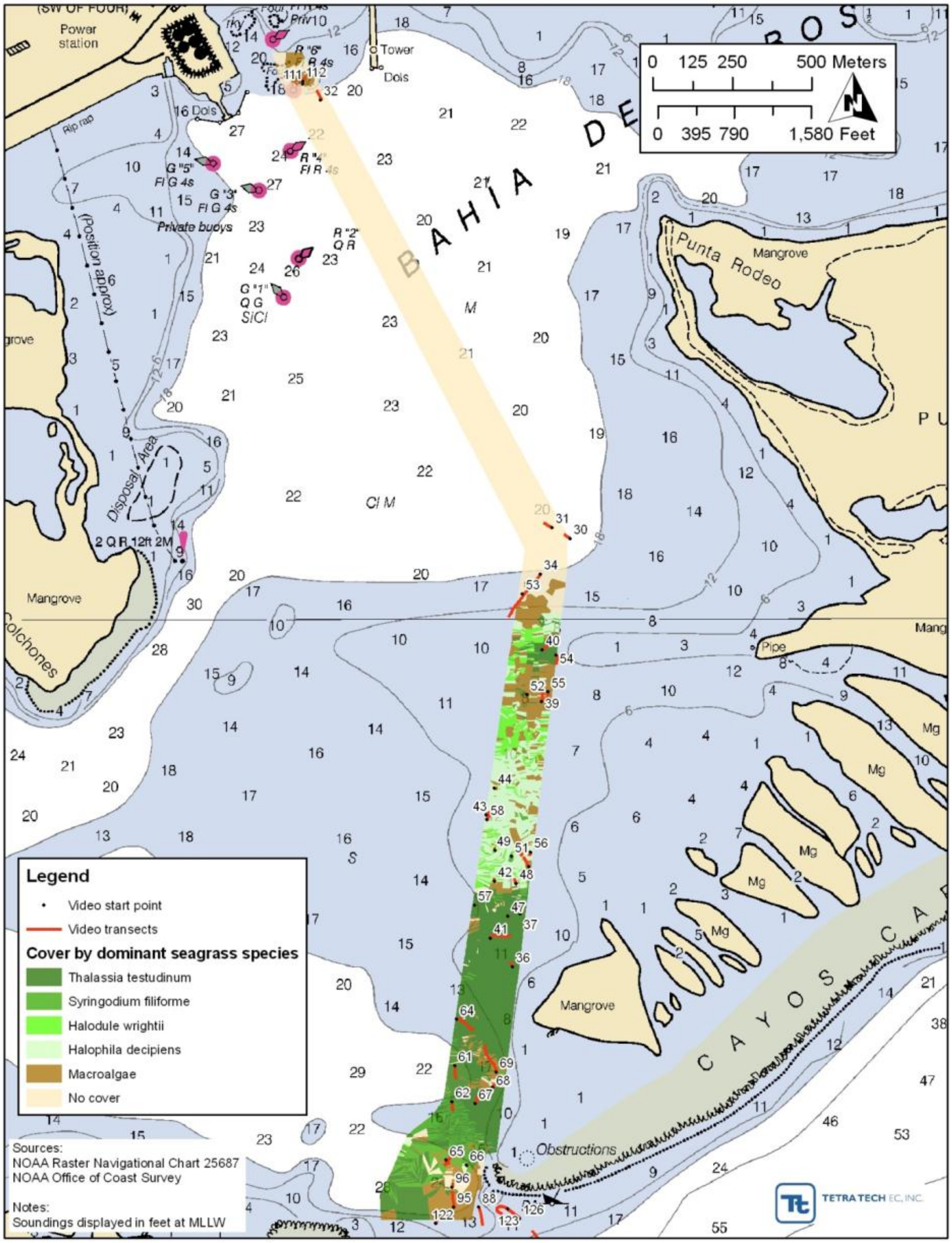

Figure 3-1 Inshore Survey Area (Tetra Tech, 2012)

Three broad-scale benthic community types were documented during the survey: seagrass, macroalgae, and infaunal (mud). Much of the inshore area (40%) has no cover of seagrass or macroalgae. Seagrass and macroalgae coverage varies from 0 to >75% throughout Area 2. Epibenthic coverage within Area 1 was consistently 0 with the exception of a small macroalgae community located at the northern end of Area 1 with cover ranging from <5 to 75 percent. Biological cover varied significantly between the two survey areas with more than 99 percent cover of epibenthic biota documented within Area 2 vs. less than 1 percent cover in Area 1. In Area 2, seagrass communities were most abundant with a total areal extent (areal abundance) of approximately 69.6 acres, followed by bare substrate (mud/sand) with 59.8 acres and macroalgae with 19.9 acres.

Four species of seagrass were documented within survey Area 2, while no seagrass was observed within survey Area 1. The four species, in decreasing order of areal abundance, include *Thalassia testudinum*, *Halophila decipiens*, *Syringodium filiforme*, and *Halodule wrightii*. Both mixed-species assemblages and monotypic-dominant stands were observed throughout survey Area 2. The most common mixed species assemblages include *Thalassia testudinum*/*Syringodium filiforme* and *Halophila decipiens*/*Halodule wrightii*.

In accordance with the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) of 1996, as amended, seagrass beds are defined as Essential Fish Habitat (EFH) that provides the waters and substrate necessary for fish spawning, breeding, feeding, and maturing. Seagrass beds are a food source for sea turtles (hawksbill [*Eretmochelys imbricata*] and green [*Chelonia mydas*]) and the Antillean manatee (*Trichechus manatus manatus*), provide spawning habitat, food and shelter for fish and invertebrate species (Caribbean spiny lobster [*Panulirus argus*], octopus [*Octopus* spp.] and queen conch [*Strombus gigas*]). Fishery Management Plans have been prepared for both *P. argus* and *S. gigas* by the Caribbean Fishery Management Council. Nurse sharks (*Ginglymostoma cirratum)* also frequent the Bay (E. O. Rodríguez-Class, pers. comm.). These species are also locally regulated under the Fishing Regulations of Puerto Rico (DRNA, 2004).

The offshore surveys were conducted along the reef zone (Area 3) and the offshore habitat within the pipeline corridor and the Offshore terminal area. The offshore survey area (Area 3) in the Baseline Benthic Characterization (Tetra Tech, 2012) is a 123-acre survey area that stretches across Boca del Infierno out to the consolidated reef edge or fore reef and west along the reef (Figure 3-2). Three broad-scale benthic zones each with distinct epibenthic cover were documented within survey Area 3: backreef rubble, gorgonian, and fore reef zones. The substrate within the backreef rubble zone consists of small to medium size rubble (<5 cm to-50 cm in diameter) well integrated with coarse grain sand. The areal extent of the backreef rubble and gorgonian zone is approximately 5 and 28 acres, respectively. The substrate within the gorgonian and fore reef zone is consolidated reef with low to moderate rugosity. The area directly offshore of Boca del Infierno was relatively flat (hardbottom pavement) with an increase in rugosity towards the east and west. Spur and groove coral reef formations and sand chutes were observed along the east and west ends of survey Area 3. Figure 3-2 presents the locations of the three benthic zones found within survey Area 3.

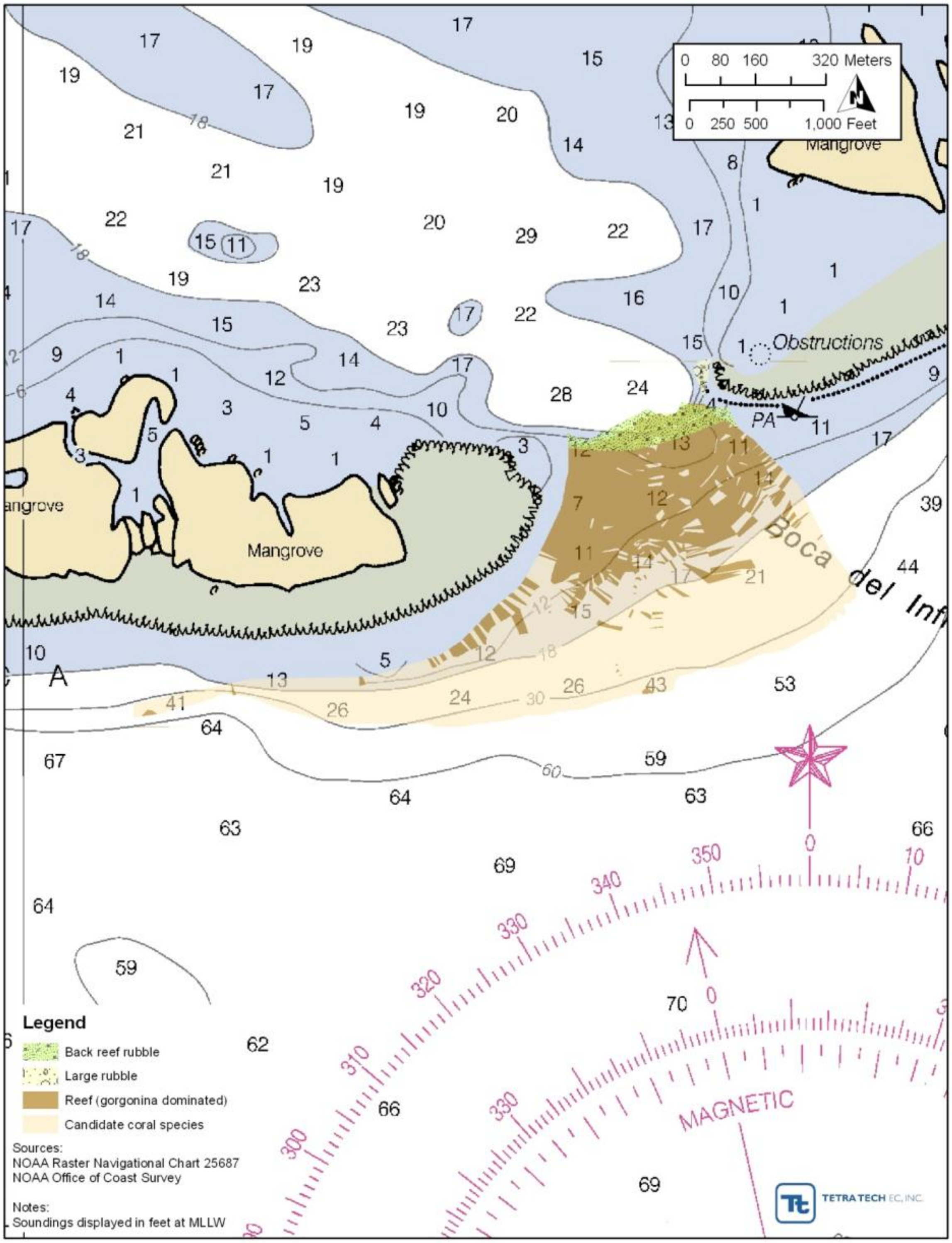

Figure 3-2 Offshore Survey Area (Tetra Tech, 2012)

Scleractinian (stony) corals were observed throughout survey Area 3. *Acropora cervicornis* and *Acropora palmata* (both listed as threatened under the ESA) along with the five stony corals recently listed as threatened under the Endangered Species Act (ESA) (Title 50 CFR 223.208 effective October 2014) were observed and/or documented within survey Area 3 (Figure 3-3). Following is a list of the five recently listed coral species documented:

- *Dendrogyra cylindrus*
- *Montastraea annularis*
- *Montastraea faveolata*
- *Montastraea franksi*
- *Mycetophyllia ferox*

Acropora cervicornis and *Acropora palmata* were regularly observed along their respective habitats. *Acropora palmata* was documented across the survey area from the landward edge of the survey area (5 ft. contour) out to a water depth of approximately 18 ft. *Acropora cervicornis* was observed regularly across the survey area from the landward edge of the survey area (5 ft. contour) out to a water depth of approximately 40 ft.

Critical habitat is a term used under the ESA and is defined as a specific geographic area(s) that is essential for the conservation of a threatened or endangered species and that may require special management and protection (FWS, 2012). Due to the presence and distribution of *Acropora* spp. (species listed as threatened under the ESA), nearly the entire extent of survey Area 3 may be considered critical habitat for ESA stony coral species.

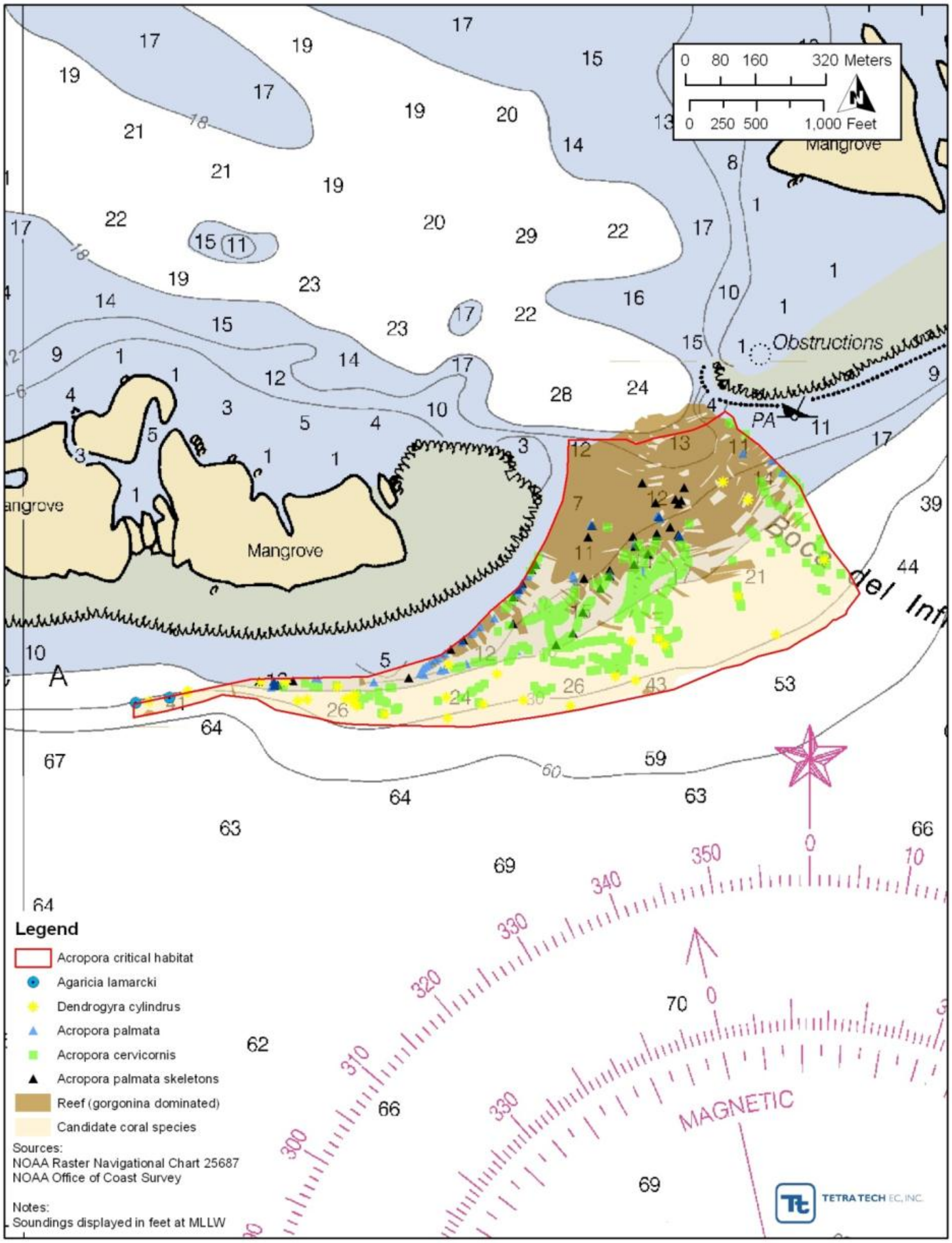

Figure 3-3 Listed ESA Coral Species Distribution

The offshore pipeline corridor and terminal area are comprised mostly of unconsolidated soft bottom habitat (fine-coarse sands) with low biological cover (Tetra Tech, 2012). During the baseline benthic characterization, the offshore survey area was stratified by substrate type. Two strata were identified and described; Coarse Sand-Offshore and Fine Sand-Offshore. The Course Sand stratum includes the habitat immediately offshore of the fore reef zone out to the south, west and east edge of the study area. This area is characterized by flat (no relief) topography. It is composed of coarse sand and shell material and with a low (10%) fine sand/silt fraction. Water depths ranged from 55 ft. to 71 ft. with an average water depth of 64 ft. Uncolonized, unconsolidated substrate (i.e., sediment [sand], rubble, and silt/mud) coverage is 82.68%, 0.14%, and 11.23%, respectively for a total of 94.05% of biologically barren ground. The total mean epibenthic biological cover found within the Course Sand stratum is 5.95%. Macroalgae accounts for the highest mean percent coverage with 2.80% followed by turf algae (0.52%), sponges (0.60%), stony corals (0.27%), and seagrass (0.09%).

The Fine Sand-Offshore stratum includes two areas immediately offshore of the fore reef zone east and west of the study area. This stratum is characterized by flat topography and firm, fine sand with a low (20%) silt/mud fraction. Water depths ranged from 62 ft. to 65 ft. with an average water depth of 64 ft. Hardbottom was not documented in this stratum; only sand with mud/silt fractions was found. Sand cover is 78.93% while silt and mud cover is 20.0%. Relief was undetectable within the stratum. Total mean biotic percent cover is insignificant (1%).

Discontinuous hardbottom habitat in the form of "patch" reefs were identified during field surveys in the offshore terminal survey area. This habitat is characterized by low relief (1 meter or less) patch reefs ranging in size from 1-m^2 to greater than 50-m^2. The patch reef habitat are biologically well developed, supporting a variety of sessile (e.g., stony corals, gorgonians, sponges, macroalgae, etc.) and motile (ichthyofauna, crustaceans, gastropods, echinoderms, etc.) organisms. A rich assemblage of stony corals including ESA listed stony coral species (*Dendrogyra cylindrus*) were observed during the survey (Tetra Tech, 2014). Figure 3-4 presents the patch reef habitat graphically.

Food resources and shelter is limited in the bank/shelf zone of the Project Area since it is predominantly comprised of low cover mud and sandy bottoms. Therefore the occurrence of commercial and recreationally important fish is likely to be large pelagic fish, sea turtles, manatees, sharks, whales, and dolphins. Species abundance and diversity of pelagic and benthic fish within the Project Area of the bank/shelf zone is unknown; however the MSFMCA recognizes the importance of non-vegetated bottoms, live bottoms and coral reefs in the Caribbean as EFH.

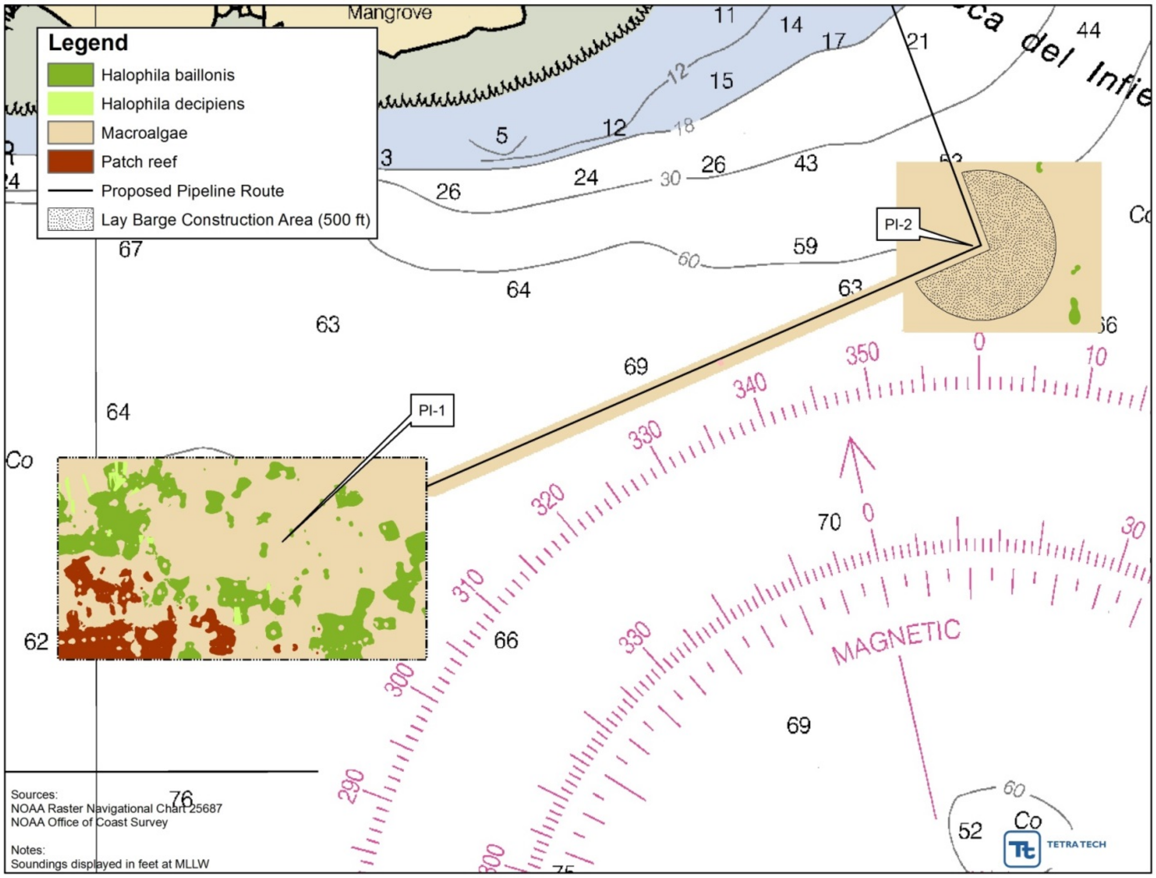

Figure 3-4. Offshore Pipeline Corridor, and Offshore Terminal Area Benthic Resource Cover

4 PROJECT IMPACTS TO AQUATIC RESOURCES

Temporary and permanent impacts to seagrass, algal and bank/shelf coral reef communities along the pipeline route are anticipated during construction and installation of the pipeline and offshore GasPort. The operational right of way (ROW) is presented as a 20-foot wide corridor; however actual direct impacts to the benthic communities are anticipated to be a fraction of this corridor as impacts within the ROW are only anticipated for and near the direct footprint of the pipeline (approximately 2 feet, outer diameter). On this basis, for the purpose of areal benthic resource impact calculations, the 20-foot operational ROW is divided into a 6-foot wide pipeline corridor (permanent impacts), flanked by adjacent 7-foot wide temporary construction impact zones. Permanent impacts are limited to the 6-foot wide pipeline corridor and the area directly impacted by the offshore berthing platform; permanent impact areal calculations are based on the extent of these zones. Temporary impacts will result in the 7-foot zones immediately adjacent to each side of the pipeline, the PI construction work areas, and the construction area surrounding the offshore berthing platform.

Temporary impacts resulting from elevated turbidity levels, sedimentation during pipeline installation, vessel mooring, and shading from lay barges are likely to occur. Although unlikely, accidental vessel contact with the seafloor and propeller wash by construction vessels may also cause temporary impacts to benthic communities in nearshore, shallow areas. Approximately 16.2 acres (inshore [1.7 acres], offshore pipeline corridor [<0.01 acres)], offshore berthing platform [9.2 acres], and PI construction work zones [5.3 acres]) of seagrass habitat may temporarily be impacted as a result of the action. These negative impacts are considered temporary; therefore, once construction activities are complete and equipment has demobilized from the Project area affected resources are likely to return to pre-construction conditions.

Permanent impacts to seagrass and soft bottom benthic communities in the bay and the offshore seagrass and patch reef communities will occur along the pipeline construction corridor and the offshore terminal area. Negative permanent impacts will result from shading, burial, bioturbation, nutrient loading, and / or smothering. Permanent impacts to seagrass habitat within the 6-foot pipeline corridor and beneath the offshore berthing platform will likely result in direct loss of resource. It is estimated that approximately 3.6 acres (inshore [0.7 acres], offshore pipeline corridor [0.02 acres], and offshore berthing platform [2.90 acres]) of seagrass habitat will be permanently impacted as a result of the action.

Temporary impacts to hard bottom habitats and the associated flora and fauna will occur as a result of the action. As described above for the soft bottom habitats, temporary impacts are associated with construction zones and are considered temporary. Impacts resulting from elevated turbidity levels, sedimentation during pipeline installation, vessel mooring, displacement or mechanical injury from propeller wash, cable and / or other equipment drag, equipment/items falling from work platform, divers contacting substrate and / or organisms during pre- and post-construction surveys, and shading from lay barges may occur. It is estimated that approximately 4.78 acres (reef pipeline corridor - gorgonian reef [0.05 acres], coral reef [0.55 acres], PI construction work zones – gorgonian reef [0.30 acres], and offshore berthing platform – patch reef [3.88 acres]) of hardbottom habitats may be impacted as a result of the action. These negative impacts are considered temporary; therefore, once construction activities are complete and equipment has demobilized from the Project area effected resources and environmental resources are likely to return to pre-construction conditions.

Permanent impacts to hard bottom habitats and the associated flora and fauna will occur along the reef complex associated with the Boca del Infierno and the offshore patch reef communities along the pipeline construction corridor and the offshore terminal area. Negative permanent impacts will result from shading, displacement, mechanical injury, burial, and / or smothering. Permanent impacts to corals within the 6-foot pipeline corridor and beneath the offshore berthing platform will likely result in direct loss of resource. It is estimated that approximately 0.46 acres (reef pipeline corridor - gorgonian reef [0.02 acres], coral reef [0.24 acres] and offshore berthing platform – patch reef [0.20 acres]) of hardbottom habitats will be permanently impacted as a result of the action. Negative impacts are considered permanent; therefore, physical and or biological resources will be permanently altered as a result of the action. Temporary and permanent impacts totals are shown by habitat type in Table 4.1.

4.1 SUMMARY OF TEMPORARY AND PERMANENT IMPACTS TO BENTHIC RESOURCES

In summary, AOGP has avoided and minimized impacts to benthic resources to the greatest extent practicable. This Plan outlines additional avoidance measures as well as the compensatory mitigation proposed to offset the remaining benthic aquatic resource impacts. Table 4-1 provides a breakdown of impacts by habitat type and project component.

The pipeline corridor delineated as a 20-foot-wide corridor, with an area of direct and permanent impact that is 6-feet wide running along the centerline of the corridor and 7-foot area on either side of temporary impacts that are expected to recover within days/weeks of pipeline installation. The pipeline installation is expected to permanently impact 0.26 acres of reef. These acreages will be confirmed by a post-construction monitoring event to document permanent and temporary impacts.

The P/I construction areas have been identified as the only expected areas of impact for construction vessels. The methodology proposed minimizes the need for larger more impactive vessels by utilizing barges equipped with anchor systems. The P/I areas will only provide for temporary impacts, no permanent impacts are expected in these areas. A post construction monitoring event will document temporary or permanent impacts.

The offshore GasPort will have the greatest seagrass impacts (2.9 acres) due to shading from the offshore structures. The calculated acreage is over estimated as the structure will permanently shade a portion of the delineated rectangle shaped area (Figure 3-4. Offshore Pipeline Corridor and Offshore Terminal Area Benthic Resource Cover). Temporary impacts will also be less as construction methodologies will be adjusted to avoid seagrass and patch reef areas.

Table 4-1 Impacts to Benthic Resources by Project Component (Acres)

Habitat Type	Pipeline Corridor (20 ft)		P/I Construction areas		Offshore GasPort		TOTAL	Permanent Impacts Only
	Temp	Perm	Temp	Perm	Temp	Perm		
Soft-bottom	2.1	0.9	0.6	0	0	0	3.6	0.9
Macro-Algae	2.0	0.9	15.2	0	40.2	19.2	77.5	20.1
Seagrass	1.7	0.7	5.3	0	9.2	2.9	19.8	3.6
Unconsolidated Reef	0.1	<0.1	0.3	0	0	0	0.4	<0.1
Consolidated Reef	0.6	0.2	0	0	0	0	0.8	0.2
Patch Reef	0	0	0	0	3.9	0.2	0.2	0.2

*Construction methodology will likely avoid direct impacts to these patch reefs identified in the temporary construction area. Secondary impacts such as shading or sedimentation will also be minimized.

5 MITIGATION WORK PLAN

The Mitigation Work Plan includes several components to address minimization of impacts to ESA species, identification of additional restoration (mitigation) areas, pre- and post-construction surveys, and long-term monitoring.

Coral Reef Mitigation Components include:

- Pre-construction surveys to identify potential coral restoration/relocation sites
- Pre-construction removal of all ESA coral species from 20-foot potential pipeline impact area.
- Relocation of corals to reef on appropriate and available substrate adjacent to pipeline at similar depth contour
- Artificial reef construction within Jobos Bay to mimic existing inshore reef habitat
- Offshore artificial patch reef construction for relocation of ESA corals that may be impacted by the offshore GasPort
- Post construction survey to assess incidental damage to corals during pipeline installation for immediate relocation
- Monitoring of relocated corals and artificial reefs for 3 years

Seagrass Mitigation Components include:

- Pre-construction surveys in Jobos Bay to map and quantify restoration sites and identify reference sites
- Topographic restoration of Cayo Caribe prop dredging scar within Jobos Bay utilizing pipeline impact area as seagrass donor site (as appropriate)

- Prop-scar restoration along shoals east of the Aguirre Power Plant utilizing pipeline impact area as seagrass donor site (as appropriate).
- Post-construction survey to assess any potential construction damage
- Restoration of any identified construction related damage to seagrass
- Monitoring of restoration sites and transplant areas for 3 years

5.1 PRE-CONSTRUCTION SURVEYS

The pre-construction surveys will be multi-purpose. Prior to construction, an in-water survey of Jobos Bay and the nearshore area will be performed to identify potential restoration sites for seagrass restoration and delineate artificial reef footprint. Restoration sites will be identified through coordination with local regulatory agency staff, resource managers and staff of JBNERR focusing on the area within the vicinity of the project or known areas ("hot spots") in need of restoration. Site assessments will quantitatively and qualitatively evaluate each feature for appropriateness as mitigation. Reference sites for comparison during routine monitoring events and coral cache sites will also be identified during the pre-construction surveys. Coral cache sites will serve as a temporary (during construction) staging area for stony corals (e.g. ESA species) that will be displaced during construction activities and returned back to its original location following the construction action. These restoration areas, reference sites and cache locations will be identified and mapped using Trimble GIS.

During the pre-construction surveys, seagrass restoration features will be bathymetrically surveyed and delineated. Additional site characterization data will be collected e necessary for the development of a restoration plan that provides site specific restoration prescriptions.

Pre-construction surveys will also document pre-construction conditions of the pipeline corridor and offshore area. The results of the survey data will be incorporated into a "Pre-Construction Benthic Characterization Report". The survey methodology will be "towed-diver" and will cover the entire project area (inshore and offshore). Surveys will review habitat conditions and the report will identify any major changes in benthic communities since the previous surveys were performed in 2012.

5.2 POST-CONSTRUCTION SURVEYS

Post-construction surveys will be performed immediately after construction actions have been completed (e.g., pipeline and offshore platform installation) and it is safe for scientific divers to enter the area. The offshore Gasport area post construction survey may be completed during a separate mobilization depending on construction sequencing. The post-construction surveys will evaluate the pipeline construction corridor to identify any incidental or unanticipated impacts from construction and verify placement of the pipeline along the reef habitat located offshore of the Boca del Infierno, where resources were relocated prior to construction. The surveys will utilize towed divers equipped with cameras to document the post-construction conditions of the benthic habitat. Any resources of "opportunity" such as displaced seagrass or detached corals will be documented and relocated to appropriate habitat in the vicinity. The offshore GasPort survey will document any impacts during construction within the temporary impact area.

5.3 CORAL RELOCATION PLAN

Coral relocation will be performed prior to construction/installation of the pipeline within the reef habitat directly offshore of the Boca del Infierno. Weather will need to be considered in the timing of the work as high seas and winds will hinder work activities.

5.3.1 CORAL COLONY REMOVAL PLAN

The centerline of the pipeline will be located and marked using a Trimble® Differential Global Positioning System (DGPS) and Hypack® 2011 marine surveying, positioning, and navigation software. The boundaries of the potential impact area will include a 20-foot wide pipeline corridor will be cleared of all ESA corals and non-ESA corals greater than 25cm in size. These corals will either be cached during construction activities for post-construction relocation back to the pipeline corridor or permanently relocated to the adjacent reef outside of any influence of construction within similar substrate and depth contour. Caches will be marked with a surface buoy and DGPS coordinates recorded to aid in site relocation. The cache will be located in a low energy environment free of rubble or debris and away from disturbance by construction activities. Selected corals will be manually relocated and placed upright within the cache area until construction activities have been completed within the Boca del Infierno. Figure 5-1.

Biologists knowledgeable in coral reef habitats and species identification, working in teams of two, will identify and relocate viable relocation candidates. Dive teams will remove stony corals meeting the relocation criteria within their respective search area (search areas will be determined in the field and will be based on the observed field conditions) and either transport the material to a nearby temporary cache location or permanently reattach each colony within the designated recipient site. The team will systematically progress to the next search area and repeat the process. Each diver will utilize a chisel and hammer to detach coral colonies. All corals will be handled carefully, minimizing contact with polyps.

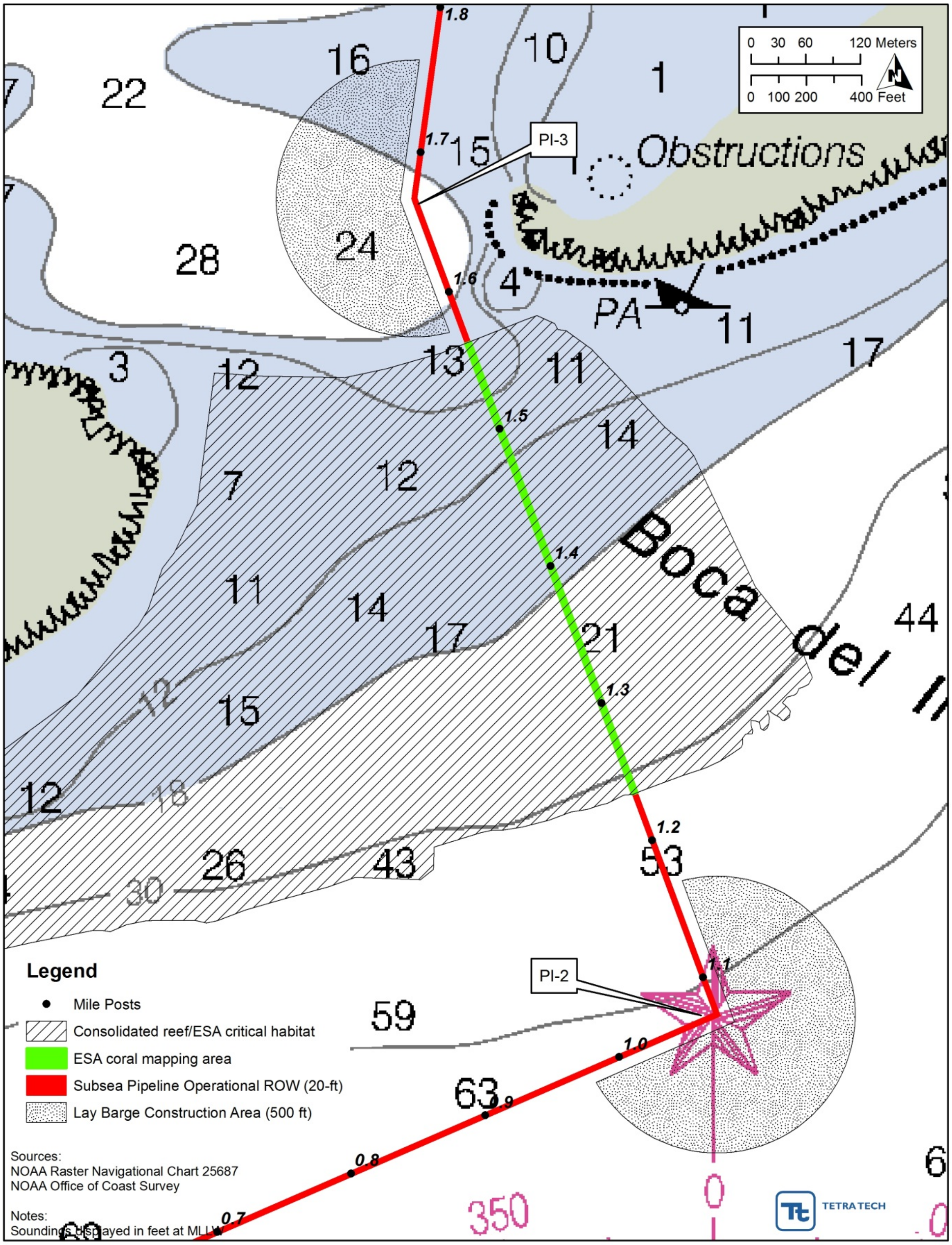

Figure 5-1 Subsea Pipeline ROW to be cleared of ESA Coral Species prior to construction.

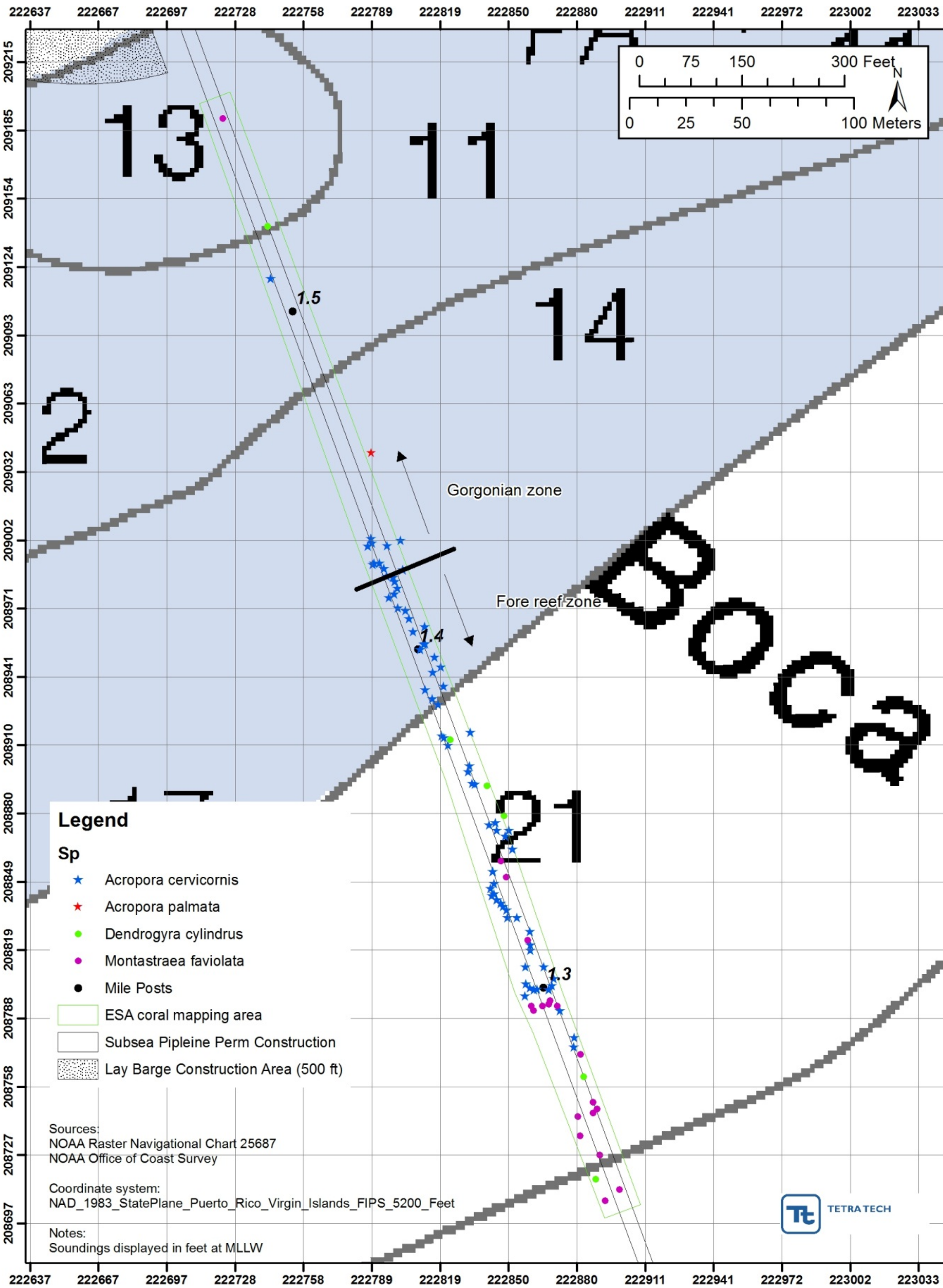

Figure 5-2 ESA Corals Mapping Results by Species

5.3.2 CORAL REATTACHMENT METHODS

The detached coral colonies will be reattached by divers using a thick, non-flowing concrete mix consisting of three parts Portland cement and one part sand aggregate. Using an electric drill, the concrete will be mixed on the boat, placed in 5-gallon buckets with lids, and delivered by a diver to the work area. A suitable location (recipient site) and orientation among the existing substrate will be determined prior to permanent attachment to the reef or restoration/mitigation sites identified during pre-construction surveys. The base of the selected coral pieces and the reattachment area will be cleaned with a wire brush to remove any algae or other biota that would compromise bonding of the concrete. Next, a sufficient amount of concrete will be placed directly on the pre-cleaned substrate creating a base. Colonies are then pressed into the concrete base and lightly twisted back and forth into position until stable. Concrete is added or removed as necessary around the edge of the colony to create a clean appearance, reduce bioerosion, provide a growing surface, and provide a strong bond with the substrate. Reattached colonies will be checked repeatedly during reattachment operations for stability and to dissipate cement fallout that may have settled on the reattached colony and/or adjacent biota. In the event colony size prohibits safe handling by a single diver, the colony will be moved utilizing a second diver.

5.3.3 DOCUMENTATION

Field notes and photographs will be collected during the reattachment efforts. A numbered tag will be installed in a central location within each reattachment area and a polar plot produced with the relative locations of the reattached biota. GPS coordinates of all numbered tags will be collected following installation. Tags will be made of rubber with laser etched enumeration and will be installed with a PK nail. Documentation of the reattached corals will include the location of relocated stony corals (direction/bearing from respective reattachment area tag), species, size of colony, and corresponding photograph. A scale will be used in the photographs for reference and future monitoring purposes.

5.3.4 ARTIFICIAL REEF

In order to offset permanent loss of 0.03 acres (1,150 square feet) of reef habitat within the 2-foot pipeline footprint, AOGP proposes to construct inshore artificial reef habitat to offset the critical habitat loss for ESA listed stony corals. Additionally, to offset any potential impacts from shading to ESA listed coral species caused by shading from the offshore GasPort, artificial patch reefs will be deployed in the offshore vicinity. These proposed patch reefs will be the recipient site for ESA corals relocated from potentially shaded areas minimizing impacts to the protected species of coral.

The inshore artificial reef will be a low relief structure comprised of limestone boulders. The reef will be designed and constructed to mimic the existing inshore reefs at similar water depth and height. Any corals of opportunity identified during post construction surveys may be relocated to the artificial reef if appropriate.

After the completion of mitigation activities, a Coral Mitigation Completion Report (Time Zero) will be prepared and submitted to the ACOE, NOAA, USFWS, and PRDNER. The Report will include an introduction and descriptive and quantitative summaries of the mitigation activities conducted, as well as maps and photo-documentation.

5.4 SEAGRASS TRANSPLANT PLAN

The AOGP seagrass mitigation plan includes pre-construction transplanting of seagrass that would otherwise be permanently impacted (6- foot impact area) by the pipeline installation. Seagrasses within the pipeline installation route include 3 species; therefore, different transplant methods will be utilized as appropriate. Seagrass within the temporary impact area will not be relocated prior to construction. Because the seagrass will be transplanted to restoration areas of greater size using seagrass plugs and sods the restoration sites will provide sufficient compensatory mitigation to offset the temporary impacts. Post-construction damage assessment surveys will document any incidental damage from construction.

5.4.1 SEAGRASS TRANSPLANTING METHODS

Potential seagrass mitigation sites have been identified within Jobos Bay along the shallow shoals just east of the Aguire Power Plant and an orphaned prop dredging site known as "Cayo Caribe". Additionally, AOGP will coordinate with local agency staff to identify appropriate sites within the project area. Mitigation sites will be outside the influence of construction but will have similar environmental characteristics in order to ensure successful transplanting of seagrass and that success criteria are met. Approximately 0.74 acres of *Thalssia testudinum*, *Syringodium filiforme*,and *Halophila decipiens* were identified during the Benthic Characterization study (Tetra Tech, 2012) to be impacted during pipeline installation. These seagrasses will be used as donor plugs and sods for seagrass restoration sites. If topographic restoration of the prop scar or prop dredge restoration sites is required, it will be performed prior to transplanting seagrass. Seagrass transplanting activities will be conducted prior to construction activities.

Transplanting seagrass is a three-step process that involves harvesting planting units from the impact area, transporting the planting units from the impact area to the mitigation area, and then transplanting the planting units to the mitigation area in the preferred density and layout. Seagrass may be harvested, handled, and transplanted in several ways including: sods, plugs, and bare root plants. Various tools and handling methods are appropriate for each type of transplant depending upon the conditions at the impact area and recipient sites, the time of year, and the equipment and manpower that are readily available.

Due to the variability in coverage and species throughout the impact area, two transplant methods, sods and core methods (plugs), will be employed as appropriate. The preferred method for *Halophila* species is collecting and transplanting sods; while the preferred method for *Thalassia testudinum and Syringodium filiforme* is the core method. This approach will give the field crews the flexibility to harvest seagrasses in a manner that is best suited for the survivorship of each planting unit. Further, with this approach, mitigation area densities can be strategically determined to provide services in a manner consistent with the mitigation goals. A goal of the transplanting efforts will be that seagrass transplanted at the mitigation area will match the existing species composition of the surrounding areas. Details of the proposed transplanting/harvest methods are described below.

5.4.1.1 Shovel Transplant Method

Planting units (sods) measuring 6 square centimeters (cm^2) (0.69 ft^2) of seagrasses will be removed from the donor (impact) area using a 9 x 11-inch (in.) shovel by divers. Subsequent to harvest, the sods are placed into sod trays (2-3 planting units per tray) and either staged under water or placed onto a manufactured Styrofoam float capable of holding eight sod trays. The sod trays minimize washout during transport to the mitigation area and the associated substrate collected with the seagrass, coupled with the support provided by the trays, minimizes the potential for stress during transport attributed to desiccation and/or further physical rhizome damage. Once the float is filled to capacity, the sods are floated to the mitigation area for planting.

At the mitigation area, small areas of sediment are excavated using the shovel. After a depression is dug, seagrass sods are retrieved from the sod trays with the shovel and placed into the depression. Once in place, the shovel is pulled away, leaving the seagrass sod behind. Inspections to match adjacent topography are made either visually with a mask and snorkel or by touch, depending on water depth and visibility. If present, ridges were leveled by hand to prevent the potential loss of material and/or erosion.

5.4.1.2 Coring Transplant Method

Divers will remove plugs (approximately 20 cm [8 in.] in diameter) with as many short-shoots as possible and deep enough to contain the rhizome mat and associated sediment using a coring device. Seagrass plugs will be placed in trays to minimize washout during transport to the restoration site. The divers will maximize the use of their buoyancy control vests to float over the donor (impact) area to minimize the potential impact of walking on the seagrass bed.

Divers will transplant the sods and plugs on approximately 0.3-m (1-ft) intervals and 0.5-m (1.6-ft) intervals depending upon the planned mitigation site seagrass densities. The plugs will be installed at the mitigation area by creating a hole in the existing sediment with the coring device for insertion of the seagrass plug. The sediment removed from the divot will be placed around the seagrass plugs to help secure the plugs.

5.4.2 DOCUMENTATION

Field notes and photographs of transplanting activities will be collected during the efforts. Transect monitoring stations will be established at the mitigation site following transplanting. Transect endpoints will be marked with semi-permanent stakes to allow for positive identification during monitoring events. The semi-permanent stakes will be constructed of approximately 6-10 inches of ½-inch polyvinyl chloride (PVC). GPS coordinates of all monitoring stakes will be collected following installation. After the completion of all field activities, a Seagrass Mitigation Completion Report (Time Zero) will be prepared and submitted to the ACOE, NOAA, USFWS, and PRDNER. The Report will include an introduction and descriptive and quantitative summaries of the mitigation activities conducted, as well as maps and photo-documentation.

6 PROJECT SITE SELECTION

6.1 CORAL MITIGATION SITE SELECTION

Stony corals meeting the relocation criteria (e.g, ESA species) within the work corridor will be either permanently reattached to suitable reef substrate immediately adjacent to the impact site or cached during construction activities for post construction relocation back to the work corridor. Suitable permanent recipient substrate was observed adjacent to and along the length of the work corridor during the ESA mapping and demography survey mapping (Tetra Tech, 2013). This area has sufficient hardbottom habitat areas where corals can be relocated. Live coral colonies are common in the immediate area; and the area in between the existing colonies will be excellent recipient sites for relocation.

The adjacent recipient sites provide identical habitat to the impact site. The area has essentially the same water depth, currents, water quality and light attenuation to ensure success of the reattached stony corals. The reef system extends both east and west of the impact area and the coral relocation can be performed immediately after the colonies are removed from the impact site or can be placed in a cache area nearby for reattachment after installation of the pipeline through the Boca del Infierno is completed.

The coral recipient site adjacent to the impact area is naturally protected to ensure long term success. The site is within a high energy inlet to Jobos Bay between two mangrove cays. The inlet is not frequently utilized for fishing or boating activities because anchoring in the area is difficult. The wave energy through the area deters recreational users. The area is also fairly shallow (approximately 11 feet) so prevents the use of the inlet by deeper draft vessels, minimizing the chance of vessel groundings or anchoring within the mitigation site, avoiding the potential for this type of damage. Additionally, the coral relocation area is located within the JBNERR which is managed by PRDNER and will provide long term protection and management.

Artificial reef site will be located within Jobos Bay and JBNERR near the Boca del Infierno. The proposed limestone reef will be located in an area that will mimic physical characteristics of existing inshore reef structures. Pre-construction surveys will delineate the specific location of the artificial reef. Offshore artificial patch reefs will be deployed within the vicinity of the Offshore Gasport at similar depth contour and physical characteristics of existing patch reefs. These reefs will be randomly placed outside any influence of the operation of the GasPort.

6.2 Seagrass Mitigation Site Selection

AOGP proposes to identify potential mitigation areas for seagrass impacts within the JBNERR. Potential mitigation sites include vessel grounding sites, anchor drags, and propeller scar areas within larger areas of existing seagrass. Other historically impacted sites, such as Cayo Caribe, within existing seagrass beds have also been identified as potential topographic restoration and recipient sites for seagrass transplanted from the construction footprint. . Typically, transplant sites in locations not currently supporting seagrass (naturally) result in low rates of success. To ensure survivorship and subsequent natural recruitment, it is generally necessary, or at least desirable, to relocate seagrasses to an area with similar physicochemical characteristics (i.e., water depth and clarity; sediment biogeochemical processes) as the original location. Transplant material will be transplanted to a mitigation site(s) within an area where seagrasses are known to exist. This approach will result in a greater chance of success and ultimately result in a larger, more continuous seagrass community.

7 PROJECT SITE PROTECTION INSTRUMENT

The mitigation sites will be located within the JBNERR and surrounding areas. The JBNERR was founded in 1981 and is managed by Puerto Rico Department of Natural and Environmental Resources (PRDNER). Established under the Coastal Zone Management Act, the PRDNER ensures that water quality, changes in biological communities and habitat alternation are monitored and in accordance with stewardship strategies. This will support the protection of the mitigation sites from future impacts. Because the restoration activities are to be performed on public property, the traditional site protection instruments (deed restriction, conservation easement, etc.) are not appropriate for this project.

8 PERFORMANCE STANDARDS

8.1 Success Criteria for Coral Mitigation

Success of the coral relocation to the mitigation areas will be based on the following criteria: after 2 years, survival of 75% for corals measuring 10-25 cm and 85% for corals measuring >25 cm. If less than the success criteria, the survival rates will be compared to the survival rates at the reference sites and tested for statistically significant differences and adjusted accordingly. If the percent survival or adjusted percent survival of a coral species is below these levels, additional corals of the same species will be transplanted using corals found detached (corals of opportunity) in natural communities or other approved source.

8.2 SUCCESS CRITERIA FOR SEAGRASS MITIGATION

Measurements of seagrass coverage and persistence have been shown to provide the necessary indicators for success of transplanted seagrass beds (Fonseca et al., 1998). Data collected from a reference sites will be used to determine the appropriate success criteria (target density) for each of the seagrass mitigation sites. To account for overall community-level seagrass flux and for seasonal or storm-related changes, data collected from the mitigation area will be compared to that of the reference site during each monitoring event. Recruitment progress relative to the reference area will be assessed using one-way, GLM ANOVA. Mitigation success will be determined by a non-significant difference in seagrass coverage between the mitigation and reference areas.

9 MONITORING AND REPORTING REQUIREMENTS

Monitoring of coral and seagrass mitigation areas will be coordinated to occur simultaneously to minimize mobilization efforts. Overall post mitigation monitoring efforts are proposed for three years; however if success criteria have been reached for any individual components of the mitigation plan (i.e. individual mitigation areas), the mitigation will be deemed successful and monitoring activities for these individual areas will cease. If mitigation components are not trending toward success, an additional 2 years of annual monitoring will be performed.

9.1 CORALS

Specific coral monitoring activities to be performed at the mitigation and reference areas include:

- Locate reattached and reference corals
- Record coral species
- Measure colony size (maximum length/width/height)
- Estimate % live and % recently dead tissue cover
- Photograph corals and representative conditions at reference site

Coral monitoring is proposed for a period of three years in order to document the survival of transplanted coral colonies into the mitigation area. If after three years, the mitigation areas are not trending toward success, an additional two years of monitoring will be performed. Mitigation success monitoring and reporting will be conducted in accordance with the schedule outlined in Table 9-2. Descriptions of the methods to be applied for each activity are described in their respective sections, below.

9.1.1 CORAL COLONY RELOCATION

Coral colonies marked and documented as described above, will be relocated using a Trimble® differential global positioning system (DGPS). A surface marker will be dropped on each reattachment area tag (pin), allowing divers to easily locate the monitoring area. Once a diver locates the pin, the coral colonies will be located using the direction/bearing from the respective reattachment area pin.

9.1.2 CORAL MONITORING

Two size measurements will be collected from each coral colony; the maximum dimension and the dimension orthogonal to the maximum. For a regularly-shaped ellipsoidal colony this corresponds to maximum length and maximum width (irregular colonies, e.g., crescent or amorphous are difficult to represent with field measurements). Accordingly, sizes of colonies are often represented as their ellipsoidal area in square centimeters. The area will be calculated using the formula for the area of a regular ellipse:

$$A = \pi r_1 r_2$$

A team of divers equipped with data sheets, measuring tapes, and cameras will enter the water to assess each transplanted coral for survival and growth Divers will assess the condition (live or dead) natural cementation (fusion) to the substrate, and growth onto the substrate. Estimates of remaining live tissue and percent mortality will be documented.   Partial mortality will be identified as the percent loss of tissue.

9.2 Seagrass

Specific seagrass monitoring activities to be performed at the mitigation and reference areas include:

- Locate monitoring transect endpoints
- Collect seagrass data at monitoring transects/quadrats fort cover-abundance and planting unit survivorship
- Photographic documentation of representative resources and conditions

Seagrass monitoring is proposed for a period of three years in order to document the survival of transplanted seagrasses and natural recruitment of seagrasses into the mitigation areas. If after three years, the mitigation areas are not trending toward success, an additional two years of monitoring will be performed. Mitigation success monitoring and reporting will be conducted in accordance with the schedule outlined in Table 9-2. Descriptions of the methods to be applied for each activity are described in their respective sections, below.

9.2.1 Seagrass Transect/Quadrat Location

Transects will be established in the mitigation and reference areas during the time-zero monitoring event in order to capture representative conditions on site and ensure adequate spacing between transects. Transect endpoints will be marked with semi-permanent stakes and recorded using a DGPS for future relocation. In situ location of the pre-determined monitoring transects and quadrat points will be performed using a Trimble® differential global positioning system (DGPS) during each subsequent monitoring event.

9.2.2 Seagrass Monitoring

A demarcated fiberglass tape (transect line) will be strung lengthwise across each area to be monitored. Quadrat stations will be determined by placing one-meter square (1-m^2) quadrats at predetermined intervals along each transect line. Each quadrat will be positioned so that the bottom left corner is on the transect meter mark specified for that station. Quadrats will be made of PVC and weighted to maintain negative buoyancy during use.

A team of divers equipped with data sheets, quadrats, and cameras will enter the water to assess each quadrat location. Each quadrat will be surveyed for Braun-Blanquet cover-abundance and planting unit survival. The methods used for each monitoring parameter are presented below.

9.2.2.1 Braun-Blanquet Cover-Abundance

A modified Braun-Blanquet (B-B) method (Braun-Blanquet, 1932; Fourqurean et al., 2001; Kirsch et al., 2005) will be used to determine percent cover and species composition of seagrasses within the mitigation and reference areas. Each quadrat will be visually inspected for seagrass and assigned a cover-abundance scale value (B-B score). B-B scores will be assigned based on cover estimates of the total seagrass projection over the substrate when visually inspected from directly above. The B-B scale provides presence-absence at the lower end of the scale (0-1) and a 25% cover range among the higher scores (2-5), thus having a measurement precision level of 25%. B-B scores will be converted to percent coverage by using the midpoint or average of each score's respective cover range. Percent cover values are then averaged over the total number of quadrats assessed within each area to yield the total percent coverage per area. B-B scores along with their respective abundance category and converted percent cover value are provided below in Table 9-1.

Table 9-1 Braun-Blanquet Cover-Abundance Scale

B-B Score	Abundance value	Percent cover value (converted)
0	Absence	0
0.1	Solitary specimen	0
0.5	Few specimens (negligible cover)	1
1	Numerous specimens (less than 5% cover	2.5
2	5% to 25% cover	15
3	25% to 50% cover	37.5
4	50% to 75% cover	62.5
5	75% to100% cover	87.5

9.2.2.2 Planting Unit Survival

Quadrat planting unit (PU) survival estimates will be conducted simultaneous to B-B percent cover data collection. One-meter square (1-m^2) quadrat subsections will be analyzed for presence/absence of transplanted seagrasses. The total number of subsections counted within each quadrat will represent the percent of PU survival within that quadrat. Planting unit percent survival will be averaged for all quadrats to yield an overall PU percent survival estimate. This parameter will be monitored until PU percent survival is not able to be captured due to the degree of both planting unit expansion and natural recruitment within the mitigation area.

9.2.3 Monitoring and Reporting Schedule

Seagrass and coral transplant monitoring is proposed for a period of three years in order to document the survivorship of the transplanted seagrasses and the natural recruitment of seagrasses into the mitigation area and the survivorship of transplanted corals. Semi-annual inspections will be conducted during the first year following transplanting; annual inspections will be conducted during the summer growing season for the following two years. If, after three years, the seagrass mitigation area is not meeting the success criteria or if the results are inconclusive, annual monitoring will be conducted for an additional two years (Years 4 and 5) to ensure that the project is trending toward success. Mitigation success monitoring and reporting will be conducted in accordance with the schedule outlined in Table 9-2.

Table 9-2. Mitigation Monitoring and Reporting Schedule

Year[1]	Monitoring	Reporting
Within 30 days following transplanting activities	TBD (Time-zero Monitoring Event)	TBD (Time-zero Monitoring Report)
1	August (1st Monitoring Event)	October (1st Monitoring Report)
2	August (2nd Monitoring Event)	October (2nd Monitoring Report)
3	August (3rd Monitoring Event)	October (3rd Monitoring Report)
4	August (4th Monitoring Event)	October (4th Monitoring Report)
5	August (5th Monitoring Event)	October (5th Monitoring Report)

[1] Monitoring in Years 4 and 5 contingent upon meeting success criteria in Years 1-3

10 MAINTENANCE PLAN

Maintenance activities generally include removal of exotic and nuisance vegetation, and identifying needs for additional plantings to enhance success of the mitigation project. Maintenance activities for the mitigation projects proposed for AOGP is not expected to be extensive due to the marine nature of the environment. Any maintenance needs such as removal of marine debris or enhancements to the mitigation to ensure success will be identified and implemented during the scheduled monitoring events.

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APPENDIX E

ICHTHYOPLANKTON ENTRAINMENT AND IMPINGEMENT ASSESSMENT FOR THE AGUIRRE OFFSHORE GASPORT PROJECT ENVIRONMENTAL IMPACT STATEMENT

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APPENDIX E

Ichthyoplankton Entrainment and Impingement Assessment for the Aguirre Offshore GasPort Project Environmental Impact Statement

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1.0 INTRODUCTION

This document presents the ichthyoplankton assessment model, assumptions, and data used by RPS ASA to calculate potential entrainment impacts on fish and invertebrate eggs and larvae associated with seawater intakes during operations of the proposed Aguirre Offshore GasPort Project. Note that entrainment impacts were calculated for the operation phase of the project only, as data on the water use intakes during construction were not provided. The calculations were performed in part by following the National Oceanic and Atmospheric Administration (NOAA)/U.S. Coast Guard (USCG) jointly developed ichthyoplankton methodology, as described in the ichthyoplankton assessment model appended to the Gulf Landing Final Environmental Impact Statement (USCG and MARAD, 2005 and subsequent revisions/clarifications). Not all of the steps described in this guidance were applicable in this case due to lack of extensive seasonal sampling. Because impingement is not a potential impact at the GasPort (e.g., intake velocity <0.5 fps, no screens), only entrainment is evaluated herein. Additionally, the Applicant performed their own entrainment and adult equivalents analysis (Tetra Tech, Inc. 2014b). While some inputs for this study (e.g., water intake volumes) were obtained from the Applicant's study, the majority of the Applicant's analysis was not used due to lack of detailed life history information for the taxa of concern. Detailed life history information is necessary to adequately determine the equivalent losses due to entrainment.

The modeling herein involves estimation of the:

- density of eggs and larvae in the intake water;
- numbers entrained based on density and volume flow in different seasons of the year (during continuous operation of the Floating Storage and Regasification Unit [FSRU] vessel and periodic deliveries from the liquefied natural gas carrier [LNGC] vessels);
- natural mortality the entrained organisms would have otherwise undergone before reaching one year of age (i.e., estimation of age-one equivalents); and
- growth and production foregone for lost individuals.

The ichthyoplankton assessment model is described in the next section. This is followed by assessments for specific species or taxa of concern that serve as indicators of the potential entrainment impacts of the project. The taxa are:

- Lutjanidae (snappers)
- Serranidae (groupers and sea basses)
- Carangidae (jacks)
- Haemulidae (grunts)
- Palinura (spiny lobster)
- Fish eggs (not identified to family)
- All unidentified and other fish larvae
- All other invertebrate larvae

The species/taxa analyzed for the ichthyoplankton entrainment assessment were chosen due to their adequate life history information and their ecological and economic importance. The density information provided by the Applicant, based on their towed ichthyoplankton net sampling as described in Tetra Tech (2012a), is only down to the family level. Therefore, key taxa of concern were chosen for entrainment calculations and specific species within those families were used as proxies for life history inputs to derive age-one equivalents and growth and production foregone for lost individuals. Table 1-1 lists the taxa of concern chosen for the entrainment analysis and their respective species used as representatives for life history inputs.

TABLE 1-1

Representative Taxa of Concern Chosen for Entrainment Calculations at the Project Location

Taxa	Common Name	Proxy Species for Life History Inputs	Rationale for Consideration
Fish Eggs	Fish Eggs	Engraulidae (bay anchovy) and Haemulidae (tomtate grunt)	Both abundant species in sampling events, thus prevalent in the area
Lutjanidae	Snappers	Silk snapper	Target reef fish in the commercial fishery
Serranidae	Groupers and Sea basses	Nassau grouper	Important continental shelf taxa
Carangidae	Jacks	Blue runner	High recreational landings as listed in the Shallow Water Reef Fish Fishery Management Plan (FMP)a
Haemulidae	Grunts	Tomtate grunt	High recreational landings as listed in the Shallow Water Reef Fish FMP
Palinura	Spiny lobsters	Caribbean spiny lobster	Important continental shelf taxa
Unidentified and All Other Fish Larvae	Unidentified and All Other Fish Larvae	Engraulidae (bay anchovy) and Haemulidae (tomtate grunt)	Majority of fish larvae collected during seasonal sampling[b]
All Other Invertebrate Larvae	Decapods, Mollusks and Cephlapods	-	Majority of invertebrate larvae collected during seasonal sampling

Sources:

[a] Caribbean Fishery Management Council (CFMC), 1985

[b] Tetra Tech 2013a, 2013b, 2013c and 2014a

Note that for the entrainment calculations of fish eggs and unidentified and other fish larvae, two proxy species were used for life history inputs in order to derive a range of growth and production foregone for lost individuals. Since the "other invertebrate larvae" is comprised of a wide range of taxa, no one proxy species could be chosen for life history inputs; thus, only raw entrainment numbers were calculated for this group.

2.0 INTAKE VOLUMES AND ASSUMPTIONS

The GasPort would accommodate two separate vessels; one for deliveries of LNG and another for LNG storage and regasification. The FSRU would be continuously moored at the GasPort, while the LNGC vessels would remain at the GasPort only while offloading product. A National Pollutant Discharge Elimination System (NPDES) permit for the FSRU would be the responsibility of the GasPort operator and the LNGCs would be privately owned and operated under permit of individual owners. Table 2-1 shows the frequency of operations for both vessels based on the expected number of deliveries per year at the proposed GasPort. The entrainment estimates were calculated based on the estimated volume of seawater that would be used by each vessel type while at the GasPort, therefore a total of four scenarios were evaluated as shown in Table 2-1.

TABLE 2-1

Operating Scenarios Evaluated for Plankton Entrainment Calculations at the Project Location for the LNGCs and FSRU

GasPort Operating Scenarios	Frequency
FSRU	Continuous Operation over all seasons (365 days each year of operation)
LNGC Vessel – 12 Deliveries per Year	3 LNG deliveries each season @ 88 hours each delivery (44 days each year of operation)
LNGC Vessel – 24 Deliveries per Year	6 LNG deliveries each season @ 88 hours each delivery (88 days each year of operation)
LNGC Vessel – 50 Deliveries per Year	12.5 LNG deliveries each season @ 88 hours each delivery (183 days each year of operation)

The normal water use requirements of the FSRU vessel would be approximately 55.96 million gallons per day (MGD) of seawater intake, operated continuously and year-round, at a rate of approximately 0.45 feet per second (fps) (Table 2-2). The water use of LNGC vessels is variable, depending on the actual vessel used for delivery (unknown at this time). However, the maximum intake volume for vessels of this class is estimated to be 81.6 MGD during offloading operations that include 88 hours of moorage at the berthing location. For the purposes of this study, the maximum intake volumes used to estimate entrainment for the FSRU and LNGC vessels are 55.96 MGD and 81.6 MGD, respectively. Entrainment impacts associated with the LNGC vessels would be associated with permits of the operators of the LNGCs.

TABLE 2-2

Summary of Standard Vessel Water Use Intakes and Discharges at the Project Location

GasPort Vessels	Water Use	Seawater Intake (MGD)
FSRU	Main condenser cooling system	47.0
	Auxiliary seawater cooling system	6.0
	Safety water curtain	0.6
	Ballast water	1.9
	Freshwater generator	0.3
	Marine growth preventative system	0.16
	Total	**55.96**
LNGCs	Main condenser cooling system	Variable; depending on actual vessel used
	Auxiliary seawater cooling system	
	Safety water curtain	
	Ballast water	
	Freshwater generator	
	Total (maximum while berthed)	**81.6**

3.0 MODEL DESCRIPTION

The NOAA/USCG jointly developed methodology for evaluating impacts of ichthyoplankton at deepwater ports was used to evaluate potential entrainment losses from the proposed project. It is assumed that all pelagic eggs and larvae in the intake water would be entrained and suffer mortality. Potential entrainment losses to eggs and larvae for a species or group due to GasPort operational intakes (FSRU continuous operation and LNGC deliveries at 12, 24, and 50 deliveries per year) were estimated by multiplying the total volume of water use by the estimated number of eggs and larvae per unit volume in the area of the GasPort. The number of eggs and larvae per unit volume was based on the Applicant's ichthyoplankton net seasonal sampling events (Tetra Tech 2013a, 2013b, 2013c and 2014a). Eggs were not identified to family or species in the Applicant's samples. These egg and larval densities represent the vertical mean for the water column, as the sampling was performed by oblique tows.

The numbers of age-one equivalents lost due to entrainment were calculated by multiplying by the survival rate from the entrained stage to one-year of age. For eggs, survival to age one (S_{e1}) is calculated as:

$$S_{e1} = 2\, S_e\, e^{-\ln(1+Se)}\, S_L\, S_j$$

where S_e, S_L, and S_j are the survival rates for each stage: egg, larvae, and juvenile. For larvae, survival to age one (S_{L1}) is calculated as:

$$S_{L1} = 2\, S_L\, e^{-\ln(1+SL)}\, S_j$$

For some taxa, the juvenile stage is broken into two or three stages.

To evaluate population level effects, the NOAA/USCG jointly developed ichthyoplankton entrainment methodology was used. This approach was recommended by NOAA Fisheries scientists advising the USCG, as described in USCG and MARAD (2005) and subsequent revisions/clarifications. The equations are based on fisheries models typically used for entrainment and impingement fisheries impact evaluations, which are described in Ricker (1975), Electric Power Research Institute (EPRI, 2004) and other sources.

The expected commercial and recreational harvest from the age-one equivalents (N_1) was estimated using natural and fishing mortality rates for annual age classes to estimate numbers that would remain alive by each age class. The number remaining alive at age t (years), N_t, is:

$$N_t = N_1\, e^{(-Z_a\,(t-1))}$$

$$Z_a = M_a + F_a$$

where Z_a is annual instantaneous total mortality, M_a is annual instantaneous natural mortality, and F_a is annual instantaneous fishing mortality, for age class a. The annual survival rate for age t (S_t) is thus:

$$S_t = e^{(-Z_t)}$$

The fraction dying in a year is $1\text{-}S_t$.

Yield foregone (Y_k) (i.e., equivalent yield) as a result of water withdrawal was calculated using the Thompson-Bell equilibrium yield model (according to guidance from NOAA/USCG) where the harvest at each age class is calculated from number starting in the class multiplied by fishing mortality rate, $(F_a/Z_a)(1-e^{-Za})$:

$$Y_k = \sum_j \sum_a L_{jk}\, S_{ja}\, W_a\, (F_a/Z_a)(1-e^{-Za})$$

Y_k = foregone yield (kg) in year k

L_{jk} = losses of individual fish of stage j in the year k
S_{ja} = cumulative survival fraction from stage j to age a
W_a = average weight (kg) of fish at age a
F_a = instantaneous annual fishing mortality rate for fish of age a
Z_a = instantaneous annual total mortality rate for fish of age a

Total natural mortality (TM_k) is calculated using an analogous model:

$$TM_k = \sum_j \sum_a L_{jk} S_{ja} W_a (M_a/Z_a)(1-e^{-Za})$$

M_a = instantaneous annual natural mortality rate for fish of age a

For this analysis, the losses are for eggs and larvae translated to 1 year of age (i.e., one stage where j=1).

Length and weight at age were estimated using the von Bertalanffy equation and a power curve of weight versus length). The equations used are as follows. For length (mm) at age t (years):

$$L_t = L_\infty [1 - e^{(-K(t - t_0))}]$$

where L_t is length (mm) at age t (years), L_∞ is the asymptotic maximum length (mm), K is the Brody growth coefficient, and t_0 is a constant. Weight as a function of length (mm) is:

$$W_t = \alpha L_t^{\beta}$$

where W_t is wet weight (g) at age t years and α and β are constants.

Production foregone (Y_k, USEPA, 2004, Chapter A-5; based on Rago, 1984 and Jensen et al., 1988), which includes yield (harvest) and the production consumed in the food web, was also estimated, using:

$$Y_k = \sum_j \sum_a [G_a L_{jk} W_a (e^{Ga-Za-1})]/[G_a - Z_a]$$

where:

G_a is the instantaneous growth rate for individuals of age a
L_{jk} = losses of individual fish of stage j in the year k
W_a = average weight (kg) of fish at age a
Z_a = instantaneous annual total mortality rate for fish of age a

Life history parameters were compiled from available literature and are summarized by taxa in Section 5 below.

Discounting at 3% per year (NOAA, 1997) is included to translate losses of the age 1+ age classes in future years (interim loss) backwards to present-day values. The discounting multiplier for translating value n years over the life of the project is calculated as:

$$(1+d)^{-n} = 1/(1+d)^n,$$

where d = 0.03.

Thus, the losses in future years have a discounted value at the time of the initial intake. In this analysis, all discounting is calculated based on the number of years over the life of the project, which is assumed to be 40 years for the GasPort project.

4.0 ICHTHYOPLANKTON AND INVERTEBRATE ZOOPLANKTON DENSITY

Towed ichthyoplankton net sampling was conducted offshore of Boca del Infierno, near Guayama, about 1 mile outside of the Jobos Bay National Estuarine Research Reserve (JBNERR) along the southern shore of the Commonwealth of Puerto Rico in Commonwealth waters over four seasonal events between May 2012 and November 2013. During each season (May 2012, March 2013, August 2013 and November 2013), four transects were sampled during a single daytime event and a single nighttime event. The locations of these transects are shown in Figure 4-1 with the transition from the old to revised transects occurring during the March 2013 sampling event.

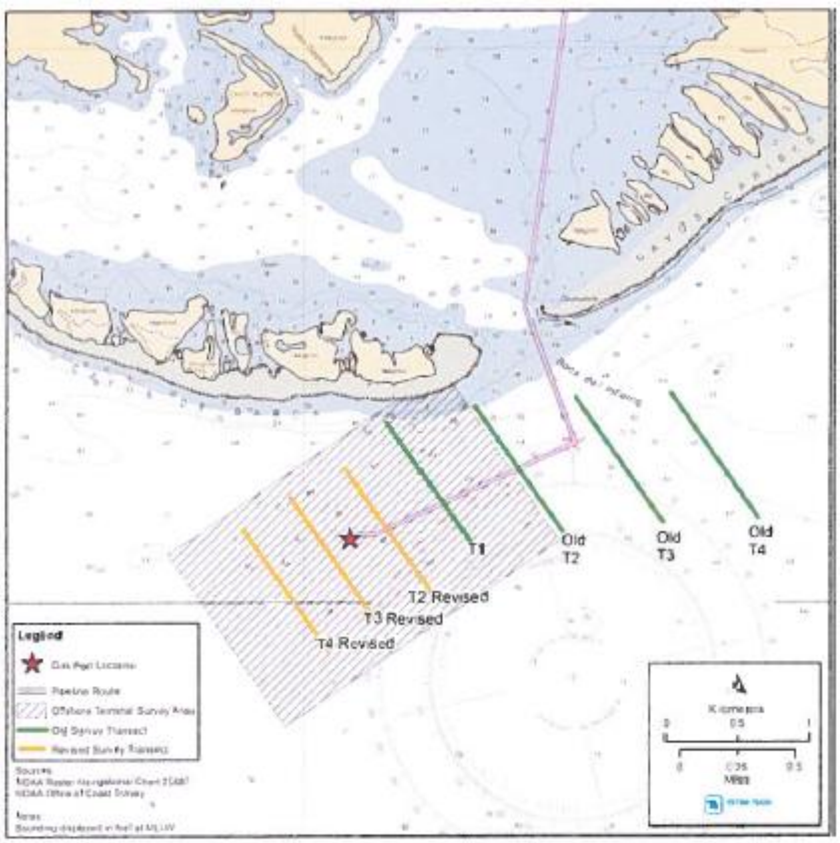

Figure 4-1. Offshore Ichthyoplankton Sampling Transects within the Project Area. Habitat and substrate types are described in Tetra Tech (2012a,b).

Ichthyoplankton were sampled from all depths across the four transects using a 0.75 m-diameter bongo net with 300-micron mesh towed from a 42 foot survey vessel. The bongo net consisted of dual 0.75 m diameter plankton nets. A collection efficiency of greater than 90 percent is typically desired and was calculated prior to the sampling event by towing the bongo net along a transect with both flowmeters and only one of the plankton nets attached, providing a ratio of the total flow measured both inside and outside of the net while under tow. This efficiency value was calculated for each sample event by dividing the total flow measured by the inside flowmeter by the total flow measured by the outside flowmeter in the frame without the cod end net. Equations for these calculations are provided in Tetra Tech, Inc. (2013b). All ichthyoplankton samples were collected at tow-speeds between 2 and 3 knots. At this speed, the duration of the 100 m^3 (minimum) target sample volume was estimated to be approximately 10 minutes. Tows were extended an additional 2 minutes to ensure the minimum sample volume was exceeded.

The collected fish and shellfish eggs and larvae were then hand-picked and sorted from each net sample. Most of the pre- and post-flexion fish larvae were identified to the family level. Shellfish larvae were identified down to class, order, or suborder, as appropriate. The total number of ichthyoplankton in each sample of a known filtered volume was used to calculate volume-based ichthyoplankton densities (number of eggs or larvae per 100 m^3 of water).

The densities of the representative taxa of concern chosen for entrainment calculations (Table 1-1) from each of the four seasonal sampling events are provided in Table 4-1.

TABLE 4-1

Densities (# of individuals) of Representative Taxa of Concern Chosen for Entrainment Calculations in the Project Area

Taxa	Mean Winter Density (#/100 m3)	Mean Winter Density (#/MG)	Mean Spring Density (#/100 m3)	Mean Spring Density (#/MG)	Mean Summer Density (#/100 m3)	Mean Summer Density (#/MG)	Mean Fall Density (#/100 m3)	Mean Fall Density (#/MG)
Total fish eggs	169	6,413	401	15,173	1,475	55,845	96	3,651
Lutjanidae	1	47	2	65	1	49	0	-
Serranidae	0.4	16	0.2	6	0	-	0.4	15
Carangidae	0	-	1	31	0.1	6	0	
Haemulidae	4	167	5	191	1	49	2	68
Palinura	3	110	0.2	9	1	45	1	36
Unidentified and other fish larvae	45	1,708	80	3,040	155	5,872	27	1,006
Other invertebrate larvae	1,151	43,573	1,481	56,068	1,629	61,661	1,847	69,907

MG = million gallons (one gallon = 0.0037854118 m^3)

5.0 MODEL INPUTS AND RESULTS FOR TAXA OF CONCERN

Data limitations exist with the density data provided by the Applicant, the primary of which is that the sampling only occurred over the course of four days, one day to represent each season. More sampling is typically needed to obtain an accurate depiction of the density of eggs and fish and invertebrate larvae in the area of the Project. These data limitations are compounded by the fact that ichthyoplankton abundance and distribution are highly variable and patchy. This patchiness derives from the natural variability of environmental influences such as water temperature, hydrographic features, spawning events and migration patterns. Additionally, the natural mortality of fish is also highly variable and depends on factors such as predation, starvation, weather, and location. Natural mortality varies among species and is greatest during early life-history stages (USEPA, 2002). Natural mortality can be as high as 96 percent for larvae and 99 percent for eggs (Houde, 1987; Lasker, 1987), and only a small percentage of newly hatched eggs or larvae typically survive to adulthood (Comyns et al., 2003).

The following subsections provide the life history information and entrainment results for each of the representative taxa of concern listed in Table 1-1.

5.1 LUTJANIDAE

Life history data were developed for silk snapper (*Lutjanus vivanus*), a prevalent species in the Project area, as a proxy species for the Lutjanidae larvae collected during sampling. These data are listed and described in Tables 5.1-1 to 5.1-6. Table 5.1-5 lists the implied number of individuals at each stage that would result in one age 1 individual, based on the assumed survival rates. Note that no Lutjanidae larvae were collected during the fall sampling event (Tetra Tech, Inc. 2014a).

Potential entrainment and impingement losses of snappers due to the intakes for the operating scenarios outlined in Table 2-1 (e.g., FSRU continuous operation and LNGC deliveries at 12, 24 and 50 per year) were estimated using the larval density data in Table 4-1. The losses were expressed as numbers of individuals entrained, equivalent numbers at age 1, and losses (kg) of age 1+ age classes per year and over the course of the project life (assumed to be 40 years) (Tables 5.1-7 to 5.1-14).

TABLE 5.1-1

Life History Parameters of Silk Snapper (*Lutjanus vivanus*)

Parameter	Value	References
Common name	Silk snapper	-
Latin name	*Lutjanus vivanus*	-
Length vs age (Von Bertalanffy equation parameters):		
L_∞ (mm)	757.0	Valle et al., 1997
K	0.1	Valle et al., 1997
t_0 (yr)	-2.08	Valle et al., 1997
Weight (g, wet) vs. Length (mm)		
α	2.07E-05	Frota, 2004
β	2.966	Frota, 2004

TABLE 5.1-2

Duration (in Days) of Life Stages of Silk Snapper (*Lutjanus vivanus*)

Stage	Stage Duration (days)	References
Egg	1	Rabalais et al., 1980
Larva	30	Assumed, typical
Juvenile 1	167	Calculated (remainder of first year)
Juvenile 2	167	Calculated (remainder of first year)

TABLE 5.1-3

Instantaneous Daily Mortality of Silk Snapper (*Lutjanus vivanus)*

Stage	Instantaneous Daily Mortality	References
Egg	0.2197	McGurk (1986) regression for fish eggs and larvae
Larva	0.08	McGurk (1986) regression for fish eggs and larvae
Juvenile 1	0.013	Peterson and Wroblewski (1984) regression
Juvenile 2	0.0037	Peterson and Wroblewski (1984) regression

TABLE 5.1-4

Instantaneous Mortality (*M* = natural, *F* = fishing), for Life Stage or Annually (Age 1+), of Silk Snapper (*Lutjanus vivanus)*

Stage	M	F	References
Egg	0.22	0.00	Calculated
Larva	2.40	0.00	Calculated
Juvenile 1	2.14	0.00	Calculated
Juvenile 2	0.62	0.00	Calculated
Age 1	0.00	0.00	Silvester et al., 1980; Pozo and Espinosa, 1982; Bryan et al., 2011; Tabash-Blanco et al., 1977
Age 2	0.40	0.30	Silvester et al., 1980; Pozo and Espinosa, 1982; Bryan et al., 2011; Tabash-Blanco et al., 1977
Age 3	0.40	0.30	Silvester et al., 1980; Pozo and Espinosa, 1982; Bryan et al., 2011; Tabash-Blanco et al., 1977
Age 4	0.40	0.30	Silvester et al., 1980; Pozo and Espinosa, 1982; Bryan et al., 2011; Tabash-Blanco et al., 1977
Age 5	0.40	0.30	Silvester et al., 1980; Pozo and Espinosa, 1982; Bryan et al., 2011; Tabash-Blanco et al., 1977
Age 6	0.40	0.30	Silvester et al., 1980; Pozo and Espinosa, 1982; Bryan et al., 2011; Tabash-Blanco et al., 1977
Age 7	0.40	0.30	Silvester et al., 1980; Pozo and Espinosa, 1982; Bryan et al., 2011; Tabash-Blanco et al., 1977
Age 8	0.40	0.30	Silvester et al., 1980; Pozo and Espinosa, 1982; Bryan et al., 2011; Tabash-Blanco et al., 1977
Age 9	0.40	0.30	Silvester et al., 1980; Pozo and Espinosa, 1982; Bryan et al., 2011; Tabash-Blanco et al., 1977
Age 10+	0.10	0.08	Silvester et al., 1980; Pozo and Espinosa, 1982; Bryan et al., 2011; Tabash-Blanco et al., 1977

TABLE 5.1-5

Number of Individuals at Each Stage that Would Result in One Age-1 Equivalent for Silk Snapper (*Lutjanus vivanus)*

Stage	Number of Individuals
Egg	196
Larva	95
Juvenile 1	9
Juvenile 2	1.4

TABLE 5.1-6

Additional Life History Inputs for Silk Snapper (*Lutjanus vivanus)* Entrainment Calculations

Parameter	Value
Survival to Age 1	3.88E-02
Production Foregone (g) per Individual Larva	1.63E-07

TABLE 5.1-7

Annual Population Impacts on Lutjanidae Larvae Under FSRU Continuous Operation

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	238,879	332,956	251,173	-
Number of Age-1 Equivalents Entrained per Year	0.039	0.054	0.041	-
Losses (kg) of Age 1+ Age Classes per Year	0.04	0.05	0.04	-

TABLE 5.1-8

Population Impacts Over 40 year Project Life on Lutjanidae Larvae Under FSRU Continuous Operation

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	9,555,150	13,318,258	10,046,937	-
Number of Age-1 Equivalents Entrained over 40 years	1.56	2.17	1.64	-
Losses (kg) of Age 1+ Age Classes over 40 years	1.48	2.06	1.56	-

TABLE 5.1-9

Annual Population Impacts on Lutjanidae Larvae Under 12 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	42,574	58,688	43,792	-
Number of Age-1 Equivalents Entrained per Year	0.007	0.010	0.007	-
Losses (kg) of Age 1+ Age Classes per Year	0.01	0.01	0.01	-

TABLE 5.1-10

Population Impacts Over 40 year Project Life on Lutjanidae Larvae Under 12 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	1,702,943	2,347,530	1,751,665	-
Number of Age-1 Equivalents Entrained over 40 years	0.28	0.38	0.29	-
Losses (kg) of Age 1+ Age Classes over 40 years	0.26	0.36	0.27	-

TABLE 5.1-11

Annual Population Impacts on Lutjanidae Larvae Under 24 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	85,147	117,377	87,583	-
Number of Age-1 Equivalents Entrained per Year	0.014	0.019	0.014	-
Losses (kg) of Age 1+ Age Classes per Year	0.01	0.02	0.01	-

TABLE 5.1-12

Population Impacts Over 40 year Project Life on Lutjanidae Larvae Under 24 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	3,405,886	4,695,060	3,503,330	-
Number of Age-1 Equivalents Entrained over 40 years	0.56	0.77	0.57	-
Losses (kg) of Age 1+ Age Classes over 40 years	0.53	0.73	0.54	-

TABLE 5.1-13

Annual Population Impacts on Lutjanidae Larvae Under 50 LNGC Annual Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	177,390	244,534	182,465	-
Number of Age-1 Equivalents Entrained per Year	0.029	0.040	0.030	-
Losses (kg) of Age 1+ Age Classes per Year	0.03	0.04	0.03	-

TABLE 5.1-14

Population Impacts Over 40 year Project Life on Lutjanidae Larvae Under 50 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	7,095,596	9,781,375	7,298,603	-
Number of Age-1 Equivalents Entrained over 40 years	1.157	1.594	1.190	-
Losses (kg) of Age 1+ Age Classes over 40 years	1.10	1.52	1.13	-

5.2 SERRANIDAE

Life history data were developed for Nassau grouper (*Epinephelus straitus*), a prevalent species in the Project area, as a proxy species for the Serranidae larvae collected during sampling. These data are listed and described in Tables 5.2-1 to 5.2-6. Table 5.2-5 lists the implied number of individuals at each stage that would result in one age 1 individual, based on the assumed survival rates. Note that no Serranidae larvae were collected during the summer sampling event (Tetra Tech, Inc. 2013c).

Potential entrainment and impingement losses of groupers due to the intakes for the operating scenarios outlined in Table 2-1 (e.g., FSRU continuous operation and LNGC deliveries at 12, 24 and 50 per year) were estimated using the larval density data in Table 4-1. The losses were expressed as numbers of individuals entrained, equivalent numbers at age 1, and losses (kg) of age 1+ age classes per year and over the course of the project life (assumed to be 40 years) (Tables 5.2-7 to 5.2-14).

TABLE 5.2-1

Life History Parameters of Nassau Grouper (*Epinephelus straitus*)

Parameter	Value	References
Common name	Nassau grouper	-
Latin name	*Epinephelus straitus*	-
Length vs age (Von Bertalanffy equation parameters):		
L_∞ (mm)	928.0	Valle et al. 1997
K	0.1	Valle et al. 1997
t_0 (yr)	0	Valle et al. 1997
Weight (g, wet) vs. Length (mm)		
α	5.67E-06	Olsen and LaPlace 1979
β	3.233	Olsen and LaPlace 1979

TABLE 5.2-2

Duration (in Days) of Life Stages of Nassau Grouper (*Epinephelus straitus*)

Stage	Stage Duration (days)	References
Egg	1	Rabalais et al., 1980
Larva	30	Assumed, typical
Juvenile 1	167	Calculated (remainder of first year)
Juvenile 2	167	Calculated (remainder of first year)

TABLE 5.2-3

Instantaneous Daily Mortality of Nassau Grouper (*Epinephelus straitus*)

Stage	Instantaneous Daily Mortality	References
Egg	0.2197	McGurk (1986) regression for fish eggs and larvae
Larva	0.08	McGurk (1986) regression for fish eggs and larvae
Juvenile 1	0.016	Peterson and Wroblewski (1984) regression
Juvenile 2	0.0062	Peterson and Wroblewski (1984) regression

TABLE 5.2-4

Instantaneous Mortality (*M* = natural, *F* = fishing), for Life Stage or Annually (Age 1+), of Nassau Grouper (*Epinephelus straitus*)

Stage	M	F	References
Egg	0.22	0.00	Calculated
Larva	2.40	0.00	Calculated
Juvenile 1	2.63	0.00	Calculated
Juvenile 2	1.03	0.00	Calculated
Age 1	0.18	0.37	Sadovy and Eklund, 1999
Age 2	0.18	0.37	Sadovy and Eklund, 1999
Age 3	0.18	0.37	Sadovy and Eklund, 1999
Age 4	0.18	0.37	Sadovy and Eklund, 1999
Age 5	0.18	0.37	Sadovy and Eklund, 1999
Age 6	0.18	0.37	Sadovy and Eklund, 1999
Age 7	0.18	0.37	Sadovy and Eklund, 1999
Age 8	0.18	0.37	Sadovy and Eklund, 1999
Age 9	0.18	0.37	Sadovy and Eklund, 1999
Age 10+	0.18	0.37	Sadovy and Eklund, 1999

TABLE 5.2-5

Number of Individuals at Each Stage that Would Result in One Age-1 Equivalent for Nassau Grouper (*Epinephelus straitus*)

Stage	Number of Individuals
Egg	483
Larva	234
Juvenile 1	21
Juvenile 2	1.9

TABLE 5.2-6

Additional Life History Inputs for Nassau Grouper (*Epinephelus straitus*) Entrainment Calculations

Parameter	Value
Survival to Age 1	2.71E-08
Production Foregone (g) per Individual Larva	5.97E-05

TABLE 5.2-7

Annual Population Impacts on Serranidae Larvae Under FSRU Continuous Operation

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	80,497	31,347	-	78,897
Number of Age-1 Equivalents Entrained per Year	0.002	0.001	-	0.002
Losses (kg) of Age 1+ Age Classes per Year	0.005	0.002	-	0.005

TABLE 5.2-8

Population Impacts Over 40 year Project Life on Serranidae Larvae Under FSRU Continuous Operation

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	3,219,890	1,257,486	-	3,155,868
Number of Age-1 Equivalents Entrained over 40 years	0.09	0.03	-	0.09
Losses (kg) of Age 1+ Age Classes over 40 years	0.19	0.08	-	0.19

TABLE 5.2-9

Annual Population Impacts on Serranidae Larvae Under 12 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	14,346	5,541	-	13,755
Number of Age-1 Equivalents Entrained per Year	0.0004	0.0002	-	0.0004
Losses (kg) of Age 1+ Age Classes per Year	0.0009	0.0003	-	0.0008

TABLE 5.2-10

Population Impacts Over 40 year Project Life on Serranidae Larvae Under 12 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	573,857	221,649	-	550,220
Number of Age-1 Equivalents Entrained over 40 years	0.02	0.01	-	0.01
Losses (kg) of Age 1+ Age Classes over 40 years	0.03	0.01	-	0.03

TABLE 5.2-11

Annual Population Impacts on Serranidae Larvae Under 24 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	28,693	11,082	-	27,511
Number of Age-1 Equivalents Entrained per Year	0.001	0.0003	-	0.001
Losses (kg) of Age 1+ Age Classes per Year	0.002	0.001	-	0.002

TABLE 5.2-12

Population Impacts Over 40 year Project Life on Serranidae Larvae Under 24 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	1,147,714	443,299	-	1,100,440
Number of Age-1 Equivalents Entrained over 40 years	0.03	0.01	-	0.03
Losses (kg) of Age 1+ Age Classes over 40 years	0.07	0.03	-	0.07

TABLE 5.2-13 **Annual Population Impacts on Serranidae Larvae Under 50 Annual LNGC Deliveries**				
Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	59,777	23,088	-	57,315
Number of Age-1 Equivalents Entrained per Year	0.002	0.001	-	0.002
Losses (kg) of Age 1+ Age Classes per Year	0.004	0.001	-	0.003

TABLE 5.2-14 **Population Impacts Over 40 year Project Life on Serranidae Larvae Under 50 Annual LNGC Deliveries**				
Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	2,391,071	923,540	-	2,292,582
Number of Age-1 Equivalents Entrained over 40 years	0.065	0.025	-	0.062
Losses (kg) of Age 1+ Age Classes over 40 years	0.14	0.06	-	0.14

5.3 CARANGIDAE

Life history data were developed for blue runner (*Caranx crysos*), a prevalent species in the Project area, as a proxy species for the Carangidae larvae collected during sampling. These data are listed and described in Tables 5.3-1 to 5.3-6. Table 5.3-5 lists the implied number of individuals at each stage that would result in one age 1 individual, based on the assumed survival rates. Note that no Carangidae larvae were collected during the winter or fall sampling events (Tetra Tech, Inc. 2013b; 2014a).

Potential entrainment and impingement losses of jacks due to the intakes for the operating scenarios outlined in Table 2-1 (e.g., FSRU continuous operation and LNGC deliveries at 12, 24 and 50 per year) were estimated using the larval density data in Table 4-1. The losses were expressed as numbers of individuals entrained, equivalent numbers at age 1, and losses (kg) of age 1+ age classes per year and over the course of the project life (assumed to be 40 years) (Tables 5.3-7 to 5.3-14).

TABLE 5.3-1 **Life History Parameters of Blue Runner (*Caranx crysos*)**		
Parameter	Value	References
Common name	Blue runner	-
Latin name	*Caranx crysos*	-
Length vs age (Von Bertalanffy equation parameters):		
L_∞ (mm)	412	Goodwin and Johnson, 1986
K	0.35	Goodwin and Johnson, 1986
t_0 (yr)	-1.17	Goodwin and Johnson, 1986
Weight (g, wet) vs. Length (mm)		
α	4.21E-05	Frota et al., 2004
β	2.861	Frota et al., 2004

TABLE 5.3-2 **Duration (in Days) of Life Stages of Blue Runner (*Caranx crysos*)**		
Stage	Stage Duration (days)	References
Egg	1	Rabalais et al., 1980
Larva	30	Assumed, typical
Juvenile 1	167	Calculated (remainder of first year)
Juvenile 2	167	Calculated (remainder of first year)

TABLE 5.3-3

Instantaneous Daily Mortality of Blue runner (*Caranx crysos*)

Stage	Instantaneous Daily Mortality	References
Egg	0.2197	McGurk (1986) regression for fish eggs and larvae
Larva	0.08	McGurk (1986) regression for fish eggs and larvae
Juvenile 1	0.012	Peterson and Wroblewski (1984) regression
Juvenile 2	0.0034	Peterson and Wroblewski (1984) regression

TABLE 5.3-4

Instantaneous Mortality (*M* = natural, *F* = fishing), for Life Stage or Annually (Age 1+), of Blue Runner (*Caranx crysos*)

Stage	M	F	References
Egg	0.22	0.00	(calculated)
Larva	2.40	0.00	(calculated)
Juvenile 1	2.07	0.00	(calculated)
Juvenile 2	0.57	0.00	(calculated)
Age 1	0.47	0.16	Frota et al. 2004; Goodwin and Johnson 1986
Age 2	0.47	0.16	Frota et al. 2004; Goodwin and Johnson 1986
Age 3	0.47	0.16	Frota et al., 2004; Goodwin and Johnson, 1986
Age 4	0.47	0.16	Frota et al., 2004; Goodwin and Johnson, 1986
Age 5	0.47	0.16	Frota et al., 2004; Goodwin and Johnson, 1986
Age 6	0.47	0.16	Frota et al., 2004; Goodwin and Johnson, 1986
Age 7	0.47	0.16	Frota et al., 2004; Goodwin and Johnson, 1986
Age 8	0.47	0.16	Frota et al., 2004; Goodwin and Johnson, 1986
Age 9	0.47	0.16	Frota et al., 2004; Goodwin and Johnson, 1986
Age 10+	0.47	0.16	Frota et al., 2004; Goodwin and Johnson, 1986

TABLE 5.3-5

Number of Individuals at Each Stage that Would Result in One Age-1 Equivalent for Blue Runner (*Caranx crysos*)

Stage	Number of Individuals
Egg	174
Larva	85
Juvenile 1	8
Juvenile 2	1.4

TABLE 5.3-6

Additional Life History Inputs for Blue Runner (*Caranx crysos*) Entrainment Calculations

Parameter	Value
Survival to Age 1	2.10E-07
Production Foregone (g) per Individual Larva	1.96E-04

TABLE 5.3-7

Annual Population Impacts on Carangidae Larvae Under FSRU Continuous Operation

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	-	155,721	28,338	-
Number of Age-1 Equivalents Entrained per Year	-	0.033	0.006	-
Losses (kg) of Age 1+ Age Classes per Year	-	0.03	0.01	-

TABLE 5.3-8

Population Impacts Over 40 year Project Life on Carangidae Larvae Under FSRU Continuous Operation

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	-	6,228,833	1,133,514	-
Number of Age-1 Equivalents Entrained over 40 years	-	1.31	0.24	-
Losses (kg) of Age 1+ Age Classes over 40 years	-	1.22	0.22	-

TABLE 5.3-9

Annual Population Impacts on Carangidae Larvae Under 12 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	-	27,448	4,941	-
Number of Age-1 Equivalents Entrained per Year	-	0.006	0.001	-
Losses (kg) of Age 1+ Age Classes per Year	-	0.005	0.001	-

TABLE 5.3-10

Population Impacts Over 40 year Project Life on Carangidae Larvae Under 12 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	-	1,097,919	197,626	-
Number of Age-1 Equivalents Entrained over 40 years	-	0.23	0.04	-
Losses (kg) of Age 1+ Age Classes over 40 years	-	0.22	0.04	-

TABLE 5.3-11

Annual Population Impacts on Carangidae Larvae Under 24 Annual LNGC Annual Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	-	54,896	9,881	-
Number of Age-1 Equivalents Entrained per Year	-	0.012	0.002	-
Losses (kg) of Age 1+ Age Classes per Year	-	0.011	0.002	-

TABLE 5.3-12

Population Impacts Over 40 year Project Life on Carangidae Larvae Under 24 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	-	2,195,839	395,252	-
Number of Age-1 Equivalents Entrained over 40 years	-	0.46	0.08	-
Losses (kg) of Age 1+ Age Classes over 40 years	-	0.43	0.08	-

TABLE 5.3-13

Annual Population Impacts on Carangidae Larvae Under 50 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	-	114,367	20,586	-
Number of Age-1 Equivalents Entrained per Year	-	0.024	0.004	-
Losses (kg) of Age 1+ Age Classes per Year	-	0.022	0.004	-

TABLE 5.3-14 **Population Impacts Over 40 year Project Life on Carangidae Larvae Under 50 Annual LNGC Deliveries**				
Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	-	4,574,664	823,442	-
Number of Age-1 Equivalents Entrained over 40 years	-	0.961	0.173	-
Losses (kg) of Age 1+ Age Classes over 40 years	-	0.90	0.16	-

5.4 HAEMULIDAE

Life history data were developed for tomtate grunt (*Haemulon aurolineatum*), a prevalent species in the Project area, as a proxy species for the Haemulidae larvae collected during sampling. These data are listed and described in Tables 5.4-1 to 5.4-6. Table 5.4-5 lists the implied number of individuals at each stage that would result in one age 1 individual, based on the assumed survival rates.

Potential entrainment and impingement losses of grunts due to the intakes for the operating scenarios outlined in Table 2-1 (e.g., FSRU continuous operation and LNGC deliveries at 12, 24 and 50 per year) were estimated using the larval density data in Table 4-1. The losses were expressed as numbers of individuals entrained, equivalent numbers at age 1, and losses (kg) of age 1+ age classes per year and over the course of the project life (assumed to be 40 years) (Tables 5.4-7 to 5.4-14).

TABLE 5.4-1 **Life History Parameters of Tomtate Grunt (*Haemulon aurolineatum*)**		
Parameter	Value	References
Common name	Tomtate grunt	-
Latin name	*Haemulon aurolineatum*	-
Length vs age (Von Bertalanffy equation parameters):		
L_∞ (mm)	230.0	Munro, 1974
K	0.35	Munro, 1974
t0 (yr)	0	Munro, 1974
Weight (g, wet) vs. Length (mm)		
α	6.19E-06	Bohnsack and Harper, 1988
β	3.208	Bohnsack and Harper, 1988

TABLE 5.4-2 **Duration (in Days) of Life Stages of Tomtate Grunt (*Haemulon aurolineatum*)**		
Stage	Stage Duration (days)	References
Egg	30	Assumed, typical (e.g., red snapper)
Larva	167	Calculated (remainder of first year))
Juvenile 1	167	Calculated (remainder of first year)
Juvenile 2	30	Assumed, typical (e.g., red snapper)

TABLE 5.4-3 **Instantaneous Daily Mortality of Tomtate Grunt (*Haemulon aurolineatum*)**		
Stage	Instantaneous Daily Mortality	References
Egg	0.2197	McGurk (1986) regression for fish eggs and larvae
Larva	0.08	McGurk (1986) regression for fish eggs and larvae
Juvenile 1	0.017	Peterson and Wroblewski (1984) regression
Juvenile 2	0.0074	Peterson and Wroblewski (1984) regression

TABLE 5.4-4

Instantaneous Mortality (*M* = natural, *F* = fishing), for Life Stage or Annually (Age 1+), of Tomtate Grunt (*Haemulon aurolineatum*)

Stage	M	F	References
Egg	0.22	0.00	Calculated
Larva	2.40	0.00	Calculated
Juvenile 1	2.82	0.00	Calculated
Juvenile 2	1.23	0.00	Calculated
Age 1	1.19	0.00	Munro, 1974; Manooch and Barans, 1982
Age 2	1.19	0.00	Munro, 1974; Manooch and Barans, 1982
Age 3	1.19	0.00	Munro, 1974; Manooch and Barans, 1982
Age 4	1.19	0.00	Munro, 1974; Manooch and Barans, 1982
Age 5	1.19	0.00	Munro, 1974; Manooch and Barans, 1982
Age 6	1.19	0.00	Munro, 1974; Manooch and Barans, 1982
Age 7	1.19	0.00	Munro, 1974; Manooch and Barans, 1982
Age 8	1.19	0.00	Munro, 1974; Manooch and Barans, 1982
Age 9	1.19	0.00	Munro, 1974; Manooch and Barans, 1982
Age 10+	1.19	0.00	Munro, 1974; Manooch and Barans, 1982

TABLE 5.4-5

Number of Individuals at Each Stage that Would Result in One Age-1 Equivalent for Tomtate Grunt (*Haemulon aurolineatum*)

Stage	Number of Individuals
Egg	712
Larva	346
Juvenile 1	30
Juvenile 2	2.2

TABLE 5.4-6

Additional Life History Inputs for Tomtate Grunt (*Haemulon aurolineatum*) Entrainment Calculations

Parameter	Value
Survival to Age 1	1.32E-08
Production Foregone (g) per Individual Larva	4.21E-05

TABLE 5.4-7

Annual Population Impacts on Haemulidae Larvae Under FSRU Continuous Operation

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	842,299	971,437	253,764	347,772
Number of Age-1 Equivalents Entrained per Year	0.011	0.013	0.003	0.005
Losses (kg) of Age 1+ Age Classes per Year	0.04	0.04	0.01	0.01

TABLE 5.4-8

Population Impacts Over 40 year Project Life on Haemulidae Larvae Under FSRU Continuous Operation

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	33,691,974	38,857,481	10,150,575	13,910,875
Number of Age-1 Equivalents Entrained over 40 years	0.44	0.51	0.13	0.18
Losses (kg) of Age 1+ Age Classes over 40 years	1.42	1.64	0.43	0.59

TABLE 5.4-9

Annual Population Impacts on Haemulidae Larvae Under 12 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	150,117	171,229	44,243	60,633
Number of Age-1 Equivalents Entrained per Year	0.002	0.002	0.001	0.001
Losses (kg) of Age 1+ Age Classes per Year	0.006	0.007	0.002	0.003

TABLE 5.4-10

Population Impacts Over 40 year Project Life on Haemulidae Larvae Under 12 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	6,004,669	6,849,177	1,769,734	2,425,335
Number of Age-1 Equivalents Entrained over 40 years	0.08	0.09	0.02	0.03
Losses (kg) of Age 1+ Age Classes over 40 years	0.25	0.29	0.07	0.10

TABLE 5.4-11

Annual Population Impacts on Haemulidae Larvae Under 24 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	300,233	342,459	88,487	121,267
Number of Age-1 Equivalents Entrained per Year	0.004	0.005	0.001	0.002
Losses (kg) of Age 1+ Age Classes per Year	0.013	0.014	0.004	0.005

TABLE 5.4-12

Population Impacts Over 40 year Project Life on Haemulidae Larvae Under 24 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	12,009,338	13,698,354	3,539,468	4,850,670
Number of Age-1 Equivalents Entrained over 40 years	0.16	0.18	0.05	0.06
Losses (kg) of Age 1+ Age Classes over 40 years	0.51	0.58	0.15	0.20

TABLE 5.4-13

Annual Population Impacts on Haemulidae Larvae Under 50 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	625,486	713,456	184,347	252,639
Number of Age-1 Equivalents Entrained per Year	0.008	0.009	0.002	0.003
Losses (kg) of Age 1+ Age Classes per Year	0.03	0.03	0.01	0.01

TABLE 5.4-14

Population Impacts Over 40 year Project Life on Haemulidae Larvae Under 50 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	25,019,455	28,538,237	7,373,891	10,105,563
Number of Age-1 Equivalents Entrained over 40 years	0.329	0.376	0.097	0.133
Losses (kg) of Age 1+ Age Classes over 40 years	1.05	1.20	0.31	0.43

5.5 PALINURA

Life history data were developed for Caribbean spiny lobster (*Panulirus argus*) as a proxy species for the Palinura larvae collected during sampling. These data are listed and described in Tables 5.5-1 to 5.5-6. Table 5.5-5 lists the implied number of individuals at each stage that would result in one age 1 individual, based on the assumed survival rates.

Potential entrainment and impingement losses of spiny lobsters due to the intakes for the operating scenarios outlined in Table 2-1 (e.g., FSRU continuous operation and LNGC deliveries at 12, 24 and 50 per year) were estimated using the larval density data in Table 4-1. The losses were expressed as numbers of individuals entrained, equivalent numbers at age 1, and losses (kg) of age 1+ age classes per year and over the course of the project life (assumed to be 40 years) (Tables 5.5-7 to 5.5-14).

TABLE 5.5-1

Life History Parameters of Caribbean Spiny Lobster (*Panulirus argus*)

Parameter	Value	References
Common name	Atlantic spiny lobster	-
Latin name	*Panulirus argus*	-
Length vs age (Von Bertalanffy equation parameters):		
L_∞ (mm)	190.0	Marx and Herrnkind, 1986
K	0.22	Marx and Herrnkind, 1986
t_0 (yr)	0	Marx and Herrnkind, 1986
Weight (g, wet) vs. Length (mm)		
α	4.12E-03	Marx and Herrnkind, 1986
β	2.64	Marx and Herrnkind, 1986

TABLE 5.5-2

Duration (in Days) of Life Stages of Caribbean Spiny Lobster (*Panulirus argus*)

Stage	Stage Duration (days)	References
Egg	1	Rabalais et al., 1980
Larva	5	Assumed age in plankton sample
Juvenile 1	179.5	Calculated (remainder of first year)
Juvenile 2	179.5	Calculated (remainder of first year)

TABLE 5.5-3

Instantaneous Daily Mortality of Caribbean Spiny Lobster (*Panulirus argus*)

Stage	Instantaneous Daily Mortality	References
Egg	1.1599	McGurk 1986 regression for fish eggs and larvae
Larva	0.73	McGurk 1986 regression for fish eggs and larvae
Juvenile 1	0.026	Peterson and Wroblewski (1984) regression
Juvenile 2	0.0058	Peterson and Wroblewski (1984) regression

TABLE 5.5-4

Instantaneous Mortality (*M* = natural, *F* = fishing), for Life Stage or Annually (Age 1+), of Caribbean Spiny Lobster (*Panulirus argus*)

Stage	M	F	References
Egg	1.16	0.00	Calculated
Larva	3.66	0.00	Calculated
Juvenile 1	4.71	0.00	Calculated
Juvenile 2	1.04	0.00	Calculated
Age 1	0.40	0.00	Marx and Herrnkind, 1986
Age 2	0.40	1.80	Marx and Herrnkind, 1986
Age 3	0.40	1.80	Marx and Herrnkind, 1986
Age 4	0.40	1.80	Marx and Herrnkind, 1986
Age 5	0.40	1.80	Marx and Herrnkind, 1986
Age 6	0.40	1.80	Marx and Herrnkind, 1986
Age 7	0.40	1.80	Marx and Herrnkind, 1986
Age 8	0.40	1.80	Marx and Herrnkind, 1986
Age 9	0.40	1.80	Marx and Herrnkind, 1986
Age 10+	0.40	1.80	Marx and Herrnkind, 1986

TABLE 5.5-5

Number of Individuals at Each Stage that Would Result in One Age-1 Equivalent for Caribbean Spiny Lobster (*Panulirus argus*)

Stage	Number of Individuals
Egg	25,621
Larva	6,272
Juvenile 1	159
Juvenile 2	1.9

TABLE 5.5-6

Additional Life History Inputs for Caribbean Spiny Lobster (*Panulirus argus*) Entrainment Calculations

Parameter	Value
Survival to Age 1	3.61E-08
Production Foregone (g) per Individual Larva	2.78E-05

TABLE 5.5-7

Annual Population Impacts on Palinura Larvae Under FSRU Continuous Operation

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	552,055	47,130	232,997	186,543
Number of Age-1 Equivalents Entrained per Year	0.020	0.002	0.008	0.007
Losses (kg) of Age 1+ Age Classes per Year	0.015	0.001	0.006	0.005

TABLE 5.5-8

Population Impacts Over 40 year Project Life on Palinura Larvae Under FSRU Continuous Operation

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	22,082,204	1,885,200	9,319,880	7,461,724
Number of Age-1 Equivalents Entrained over 40 years	0.80	0.07	0.34	0.27
Losses (kg) of Age 1+ Age Classes over 40 years	0.61	0.05	0.26	0.21

TABLE 5.5-9

Annual Population Impacts on Palinura Larvae Under 12 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	98,389	8,307	40,623	32,523
Number of Age-1 Equivalents Entrained per Year	0.0036	0.0003	0.0015	0.0012
Losses (kg) of Age 1+ Age Classes per Year	0.0027	0.0002	0.0011	0.0009

TABLE 5.5-10

Population Impacts Over 40 year Project Life on Palinura Larvae Under 12 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	3,935,547	332,293	1,624,904	1,300,938
Number of Age-1 Equivalents Entrained over 40 years	0.14	0.01	0.06	0.05
Losses (kg) of Age 1+ Age Classes over 40 years	0.11	0.01	0.05	0.04

TABLE 5.5-11

Annual Population Impacts on Palinura Larvae Under 24 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	196,777	16,615	81,245	65,047
Number of Age-1 Equivalents Entrained per Year	0.007	0.001	0.003	0.002
Losses (kg) of Age 1+ Age Classes per Year	0.0055	0.0005	0.0023	0.0018

TABLE 5.5-12

Population Impacts Over 40 year Project Life on Palinura Larvae Under 24 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	7,871,093	664,586	3,249,807	2,601,875
Number of Age-1 Equivalents Entrained over 40 years	0.3	0.0	0.1	0.1
Losses (kg) of Age 1+ Age Classes over 40 years	0.2	0.02	0.1	0.1

TABLE 5.5-13

Annual Population Impacts on Palinura Larvae Under 50 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	409,953	34,614	169,261	135,514
Number of Age-1 Equivalents Entrained per Year	0.015	0.001	0.006	0.005
Losses (kg) of Age 1+ Age Classes per Year	0.011	0.001	0.005	0.004

TABLE 5.5-14

Population Impacts Over 40 year Project Life on Palinura Larvae Under 50 Annual LNGC Deliveries

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	16,398,111	1,384,554	6,770,432	5,420,574
Number of Age-1 Equivalents Entrained over 40 years	0.59	0.05	0.24	0.20
Losses (kg) of Age 1+ Age Classes over 40 years	0.46	0.04	0.19	0.15

5.6 FISH EGGS

To derive age-1 equivalent and production foregone losses for fish eggs, life history data for Haemulidae, with tomtate grunt (*Haemulon aurolineatum)* as the proxy, and Engraulidae, with bay anchovy (*Anchoa mitchilli)* as the proxy, were used to develop of a range of results. The data for bay anchovy are listed and described in Tables 5.6-1 to 5.6-6. Table 5.6-5 lists the implied number of individuals at each stage that would result in one age 1 individual, based on the assumed survival rates. The life history data used for tomtate grunt are provided in Tables 5.4-1 to 5.4-6.

Potential entrainment and impingement losses of fish eggs due to the intakes for the operating scenarios outlined in Table 2-1 (e.g., FSRU continuous operation and LNGC deliveries at 12, 24 and 50 per year) were estimated using the egg density data in Table 4-1. The losses were expressed as numbers of individuals entrained, equivalent numbers at age 1, and losses (kg) of age 1+ age classes per year and over the course of the project life (assumed to be 40 years) (Tables 5.6-7 to 5.6-14 using Engraulidae life history, and 5.6-15 to 5.6-22 using Haemulidae life history). Note that the number of age-1 equivalents entrained, production foregone, and losses of age 1+ age classes in future years were all calculated from the fertilized egg stage. The total raw entrainment numbers are based on the actual number of fish eggs counted from the four seasonal sampling events.

TABLE 5.6-1

Life History Parameters of Bay Anchovy (*Anchoa mitchilli)*

Parameter	Value	References
Common name	Bay anchovy	-
Latin name	*Anchoa mitchilli*	-
Length vs age (Von Bertalanffy equation parameters):		
L_∞ (mm)	107.0	Newberger and Houde, 1995
K	0.36	Newberger and Houde, 1995
t_0 (yr)	-0.81	Newberger and Houde, 1995
Weight (g, wet) vs. Length (mm)		
α	9.51E-06	Dawson, 1965
β	3.18	Dawson, 1965

TABLE 5.6-2

Duration (in Days) of Life Stages of Bay Anchovy (*Anchoa mitchilli)*

Stage	Stage Duration (days)	References
Egg	1	Rabalais et al., 1980
Larva	30	Assumed, typical
Juvenile 1	167	Calculated (remainder of first year)
Juvenile 2	167	Calculated (remainder of first year)

TABLE 5.6-3

Instantaneous Daily Mortality of Bay Anchovy (*Anchoa mitchilli)*

Stage	Instantaneous Daily Mortality	References
Egg	0.2197	McGurk (1986) regression for fish eggs and larvae
Larva	0.08	McGurk (1986) regression for fish eggs and larvae
Juvenile 1	0.018	Peterson and Wroblewski (1984) regression
Juvenile 2	0.0083	Peterson and Wroblewski (1984) regression

TABLE 5.6-4

Instantaneous Mortality (*M* = natural, *F* = fishing), for Life Stage or Annually (Age 1+), of Bay anchovy (*Anchoa mitchilli)*

Stage	M	F	References
Egg	0.22	0	Calculated
Larva	2.40	0	Calculated
Juvenile 1	2.96	0	Calculated
Juvenile 2	1.38	0	Calculated
Age 1	2.30	0	USEPA, 2002
Age 2	2.30	0	USEPA, 2002
Age 3	2.30	0	USEPA, 2002
Age 4	2.30	0	USEPA, 2002
Age 5	2.30	0	USEPA, 2002
Age 6	2.30	0	USEPA, 2002
Age 7	2.30	0	USEPA, 2002
Age 8	2.30	0	USEPA, 2002
Age 9	2.30	0	USEPA, 2002
Age 10+	2.30	0	USEPA, 2002

TABLE 5.6-5

Number of Individuals at Each Stage that Would Result in One Age-1 Equivalent for Bay Anchovy (*Anchoa mitchilli)*

Stage	Number of Individuals
Egg	952
Larva	462
Juvenile 1	40
Juvenile 2	2.5

TABLE 5.6-6

Additional Life History Inputs for Bay Anchovy (*Anchoa mitchilli)* Entrainment Calculations

Parameter	Value
Survival to Age 1	7.79E-09
Production Foregone (g) per Individual Larva	3.88E-05

TABLE 5.6-7

Annual Population Impacts on Fish Eggs Under FSRU Continuous Operation, Assuming Life History of Bay Anchovy (proxy for Engraulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	25,926,039	62,024,952	230,798,420	15,091,059
Number of Age-1 Equivalents Entrained per Year	0.202	0.483	1.798	0.118
Losses (kg) of Age 1+ Age Classes per Year [a]	1.0	2.4	9.0	0.6

[a] Estimates calculated using eggs at time of hatching

TABLE 5.6-8

Population Impacts Over 40 year Project Life on Fish Eggs Under FSRU Continuous Operation, Assuming Life History of Bay Anchovy (proxy for Engraulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	1,037,041,556	2,480,998,082	9,231,936,782	603,642,374
Number of Age-1 Equivalents Entrained over 40 years	8.1	19.3	71.9	4.7
Losses (kg) of Age 1+ Age Classes over 40 years	40.2	96.3	358.3	23.4

TABLE 5.6-9

Annual Population Impacts on Fish Eggs Under 12 Annual LNGC Deliveries, Assuming Life History of Bay Anchovy (proxy for Engraulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	4,620,605	10,932,769	40,239,274	2,631,098
Number of Age-1 Equivalents Entrained per Year	0.04	0.09	0.31	0.02
Losses (kg) of Age 1+ Age Classes per Year [a]	0.2	0.4	1.6	0.1

[a] Estimates calculated using eggs at time of hatching

TABLE 5.6-10

Population Impacts Over 40 year Project Life on Fish Eggs Under 12 Annual LNGC Deliveries, Assuming Life History of Bay Anchovy (proxy for Engraulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	184,824,180	437,310,771	1,609,570,978	105,243,923
Number of Age-1 Equivalents Entrained over 40 years	1.4	3.4	12.5	0.8
Losses (kg) of Age 1+ Age Classes over 40 years	7.2	17.0	62.5	4.1

TABLE 5.6-11

Annual Population Impacts on Fish Eggs Under 24 Annual LNGC Deliveries, Assuming Life History of Bay Anchovy (proxy for Engraulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	9,241,209	21,865,539	80,478,549	5,262,196
Number of Age-1 Equivalents Entrained per Year	0.1	0.2	0.6	0.0
Losses (kg) of Age 1+ Age Classes per Year [a]	0.4	0.8	3.1	0.2

[a] Estimates calculated using eggs at time of hatching

TABLE 5.6-12

Population Impacts Over 40 year Project Life on Fish Eggs Under 24 Annual LNGC Deliveries, Assuming Life History of Bay Anchovy (proxy for Engraulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	369,648,360	874,621,542	3,219,141,955	210,487,846
Number of Age-1 Equivalents Entrained over 40 years	2.9	6.8	25.1	1.6
Losses (kg) of Age 1+ Age Classes over 40 years	14.3	33.9	124.9	8.2

TABLE 5.6-13

Annual Population Impacts on Fish Eggs Under 50 Annual LNGC Deliveries, Assuming Life History of Bay Anchovy (proxy for Engraulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	19,252,519	45,553,205	167,663,644	10,962,909
Number of Age-1 Equivalents Entrained per Year	0.1	0.4	1.3	0.1
Losses (kg) of Age 1+ Age Classes per Year [a]	0.7	1.8	6.5	0.4

[a] Estimates calculated using eggs at time of hatching

TABLE 5.6-14

Population Impacts Over 40 year Project Life on Fish Eggs Under 50 Annual LNGC Deliveries, Assuming Life History of Bay Anchovy (proxy for Engraulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	770,100,751	1,822,128,213	6,706,545,740	438,516,346
Number of Age-1 Equivalents Entrained over 40 years	6.0	14.2	52.2	3.4
Losses (kg) of Age 1+ Age Classes over 40 years	29.9	70.7	260.3	17.0

TABLE 5.6-15

Annual Population Impacts on Fish Eggs Under FSRU Continuous Operation, Assuming Life History of Tomtate Grunt (proxy for Haemulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	25,926,039	62,024,952	230,798,420	15,091,059
Number of Age-1 Equivalents Entrained per Year	0.34	0.82	3.04	0.20
Losses (kg) of Age 1+ Age Classes per Year [a]	1.1	2.6	9.7	0.6

[a] Estimates calculated using eggs at time of hatching

TABLE 5.6-16

Population Impacts Over 40 year Project Life on Fish Eggs Under FSRU Continuous Operation, Assuming Life History of Tomtate Grunt (proxy for Haemulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	1,037,041,556	2,480,998,082	9,231,936,782	603,642,374
Number of Age-1 Equivalents Entrained over 40 years	13.6	32.6	121.5	7.9
Losses (kg) of Age 1+ Age Classes over 40 years	43.6	104.4	388.5	25.4

TABLE 5.6-17

Annual Population Impacts on Fish Eggs Under 12 Annual LNGC Deliveries, Assuming Life History of Tomtate Grunt (proxy for Haemulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	4,620,605	10,932,769	40,239,274	2,631,098
Number of Age-1 Equivalents Entrained per Year	0.1	0.1	0.5	0.0
Losses (kg) of Age 1+ Age Classes per Year [a]	0.2	0.5	1.7	0.1

[a] Estimates calculated using eggs at time of hatching

TABLE 5.6-18

Population Impacts Over 40 year Project Life on Fish Eggs Under 12 Annual LNGC Deliveries, Assuming Life History of Tomtate Grunt (proxy for Haemulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	184,824,180	437,310,771	1,609,570,978	105,243,923
Number of Age-1 Equivalents Entrained over 40 years	2.4	5.8	21.2	1.4
Losses (kg) of Age 1+ Age Classes over 40 years	7.8	18.4	67.7	4.4

TABLE 5.6-19

Annual Population Impacts on Fish Eggs Under 24 Annual LNGC Deliveries, Assuming Life History of Tomtate Grunt (proxy for Haemulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	9,241,209	21,865,539	80,478,549	5,262,196
Number of Age-1 Equivalents Entrained per Year	0.1	0.3	1.1	0.1
Losses (kg) of Age 1+ Age Classes per Year [a]	0.4	0.9	3.4	0.2

[a] Estimates calculated using eggs at time of hatching

TABLE 5.6-20

Population Impacts Over 40 year Project Life on Fish Eggs Under 24 Annual LNGC Deliveries, Assuming Life History of Tomtate Grunt (proxy for Haemulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	369,648,360	874,621,542	3,219,141,955	210,487,846
Number of Age-1 Equivalents Entrained over 40 years	4.9	11.5	42.4	2.8
Losses (kg) of Age 1+ Age Classes over 40 years	15.6	36.8	135.5	8.9

TABLE 5.6-21

Annual Population Impacts on Fish Eggs Under 50 Annual LNGC Deliveries, Assuming Life History of Tomtate Grunt (proxy for Haemulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	19,252,519	45,553,205	167,663,644	10,962,909
Number of Age-1 Equivalents Entrained per Year	0.3	0.6	2.2	0.1
Losses (kg) of Age 1+ Age Classes per Year[a]	0.8	1.9	7.1	0.5

[a] Estimates calculated using eggs at time of hatching

TABLE 5.6-22

Population Impacts Over 40 year Project Life on Fish Eggs Under 50 Annual LNGC Deliveries, Assuming Life History of Tomtate Grunt (proxy for Haemulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	770,100,751	1,822,128,213	6,706,545,740	438,516,346
Number of Age-1 Equivalents Entrained over 40 years	10.1	24.0	88.3	5.8
Losses (kg) of Age 1+ Age Classes over 40 years	32.4	76.7	282.2	18.5

5.7 ALL OTHER FISH LARVAE

To derive age-1 equivalent and production foregone losses for all other fish larvae (including the unidentified larvae collected during sampling), life history data for Haemulidae, with tomtate grunt (*Haemulon aurolineatum)* as the proxy, and Engraulidae, with bay anchovy (*Anchoa mitchilli)* as the proxy, were used to develop of a range of results. The life history data used for bay anchovy are provided in Tables 5.6-1 to 5.6-6, and the data for tomtate grunt are provided in Tables 5.4-1 to 5.4-6. Table 5.7-1 lists all of the taxa collected during the four seasonal sampling events (Tetra Tech 2013a, 2013b, 2013c and 2014a).

Potential entrainment and impingement losses of all other fish larvae due to the intakes for the operating scenarios outlined in Table 2-1 (e.g., FSRU continuous operation and LNGC deliveries at 12, 24 and 50 per year) were estimated using the larval density data in Table 4-1. The losses were expressed as numbers of individuals entrained, equivalent numbers at age 1, and losses (kg) of age 1+ age classes per year and over the course of the project life (assumed to be 40 years) (Tables 5.7-2 to 5.7-9 using life history inputs for Engraulidae, and Tables 5.7-10 to 5.7-17 using life history inputs for Haemulidae).

TABLE 5.7-1

Species List of Ichthyoplankton Collected by Aguirre LLC at the Proposed FSRU Location

Family	Common Name
Nemichthyidae	Snipe eels
Ophichthidae	Snake eels
Atherinidae	Silversides
Synodontidae	Lizardfishes
Unknown Beloniformid	--
Hemiramphidae	Half-beaks
Exocoetidae	Flying fishes
Berycidae	Redfishes/Alfonsinos
Clupeidae/Engraulidae	Sardines/Anchovies
Gobiesocidae	Clingfishes
Antennariidae	Frogfishes
Myctophidae	Myctophids
Mugiliformes	Mugilidae
Ophidiidae	Cusk-eels
Bythitidae	Brotulas
Apogonidae	Cardinalfishes
Bleniidae	Blennies
Callionymidae	Dragonets
Carangidae	Jacks
Coryphaenidae	Dolphinfishes
Eleotridae	Sleepers
Ephippidae	Spadefishes
Gerreidae	Mojarras
Gobiidae	Gobies
Haemulidae	Grunts
Labridae	Wrasses
Lutjanidae	Snappers
Microdesmidae	Wormfishes
Opistognathidae	Jawfishes
Pleuronectiformes	Flounders
Pomacanthidae	Angelfishes
Pomacentridae	Damselfishes
Scaridae	Parrotfishes
Sciaenidae	Drums/Croakers
Scombridae	Tunas/Mackerels
Serranidae	Sea Basses/Groupers

TABLE 5.7-1 (cont'd)

Species List of Ichthyoplankton Collected by Aguirre LLC at the Proposed FSRU Location

Family	Common Name
Sparidae	Porgies
Sphyraenidae	Barracudas
Tripterygiidae	Triplefin Blennies
Bothidae	Left-eye Flounders
Scorpaenidae	Scorpionfishes
Syngnathidae	Pipefishes
Aulostomidae	Trumpetfishes
Balistidae	Triggerfishes
Monacanthidae	Filefishes
Ostraciidae	Trunkfishes
Tetraodontidae	Porcupinefishes
Fish egg	--
Unidentified fish larvae	--

TABLE 5.7-2

Annual Population Impacts on Other and Unidentified Fish Larvae Under FSRU Continuous Operation, Assuming Life History of Bay Anchovy (proxy for Engraulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	8,602,885	15,480,914	30,230,885	5,178,506
Number of Age-1 Equivalents Entrained per Year	0.1	0.1	0.2	0.0
Losses (kg) of Age 1+ Age Classes per Year	0.3	0.6	1.2	0.2

TABLE 5.7-3

Population Impacts Over 40 year Project Life on Fish Eggs Under FSRU Continuous Operation, Assuming Life History of Bay Anchovy (proxy for Engraulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	344,115,396	619,236,549	1,209,235,386	207,140,227
Number of Age-1 Equivalents Entrained over 40 years	2.7	4.8	9.4	1.6
Losses (kg) of Age 1+ Age Classes over 40 years	13.4	24.0	46.9	8.0

TABLE 5.7-4

Annual Population Impacts on Other and Unidentified Fish Larvae Under 12 Annual LNGC Deliveries, Assuming Life History of Bay Anchovy (proxy for Engraulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	1,533,228	2,728,729	5,270,698	902,863
Number of Age-1 Equivalents Entrained per Year	0.01	0.02	0.04	0.01
Losses (kg) of Age 1+ Age Classes per Year	0.1	0.1	0.2	0.0

TABLE 5.7-5

Population Impacts Over 40 year Project Life on Fish Eggs Under FSRU Continuous Operation, Assuming Life History of Bay Anchovy (proxy for Engraulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	61,329,120	109,149,142	210,827,937	36,114,513
Number of Age-1 Equivalents Entrained over 40 years	0.5	0.9	1.6	0.3
Losses (kg) of Age 1+ Age Classes over 40 years	2.4	4.2	8.2	1.4

TABLE 5.7-6

Annual Population Impacts on Other and Unidentified Fish Larvae Under 24 Annual LNGC Deliveries, Assuming Life History of Bay Anchovy (proxy for Engraulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	3,066,456	5,457,457	10,541,397	1,805,726
Number of Age-1 Equivalents Entrained per Year	0.02	0.04	0.08	0.01
Losses (kg) of Age 1+ Age Classes per Year	0.12	0.21	0.41	0.07

TABLE 5.7-7

Population Impacts Over 40 year Project Life on Fish Eggs Under FSRU Continuous Operation, Assuming Life History of Bay Anchovy (proxy for Engraulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	122,658,240	218,298,285	421,655,873	72,229,025
Number of Age-1 Equivalents Entrained over 40 years	1.6	2.9	5.5	1.0
Losses (kg) of Age 1+ Age Classes over 40 years	4.8	8.5	16.4	2.8

TABLE 5.7-8

Annual Population Impacts on Other and Unidentified Fish Larvae Under 50 Annual LNGC Deliveries, Assuming Life History of Bay Anchovy (proxy for Engraulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	6,388,450	11,369,702	21,961,243	3,761,928
Number of Age-1 Equivalents Entrained per Year	0.05	0.09	0.17	0.03
Losses (kg) of Age 1+ Age Classes per Year	0.25	0.44	0.85	0.15

TABLE 5.7-9

Population Impacts Over 40 year Project Life on Fish Eggs Under FSRU Continuous Operation, Assuming Life History of Bay Anchovy (proxy for Engraulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	255,537,999	454,788,093	878,449,736	150,477,136
Number of Age-1 Equivalents Entrained over 40 years	2.0	3.5	6.8	1.2
Losses (kg) of Age 1+ Age Classes over 40 years	9.9	17.6	34.1	5.8

TABLE 5.7-10

Annual Population Impacts on Other and Unidentified Fish Larvae Under FSRU Continuous Operation, Assuming Life History of Tomtate Grunt (proxy for Haemulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	8,602,885	15,480,914	30,230,885	5,178,506
Number of Age-1 Equivalents Entrained per Year	0.1	0.2	0.4	0.1
Losses (kg) of Age 1+ Age Classes per Year	0.4	0.7	1.3	0.2

TABLE 5.7-11

Population Impacts Over 40 year Project Life on Fish Eggs Under FSRU Continuous Operation, Assuming Life History of Tomtate Grunt (proxy for Haemulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	344,115,396	619,236,549	1,209,235,386	207,140,227
Number of Age-1 Equivalents Entrained over 40 years	4.5	8.1	15.9	2.7
Losses (kg) of Age 1+ Age Classes over 40 years	14.5	26.1	50.9	8.7

TABLE 5.7-12

Annual Population Impacts on Other and Unidentified Fish Larvae Under 12 Annual LNGC Deliveries, Assuming Life History of Tomtate Grunt (proxy for Haemulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	1,533,228	2,728,729	5,270,698	902,863
Number of Age-1 Equivalents Entrained per Year	0.02	0.04	0.07	0.01
Losses (kg) of Age 1+ Age Classes per Year	0.1	0.1	0.2	0.04

TABLE 5.7-13

Population Impacts Over 40 year Project Life on Fish Eggs Under FSRU Continuous Operation, Assuming Life History of Tomtate Grunt (proxy for Haemulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	61,329,120	109,149,142	210,827,937	36,114,513
Number of Age-1 Equivalents Entrained over 40 years	0.8	1.4	2.8	0.5
Losses (kg) of Age 1+ Age Classes over 40 years	2.6	4.6	8.9	1.5

TABLE 5.7-14

Annual Population Impacts on Other and Unidentified Fish Larvae Under 24 Annual LNGC Deliveries, Assuming Life History of Tomtate Grunt (proxy for Haemulidae)

Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	3,066,456	5,457,457	10,541,397	1,805,726
Number of Age-1 Equivalents Entrained per Year	0.04	0.07	0.14	0.02
Losses (kg) of Age 1+ Age Classes per Year	0.13	0.23	0.44	0.08

TABLE 5.7-15 **Population Impacts Over 40 year Project Life on Fish Eggs Under FSRU Continuous Operation, Assuming Life History of Tomtate Grunt (proxy for Haemulidae)**				
Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	122,658,240	218,298,285	421,655,873	72,229,025
Number of Age-1 Equivalents Entrained over 40 years	1.6	2.9	5.5	1.0
Losses (kg) of Age 1+ Age Classes over 40 years	5.2	9.2	17.7	3.0

TABLE 5.7-16 **Annual Population Impacts on Other and Unidentified Fish Larvae Under 50 Annual LNGC Deliveries, Assuming Life History of Tomtate Grunt (proxy for Haemulidae)**				
Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained per Year	6,388,450	11,369,702	21,961,243	3,761,928
Number of Age-1 Equivalents Entrained per Year	0.1	0.1	0.3	0.05
Losses (kg) of Age 1+ Age Classes per Year	0.3	0.5	0.9	0.2

TABLE 5.7-17 **Population Impacts Over 40 year Project Life on Fish Eggs Under FSRU Continuous Operation, Assuming Life History of Tomtate Grunt (proxy for Haemulidae)**				
Estimated Loss	Winter	Spring	Summer	Fall
Total Number of Individuals Entrained over 40 years	255,537,999	454,788,093	878,449,736	150,477,136
Number of Age-1 Equivalents Entrained over 40 years	3.4	6.0	11.6	2.0
Losses (kg) of Age 1+ Age Classes over 40 years	10.8	19.1	37.0	6.3

5.8 ALL OTHER INVERTEBRATE LARVAE

The other invertebrate larvae collected during the four seasonal sampling events included hermit crabs (Section Anomura), true crabs (Section Brachyura), shrimps (Sub-Order Natantia), gastropods (Class Gastropoda), and squids (Order Teuthoidea). Since the life history of all of these groups is so varied, estimates of equivalent numbers at age 1, and losses (kg) of age 1+ age classes in future years were not derived for this group. The total annual number of individuals entrained for these other invertebrate larval groups is provided in Table 5.8-1 and the total entrainment over the project life of 40 years is in Table 5.8-2.

TABLE 5.8-1 **Total Annual Entrainment (# of individuals) for Other Invertebrate Larvae Under All Operating Scenarios**				
Operating Scenario	Winter	Spring	Summer	Fall
FSRU Continuous Operation	218,823,329	284,703,259	316,543,183	358,877,082
LNGC, 12 Annual Deliveries	39,111,075	50,326,843	55,346,961	62,748,962
LNGC, 24 Annual Deliveries	78,222,151	100,653,687	110,693,923	125,497,923
LNGC, 50 Annual Deliveries)	162,962,814	209,695,180	230,612,339	261,454,007

TABLE 5.8-2 **Total Entrainment (# of individuals) Over Project Life of 40 Years for Other Invertebrate Larvae Under All Operating Scenarios**				
Operating Scenario	Winter	Spring	Summer	Fall
FSRU Continuous Operation	8,752,933,160	11,388,130,360	12,661,727,320	14,355,083,280
LNGC, 12 Annual Deliveries	1,564,443,000	2,013,073,720	2,213,878,440	2,509,958,480
LNGC, 24 Annual Deliveries	3,128,886,040	4,026,147,480	4,427,756,920	5,019,916,920
LNGC, 50 Annual Deliveries)	6,518,512,560	8,387,807,200	9,224,493,560	10,458,160,280

5.9 SUMMARY

The predicted entrainment and mortality results are summarized by representative taxa of concern in Tables 5.9-1 to 5.9-8.

TABLE 5.9-1 **Annual Population Impacts Under FSRU Continuous Operations**						
					Annual Losses of Age 1+ Age Classes	
Taxa	Common Name	Stage	Number of Individuals (millions)	Number of Age-1 Equivalents	lbs	kg
Lutjanidae	snappers	larvae	0.8	0.13	0.3	0.1
Serranidae	groupers	larvae	0.2	0.01	0.28	0.13
Carangidae	jacks	larvae	0.2	0.04	0.03	0.01
Haemulidae	grunts	larvae	2.4	0.03	0.08	0.04
Palinura	spiny lobster	larvae	1.0	0.04	0.22	0.10
All other fish taxa as Engraulidae	anchovies	larvae	59.5	0.46	0.06	0.03
All other fish taxa as Haemulidae	grunts	larvae	59.5	0.78	0.22	0.10
Fish eggs as Engraulidae	anchovies	eggs	333.8	2.60	5.52	2.50
Fish eggs as Haemulidae	grunts	eggs	333.8	4.39	28.56	12.96

TABLE 5.9-2 **Population Impacts Over Project Life of 40 Years Under FSRU Continuous Operations**						
					Losses of Age 1+ Age Classes Over Future (40) Years	
Taxa	Common Name	Stage	Number of Individuals (millions)	Number of Age-1 Equivalents	lbs	kg
Lutjanidae	snappers	larvae	32.9	5.4	11.2	5.1
Serranidae	groupers	larvae	7.6	0.2	1.0	0.5
Carangidae	jacks	larvae	7.4	1.5	3.2	1.4
Haemulidae	grunts	larvae	96.6	1.3	9.0	4.1
Palinura	spiny lobster	larvae	40.7	1.5	2.5	1.1
All other fish taxa as Engraulidae	anchovies	larvae	2,379.7	18.5	9.0	4.1
All other fish taxa as Haemulidae	grunts	larvae	2,379.7	31.3	220.8	100.1
Fish eggs as Engraulidae	anchovies	eggs	13,353.6	104.0	1,142.5	518.2
Fish eggs as Haemulidae	grunts	eggs	13,353.6	175.7	1,238.8	561.9

TABLE 5.9-3

Annual Population Impacts Under 12 LNGC Deliveries per Year

Taxa	Common Name	Stage	Number of Individuals (millions)	Number of Age-1 Equivalents	Annual Losses of Age 1+ Age Classes	
					lbs	kg
Lutjanidae	snappers	larvae	0.1	0.02	0.05	0.02
Serranidae	groupers	larvae	0.03	0.001	0.004	0.002
Carangidae	jacks	larvae	0.03	0.01	0.01	0.01
Haemulidae	grunts	larvae	0.4	0.01	0.04	0.02
Palinura	spiny lobster	larvae	0.2	0.01	0.01	0.01
All other fish taxa as Engraulidae	anchovies	larvae	10.4	0.08	0.04	0.02
All other fish taxa as Haemulidae	grunts	larvae	10.4	0.14	0.97	0.44
Fish eggs as Engraulidae	anchovies	eggs	58.4	0.46	5.00	2.27
Fish eggs as Haemulidae	grunts	eggs	58.4	0.77	5.42	2.46

TABLE 5.9-4

Population Impacts Over Project Life of 40 Years Under 12 LNGC Deliveries per Year

Taxa	Common Name	Stage	Number of Individuals (millions)	Number of Age-1 Equivalents	Losses of Age 1+ Age Classes Over Future (40) Years	
					lbs	kg
Lutjanidae	snappers	larvae	5.8	0.9	2.0	0.9
Serranidae	groupers	larvae	1.35	0.04	0.2	0.1
Carangidae	jacks	larvae	1.30	0.3	0.6	0.3
Haemulidae	grunts	larvae	17.0	0.2	1.6	0.7
Palinura	spiny lobster	larvae	7.2	0.3	0.4	0.2
All other fish taxa as Engraulidae	anchovies	larvae	417.4	3.3	1.6	0.7
All other fish taxa as Haemulidae	grunts	larvae	417.4	5.5	38.7	17.6
Fish eggs as Engraulidae	anchovies	eggs	2,336.9	18.2	199.9	90.7
Fish eggs as Haemulidae	grunts	eggs	2,336.9	30.8	216.8	98.3

TABLE 5.9-5

Annual Population Impacts Under 24 LNGC Deliveries per Year

Taxa	Common Name	Stage	Number of Individuals (millions)	Number of Age-1 Equivalents	Annual Losses of Age 1+ Age Classes	
					lbs	kg
Lutjanidae	snappers	larvae	0.3	0.05	0.10	0.04
Serranidae	groupers	larvae	0.1	0.002	0.01	0.004
Carangidae	jacks	larvae	0.1	0.01	0.03	0.01
Haemulidae	grunts	larvae	0.9	0.01	0.08	0.04
Palinura	spiny lobster	larvae	0.4	0.01	0.02	0.01
All other fish taxa as Engraulidae	anchovies	larvae	20.9	0.16	0.08	0.04
All other fish taxa as Haemulidae	grunts	larvae	20.9	0.27	1.94	0.88
Fish eggs as Engraulidae	anchovies	eggs	116.8	0.91	10.00	4.53
Fish eggs as Haemulidae	grunts	eggs	116.8	1.54	10.84	4.92

TABLE 5.9-6

Population Impacts Over Project Life of 40 Years Under 24 LNGC Deliveries per Year

Taxa	Common Name	Stage	Number of Individuals (millions)	Number of Age-1 Equivalents	Losses of Age 1+ Age Classes Over Future (40) Years	
					lbs	kg
Lutjanidae	snappers	larvae	11.6	1.9	4.0	1.8
Serranidae	groupers	larvae	2.7	0.1	0.4	0.2
Carangidae	jacks	larvae	2.6	0.5	1.1	0.5
Haemulidae	grunts	larvae	34.1	0.4	3.2	1.4
Palinura	spiny lobster	larvae	14.4	0.5	0.9	0.4
All other fish taxa as Engraulidae	anchovies	larvae	834.8	6.5	3.2	1.4
All other fish taxa as Haemulidae	grunts	larvae	834.8	11.0	77.4	35.1
Fish eggs as Engraulidae	anchovies	eggs	4,673.9	36.4	399.9	181.4
Fish eggs as Haemulidae	grunts	eggs	4,673.9	61.5	433.6	196.7

TABLE 5.9-7

Annual Population Impacts Under 50 LNGC Deliveries per Year

Taxa	Common Name	Stage	Number of Individuals (millions)	Number of Age-1 Equivalents	Annual Losses of Age 1+ Age Classes	
					lbs	kg
Lutjanidae	snappers	larvae	0.6	0.10	0.21	0.09
Serranidae	groupers	larvae	0.1	0.004	0.02	0.01
Carangidae	jacks	larvae	0.1	0.03	0.06	0.03
Haemulidae	grunts	larvae	1.8	0.02	0.16	0.07
Palinura	spiny lobster	larvae	0.7	0.03	0.05	0.02
All other fish taxa as Engraulidae	anchovies	larvae	43.5	0.34	0.16	0.07
All other fish taxa as Haemulidae	grunts	larvae	43.5	0.57	4.03	1.83
Fish eggs as Engraulidae	anchovies	eggs	243.4	1.90	20.83	9.45
Fish eggs as Haemulidae	grunts	eggs	243.4	3.20	22.58	10.24

TABLE 5.9-8

Population Impacts Over Project Life of 40 Years Under 50 LNGC Deliveries per Year

Taxa	Common Name	Stage	Number of Individuals (millions)	Number of Age-1 Equivalents	Losses of Age 1+ Age Classes Over Future (40) Years	
					Lbs	kg
Lutjanidae	snappers	larvae	24.2	3.9	8.3	3.7
Serranidae	groupers	larvae	5.6	0.2	0.7	0.3
Carangidae	jacks	larvae	5.4	1.1	2.3	1.1
Haemulidae	grunts	larvae	71.0	0.9	6.6	3.0
Palinura	spiny lobster	larvae	30.0	1.1	1.8	0.8
All other fish taxa as Engraulidae	anchovies	larvae	1,739.3	13.5	6.6	3.0
All other fish taxa as Haemulidae	grunts	larvae	1,739.3	22.9	161.3	73.2
Fish eggs as Engraulidae	anchovies	eggs	9,737.3	75.9	833.1	377.9
Fish eggs as Haemulidae	grunts	eggs	9,737.3	128.1	903.3	409.7

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APPENDIX F

PROCEDURES GUIDING THE UNANTICIPATED DISCOVERY OF CULTURAL RESOURCES AND HUMAN REMAINS

APPENDIX 4C

Procedures Guiding the Unanticipated Discovery of Cultural Resources and Human Remains

Introduction

This plan represents the approach that Excelerate Energy will use to address the unanticipated discovery of any potentially significant submerged cultural resources during the Excelerate Energy Aguirre Offshore GasPort Project (Project), as well as, any unanticipated discoveries within the onshore portion of the Project. This plan has been prepared pursuant to Section 106 of the National Historic Preservation Act of 1966 (36 CFR 800) as amended, and the Native American Graves Protection and Repatriation Act (NAGPRA) (43 CFR 10). All work is undertaken pursuant to the Secretary of Interior's Standards and Guidelines for Archaeology and Historic Preservation (48 Fed. Reg. 44716-42). For portions of the Project in waters under the jurisdiction of the Commonwealth of Puerto Rico, this plan is prepared pursuant to *Law 112 or Law for the Protection of the Terrestrial Archaeological Patrimony of Puerto Rico (Ley de Protección del Patrimonio Arqueológico Terrestre de Puerto Rico* This set of regulations was enacted in 1988 with recent amendments to the regulatory structure; *Law 10 of 1987 Law for the Protection, Conservation and Study of Subaquatic Sites and Archaeological Resources (Ley de Protección, Conservación y Estudio de Sitios y Recursos Arqueológicos Subacuaticos)* and *Law 111 of 1985 Law for the Protection and Conservation of Caves, Caverns or Sinkholes of Puerto Rico (Ley para la Protección y Conservación de Cuevas, Cavernas o Sumideros de Puerto Rico).*

The purpose of the archaeological investigations undertaken as part of Excelerate Energy's Aguirre GasPort Project is to determine the presence or absence of potentially significant submerged and/or onshore cultural resources in the proposed project area. However, in the event of an unanticipated discovery, work in the vicinity of the find will not resume until the FERC agrees that work may resume.

Notification Procedures

Artifacts encountered during the Project will be guided by The Commonwealth of Puerto Rico's laws and guidelines, federal regulations 36 CFR 800.13, and 43 CFR 10.5.

Artifact Discoveries

1. In the unlikely event that artifacts or features are uncovered or damaged, including but not limited to pottery, bone, stone, tools, archaeological features and shipwrecks, that activity shall be halted immediately until such time as it can be determined whether or not the materials in question are cultural, and if so whether they represent a potentially significant archaeological site.
2. If artifacts are identified by construction personnel, the contractor's construction foreman will be notified immediately. The foreman will notify Excelerate Energy's construction manager. Notification will include details including but not limited to the precise location and time of the discovery, as well as the nature of the discovery.
3. Upon notification of such a discovery, Excelerate Energy will notify the Puerto Rico SHPO (PRSHPO), and Excelerate Energy's cultural resource consultants within 48 hours to review the discovery.

4. In consultation with the above-mentioned parties (i.e., PRSHPO and cultural resource consultant), Excelerate Energy or its agents will determine the cultural significance of the discovery. If the discovery is deemed potentially significant, Excelerate Energy, in consultation with the above mentioned parties, will take steps to mitigate further adverse effects to the discovery, including avoidance or further archaeological analysis. Should further archaeological analysis be deemed necessary, the objective of any cultural resource investigations will be to collect the data as accurately as possible and in a timely manner in order to minimize construction delays.

Discovery of Human Remains

Treatment of human remains encountered during the project will be guided by the Advisory Council on Historic Preservation, 36 CFR 800, the Commonwealth of Puerto Rico's laws and guidelines, and the Commonwealth of Puerto Rico's guidance on human burials. According to the Advisory Council, treatment of human remains should follow these principles:

1. Human remains should not be disinterred unless required in advance of some kind of disturbance.
2. Disinterment should be done carefully, respectfully and completely and in accordance with proper archaeological methods.
3. Human remains and associated grave goods shall be reburied in consultation with the descendants of the dead.
4. Prior to reburial, scientific studies should be performed as necessary.
5. Where objections exist to the scientific study by the descendants of the dead, the study shall not be carried out unless the value of the scientific research of the remains outweighs the objections descendants may have to the study.

These procedures will be followed in the event human remains are discovered during Project activities:

1. If human remains are identified during construction, all construction activities will cease immediately in the area of the find.
2. Excelerate Energy's construction manager will be notified immediately and informed of the discovery.
3. Excelerate Energy's construction manager will in turn notify the proper jurisdictional authorities including the Medical Examiner, the PRSHPO, and the archaeological consultant.
4. The Medical Examiner will determine whether the remains are recent or archaeological.
5. The proper jurisdictional authorities will determine the disposition of the remains.
6. Excelerate Energy will delay commencement of work pending receipt of notification from FERC that work may resume.

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APPENDIX G

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APPENDIX G
LIST OF PREPARERS

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APPENDIX H

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APPENDIX I

SUBJECT INDEX

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