BROADWATER

RESOURCE REPORT NO. 6

GEOLOGICAL RESOURCES

FOR A

PROJECT TO CONSTRUCT AND OPERATE A

LIQUEFIED NATURAL GAS RECEIVING TERMINAL

IN

LONG ISLAND SOUND

LONG ISLAND, NEW YORK

UNITED STATES OF AMERICA

JANUARY 2006

PUBLIC

BW001810

RESOURCE REPORT 6—GEOLOGICAL RESOURCES

Minimum Filing Requirement	Location in Environmental Report
• • Identify the location (by milepost) of mineral resources and any planned or active surface mines crossed by the proposed facilities. (§ 380.12 (h) (1 & 2))	Section 6.2.3
• • Identify any geologic hazards to the proposed facilities. (§ 380.12 (h) (2))	Section 6.3
• • Discuss the need for and locations where blasting may be necessary in order to construct the proposed facilities. (§ 380.12 (h) (3))	Section 6.4
• • For LNG projects in seismic areas, the materials required by "Data Requirements for the Seismic Review of LNG Facilities," NBSIR84-2833. (§ 380.12 (h) (5))	Section 6.3.1
• • For underground storage facilities, how drilling activity by others within or adjacent to the facilities would be monitored, and how old wells would be located and monitored within the facility boundaries. (§ 380.12 (h) (6))	Not applicable

Environmental Information Request
October 19, 2005

Request	Location in Environmental Report
24. Specify the proximity of the nearest geologic fault to the project route, and identify the seismic activity specifically associated with the nearest fault.	Section 6.3.1; Table 6-1; and Figures 6-5, 6-6, 6-7, and 6-8
25. Specify the proximity of the nearest geologic fault to the project route, and identify the seismic activity specifically associated with the nearest fault.	Section 6.4
26. Resource Report 6 (section 6.4) indicates it is not anticipated that blasting will be required for trenching. Clarify whether Broadwater would avoid the use of blasting or not. If blasting would be avoided, what methods would be used to trench through any bedrock? If blasting could be used,	Section 6.4

Environmental Information Request
October 19, 2005

Request		Location in Environmental Report
	what would the impacts be to geological, sediment, water, and marine resources.	
27.	Describe potential impacts and appropriate mitigation measures to minimize impacts to geological resources associated with sheet-piling as it relates to the uncertainty of substrate type and sheet-piling depth.	Section 6.2.2

Summary of Outstanding Environmental information Requests

Request	Location in Environmental Report
Specific impacts to be addressed included:	
• The likelihood and type of seismic impacts to the proposed project associated with the Brantford Structure relative to the magnitude and frequency of seismic activity. Draft Resource Report 6 provides the historic seismic activity and likelihood of an event, but does not describe the potential impacts to this specific project.	Section 6.3.1

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List of Acronyms and Abbreviations

ACP	Atlantic Coastal Plain
bcf	billion cubic feet
bcfd	billion cubic feet per day
CFR	Code of Federal Regulations
FERC	Federal Energy Regulatory Commission
FSRU	Floating Storage and Regasification Unit
IGTS	Iroquois Gas Transmission System
km	kilometer
LNG	liquefied natural gas
m	meter
m^2	square meter
%g	percentage of the force of gravity
STV	shell and tube vaporizer
USGS	United States Geological Survey
YMS	yoke mooring system

6. GEOLOGY

6.1 INTRODUCTION

Broadwater Energy, a joint venture between TCPL USA LNG Inc. and Shell Broadwater Holdings LLC, is filing an application with the Federal Energy Regulatory Commission (FERC) seeking all of the necessary authorizations pursuant to the Natural Gas Act to construct and operate a marine liquefied natural gas (LNG) terminal and subsea pipeline for the importation, storage, regasification, and transportation of natural gas. The Broadwater LNG Project (the Project) will increase the availability of natural gas to the New York and Connecticut markets through an interconnection with the Iroquois Gas Transmission System (IGTS). The FERC application for the Project requires the submittal of 13 Resource Reports, with each report evaluating Project effects on a particular aspect of the environment.

Resource Report 6 describes the geological characteristics, resources, hazards, environmental consequences, and mitigation associated with the proposed LNG Project off the coast of New York in Long Island Sound (the Sound). Impacts on surficial sediments resulting from construction activities are discussed in Resource Report 2, Water Quality, and Resource Report 7, Soils.

The proposed Broadwater LNG terminal will be located in Long Island Sound (the Sound), approximately 9 miles (14.5 kilometers [km]) from the shore of Long Island in New York State waters, as shown on Figure 6-1. The LNG terminal facilitates the sea-to-land transfer of natural gas. It will be designed to receive, store, and regasify LNG at an average throughput of 1.0 billion cubic feet per day (bcfd) and will be capable of delivering a peak throughput of 1.25 bcfd. The Project will deliver the regasified LNG to the existing interstate natural gas pipeline system via an interconnection to the IGTS pipeline. Onshore facilities are discussed in the Onshore Facilities Resource Reports.

The proposed LNG terminal will consist of a floating storage and regasification unit (FSRU) that is approximately 1,215 feet (370 meters [m]) in length, 200 feet (60 m) in width, and rising approximately 80 feet (25 m) above the water line to the trunk deck. The FSRU's draft is approximately 40 feet (12 m). The freeboard and mean draft of the FSRU will generally not vary throughout operating conditions. This is achieved by ballast control to maintain the FSRU's trim, stability, and draft. The FSRU will be designed with a net storage capacity of approximately 350,000 cubic meters [m^3] of LNG (equivalent to 8 billion cubic feet [bcf] of natural gas) with base vaporization capabilities of 1.0 bcfd using a closed-loop shell and tube vaporization (STV) system. The LNG will be delivered to the FSRU in LNG carriers with cargo capacities ranging from approximately 125,000 m^3 up to a potential future size of 250,000 m^3 at the frequency of two to three carriers per week.

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\\BUFSDL4\GIS\\Pensacola\LNG\BROADWATER\Maps\MXD\Resource_Reports_Final\RR6\site_map_with_Eastchester.mxd 01/11/2006

Source: ESRI StreetMap, 2002.

Figure 6-1
Proposed Broadwater Project
Location in Long Island Sound

The FSRU will be connected to the send-out pipeline, which rises from the seabed and is supported by a stationary tower structure. In addition to supporting the pipeline, the stationary tower also serves the purpose of securing the FSRU in such a manner to allow it to orient in response to prevailing wind, wave, and current conditions (i.e., weathervane) around the tower. The tower, which is secured to the seabed by four legs, will house the yoke mooring system (YMS) allowing the FSRU to weathervane around the tower. The total area under the tower structure, which is of open design, will be approximately 13,180 square feet (1,225 square meters [m^2]).

A 30-inch-diameter natural gas pipeline will deliver the vaporized natural gas to the existing IGTS pipeline. It will be installed beneath the seafloor from the stationary tower structure to an interconnection location at the existing 24-inch-diameter subsea section of the IGTS pipeline, approximately 22 miles (35 km) west of the proposed FSRU site. To stabilize and protect the operating components, sections of the pipeline will be covered with engineered back-fill material or spoil removed during the lowering operation. Figure 6-1 presents the proposed pipeline route.

6.2 PHYSIOGRAPHY AND GEOLOGY OF THE PROJECT AREA

6.2.1 Physical Characteristics of Long Island Sound

Long Island Sound is a northeast-southwest trending basin that is approximately 112 miles (180 km) long and 21 miles (34 km) across at its widest point, with a total area of 1,300 square miles (3,370 km^2). The Sound can be divided into three regions: the eastern, central, and western basins. The eastern basin is the deepest, with depths exceeding 328 feet (100 m) in some places; salinity and tidal currents are also greatest in this basin. The central basin is the largest of the three basins and is characterized by slower tidal currents, lower salinities, and warmer waters. The western basin is the smallest of the three and is often included with discussions of the central basin of the Sound; however, it is distinguished by the presence of the Hempstead Sill and its proximity to the East River. Stratford Shoal, which traverses the mid-Sound, limits water circulation between the central and western basins.

The physical structure of Long Island Sound began to take on its present shape approximately 26,000 years ago by the processes of glaciation, ice retreat, and marine submergence (i.e., rise in sea level). The southern shore of Long Island is dominated by at least two (Harbor Hill and Ronkonkoma) terminal (end) moraines (a ridge of glacial deposits marking the maximum advance of the glacier) deposited by the Late Wisconsin glacier. The moraines consist predominantly of sand and gravel-rich material. As the glacier retreated northward, glacial Lake Connecticut was formed over most of the present Sound area, accumulating extensive fine-grained, glacial-lacustrine sediments. The north (Connecticut) shore of the Sound was reshaped by the retreating Wisconsin glacier, which deposited coarse-grained glacio-deltaic sediments in the form of lacustrine fans and moraines. The majority of the harbors along the north shore of the Sound have river systems draining into them, while harbors on the south shore lack the riverine input and are both sandier and larger than those to the north. Four major rivers drain from

Connecticut into the Sound. These are the Thames, the Connecticut, the Quinnipiac, and the Housatonic, all of which carry significant quantities of alluvial deposits for distribution throughout the Sound. In the Sound, Holocene sediments have continued to accumulate, primarily through alluvial deposition. These Holocene-aged deposits consist primarily of peats, muds, and alluvium from streams and shore deposits. The thickness of these deposits varies significantly throughout the Sound, depending on the rate of sediment accretion.

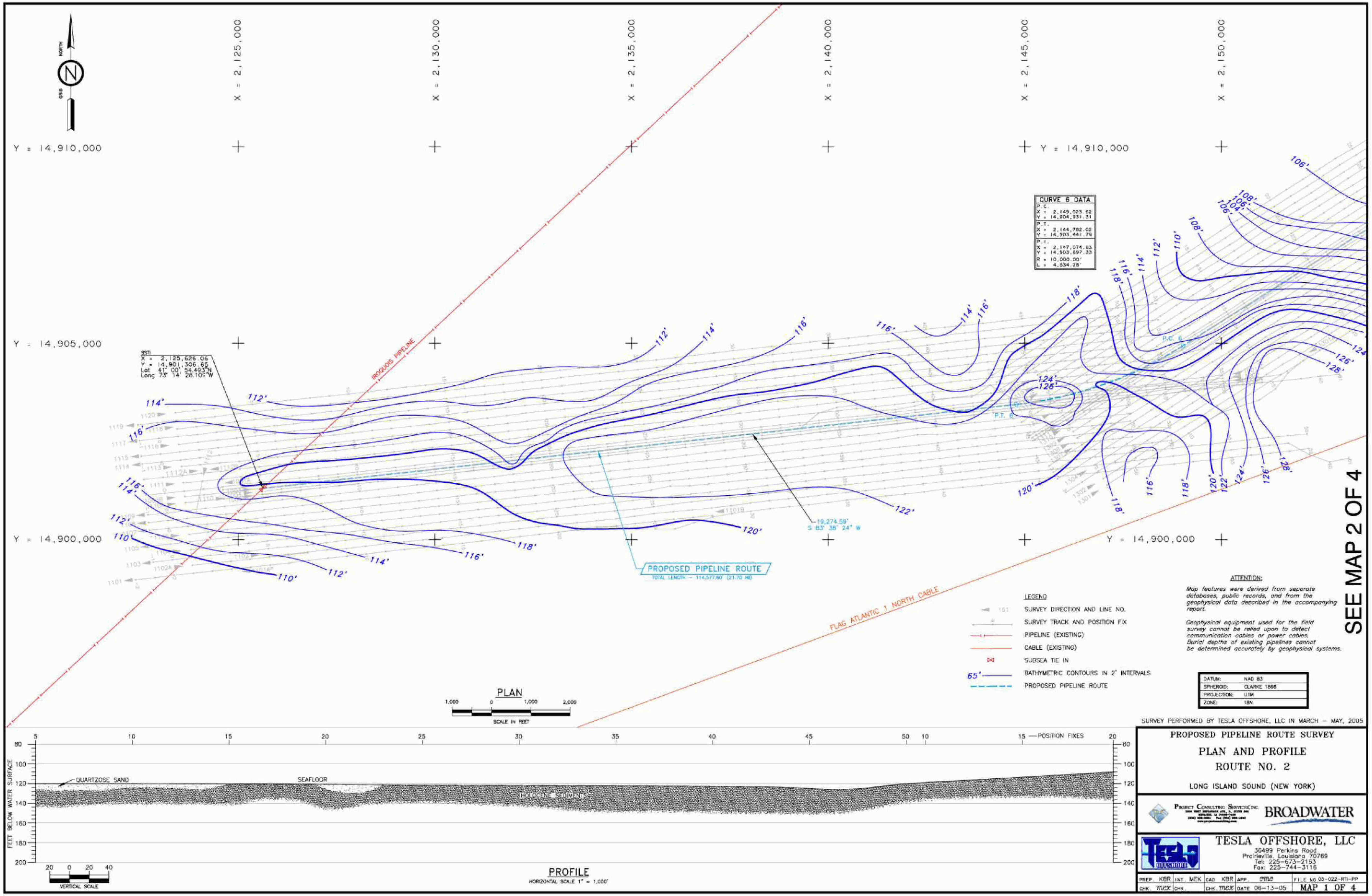
The seafloor is generally irregular in the eastern part of the Sound, where water depths are generally 130 to 165 feet (40 to 50 m) and occasionally exceed 328 feet (100 m). In the central and western part of the Sound, broad areas of smooth, muddy and sandy sea floor are interrupted by the Stratford and Norwalk Shoals. These shoals consist of irregular assemblages of topographic highs and lows that are oriented north-south across the Sound and have a maximum relief of 130 feet (40 m) (Knebel et al. 1999). In the areas of smooth sea floor, the bottom slopes toward an east-west axial depression, which is narrowest and deepest where it cuts across shoal complexes.

Knebel et al. (1999) studied the distribution of bottom sediments in Long Island Sound and outlined the major processes that control the characteristics of sediments in these environments. The study included the collection of sidescan sonographs and data developed from analysis of grab samples and video observations at 146 points along or near the survey tracks. Based on this data, four categories of bottom sedimentary environments were identified in the 850-square-mile (2,200 km^2) study area. These four environments reflect the four major processes that operate in the area—deposition of fine grained material, bedload transport of coarse-grained material, sorting and reworking of sediments, and erosion (often described as nondepositional).

Based on the spring 2005 field surveys completed for Broadwater, water depths range from approximately 55 to 130 feet (17 to 40 m) along the proposed pipeline route. Figure 6-2 presents the sampling locations evaluated during the 2005 field surveys. The shallowest depths occur over the Stratford Shoal, and the deepest depths (>100 feet [30 m]) occur to the west and east of the shoal (between sample locations C-2 and IC-7, and IC-14 and C-19, respectively). Water depths in the eastern 7.5 miles of the proposed route (between sample locations C-20 and C-28) and at the proposed FSRU location are consistently about 95 feet (29 m) deep, with the depth at the FSRU centerpoint at 93 feet (28 m) below sea level. Tidal fluctuations in the Sound can reach 8 feet (2.4 m) with strong currents following each tidal change between slack tides. Current speed and direction is influenced by daily wind patterns and speeds, but is notably stronger over the Stratford Shoal. Figure 6-3a through 6-3d provides the topographic plan and profile of the Long Island Sound along the preferred route developed from the geophysical surveys completed by Broadwater.

Source: U.S. Geological Survey Open-File Report OFR 00-304, 2000;
Broadwater Surveys conducted in April/May 2005.

Figure 6-2 Broadwater Sampling Stations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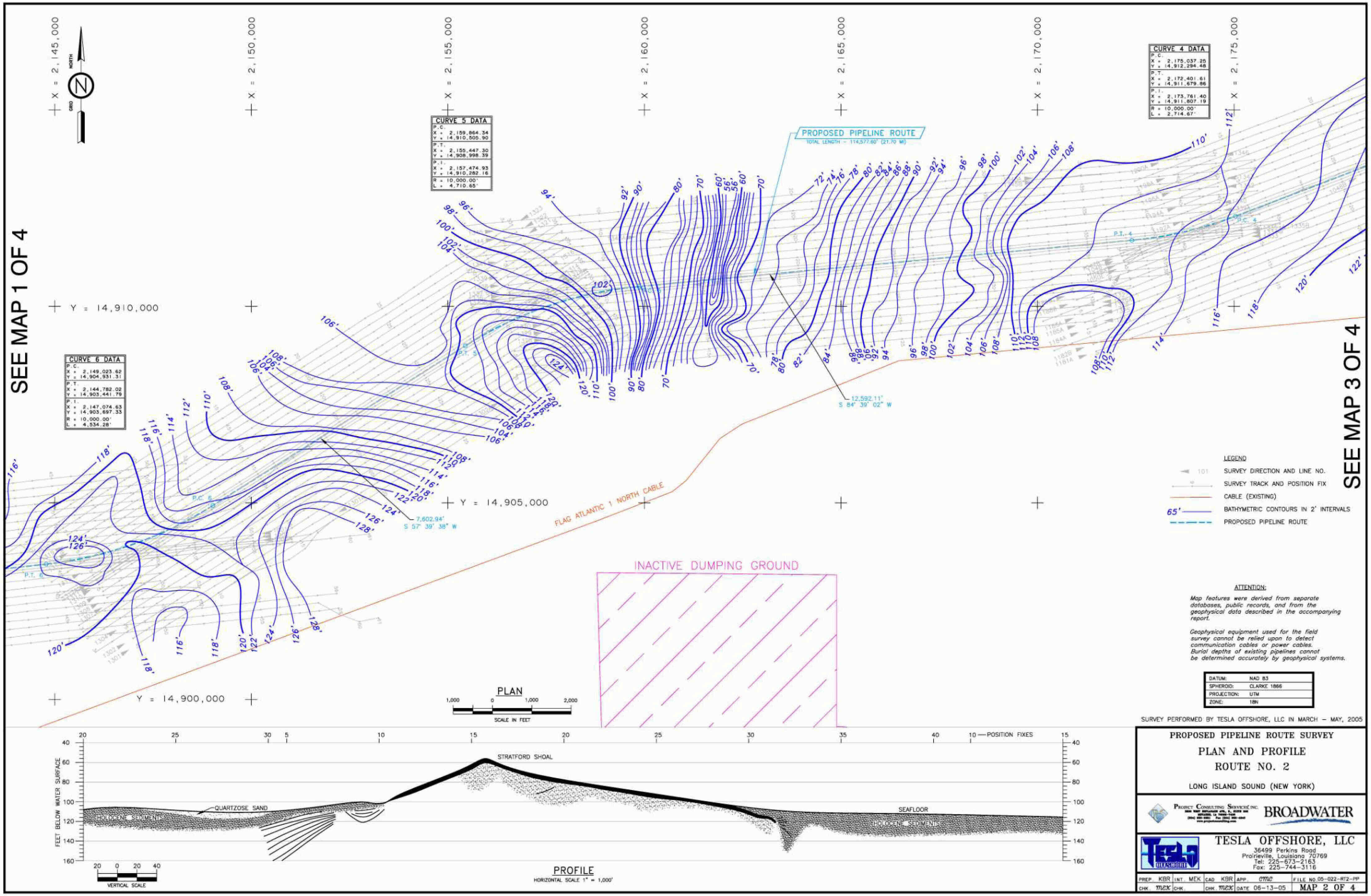
X = 2,130,000
X = 2,135,000
X = 2,140,000
X = 2,145,000
X = 2,150,000
Y = 14,910,000
Y = 14,905,000
Y = 14,900,000
IROQUOIS PIPELINE
FLAG ATLANTIC 1 NORTH CABLE
SSTI
X = 2,125,626.06
Y = 14,901,306.65
Lat 41° 00' 54.493"N
Long 73° 14' 28.109"W
CURVE 6 DATA
P.C.
X = 2,149,023.62
Y = 14,904,931.31
P.T.
X = 2,144,782.02
Y = 14,903,441.79
P.I.
X = 2,147,074.63
Y = 14,903,697.33
R = 10,000.00'
L = 4,534.28'
P.C. 6
P.T. 6
19,274.59'
S 83° 38' 24" W
PROPOSED PIPELINE ROUTE
TOTAL LENGTH - 114,577.60' (21.70 MI)
SEE MAP 2 OF 4
LEGEND
SURVEY DIRECTION AND LINE NO.
SURVEY TRACK AND POSITION FIX
PIPELINE (EXISTING)
CABLE (EXISTING)
SUBSEA TIE IN
BATHYMETRIC CONTOURS IN 2' INTERVALS
PROPOSED PIPELINE ROUTE
ATTENTION:
Map features were derived from separate databases, public records, and from the geophysical data described in the accompanying report.
Geophysical equipment used for the field survey cannot be relied upon to detect communication cables or power cables. Burial depths of existing pipelines cannot be determined accurately by geophysical systems.
DATUM: NAD 83
SPHEROID: CLARKE 1866
PROJECTION: UTM
ZONE: 18N
PLAN
SCALE IN FEET
PROFILE
HORIZONTAL SCALE 1" = 1,000'
VERTICAL SCALE
FEET BELOW WATER SURFACE
QUARTZOSE SAND
SEAFLOOR
HOLOCENE SEDIMENTS
POSITION FIXES
SURVEY PERFORMED BY TESLA OFFSHORE, LLC IN MARCH – MAY, 2005
PROPOSED PIPELINE ROUTE SURVEY
PLAN AND PROFILE
ROUTE NO. 2
LONG ISLAND SOUND (NEW YORK)
PROJECT CONSULTING SERVICES, INC.
BROADWATER
TESLA OFFSHORE, LLC
36499 Perkins Road
Prairieville, Louisiana 70769
Tel: 225-673-2163
Fax: 225-744-3116
PREP. KBR
INT. MEK
CAD KBR
APP. cmc
FILE NO. 05-022-RTI-PP
CHK. mex
CHK.
CHK. mex
DATE 06-13-05
MAP 1 OF 4



SEE MAP 1 OF 4
SEE MAP 3 OF 4
X = 2,145,000
X = 2,150,000
X = 2,155,000
X = 2,160,000
X = 2,165,000
X = 2,170,000
X = 2,175,000
Y = 14,910,000
Y = 14,905,000
Y = 14,900,000
NORTH
GRID
CURVE 4 DATA
P.C.
X = 2,175,037.25
Y = 14,912,294.48
P.T.
X = 2,172,401.61
Y = 14,911,579.86
P.I.
X = 2,173,761.40
Y = 14,911,807.19
R = 10,000.00'
L = 2,714.67'
CURVE 5 DATA
P.C.
X = 2,159,864.34
Y = 14,910,505.90
P.T.
X = 2,155,447.30
Y = 14,908,998.39
P.I.
X = 2,157,474.93
Y = 14,910,262.16
R = 10,000.00'
L = 4,710.65'
CURVE 6 DATA
P.C.
X = 2,149,023.62
Y = 14,904,931.31
P.T.
X = 2,144,782.02
Y = 14,903,441.79
P.I.
X = 2,147,074.63
Y = 14,903,697.33
R = 10,000.00'
L = 4,534.28'
PROPOSED PIPELINE ROUTE
12,592.11'
S 84° 39' 02" W
7,602.94'
S 57° 39' 38" W
P.C. 6
P.T. 6
P.T. 5
P.I. 4
P.C. 4
FLAG ATLANTIC 1 NORTH CABLE
INACTIVE DUMPING GROUND
LEGEND
SURVEY DIRECTION AND LINE NO.
SURVEY TRACK AND POSITION FIX
CABLE (EXISTING)
BATHYMETRIC CONTOURS IN 2' INTERVALS
PROPOSED PIPELINE ROUTE
ATTENTION:
Map features were derived from separate databases, public records, and from the geophysical data described in the accompanying report.
Geophysical equipment used for the field survey cannot be relied upon to detect communication cables or power cables. Burial depths of existing pipelines cannot be determined accurately by geophysical systems.
DATUM: NAD 83
SPHEROID: CLARKE 1866
PROJECTION: UTM
ZONE: 18N
PLAN
SCALE IN FEET
SURVEY PERFORMED BY TESLA OFFSHORE, LLC IN MARCH – MAY, 2005
POSITION FIXES
STRATFORD SHOAL
QUARTZOSE SAND
HOLOCENE SEDIMENTS
SEAFLOOR
FEET BELOW WATER SURFACE
VERTICAL SCALE
PROFILE
HORIZONTAL SCALE 1" = 1,000'
PROPOSED PIPELINE ROUTE SURVEY
PLAN AND PROFILE
ROUTE NO. 2
LONG ISLAND SOUND (NEW YORK)
Project Consulting Services, Inc.
BROADWATER
TESLA OFFSHORE, LLC
36499 Perkins Road
Prairieville, Louisiana 70769
Tel: 225-673-2163
Fax: 225-744-3116
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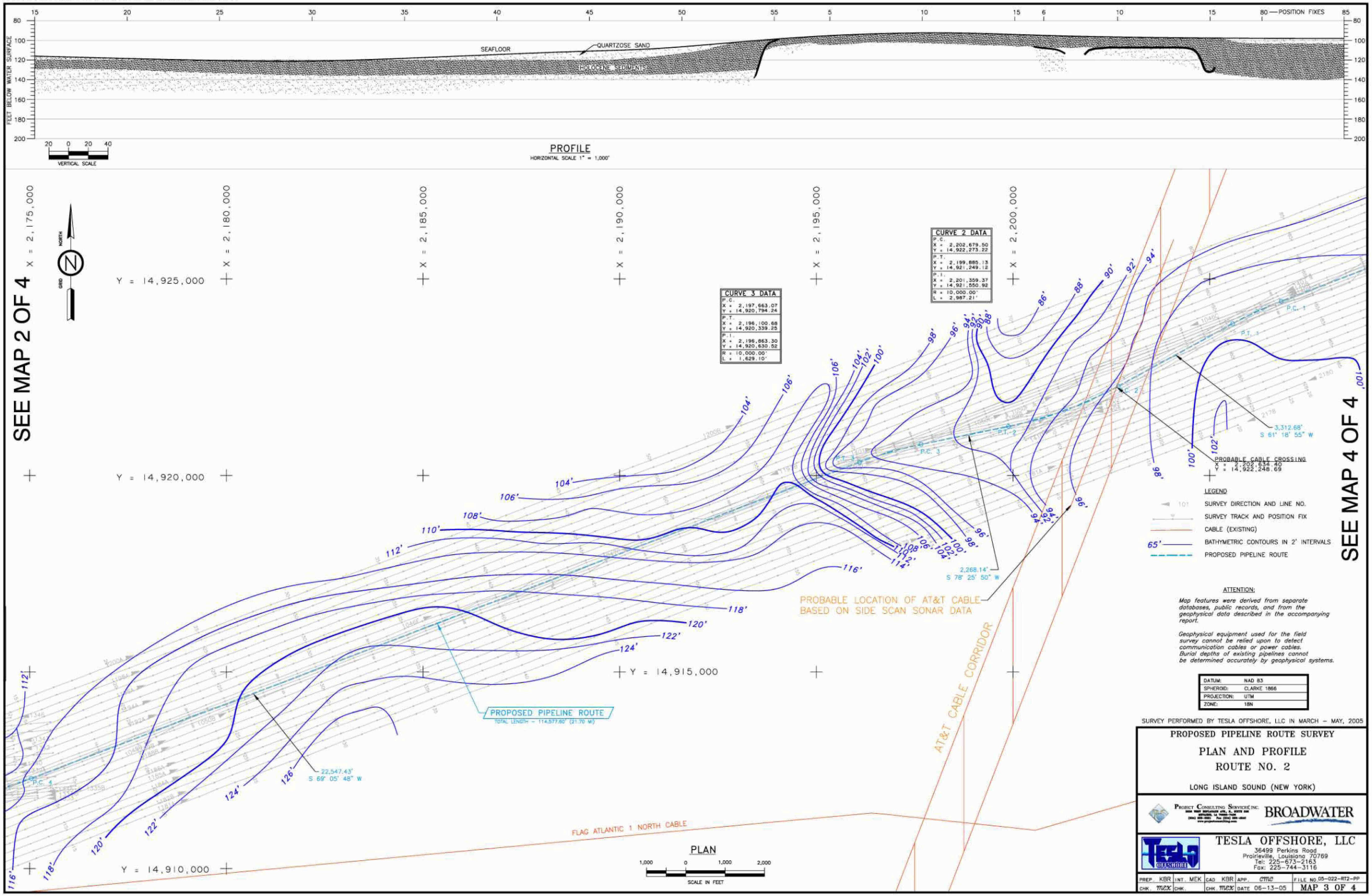
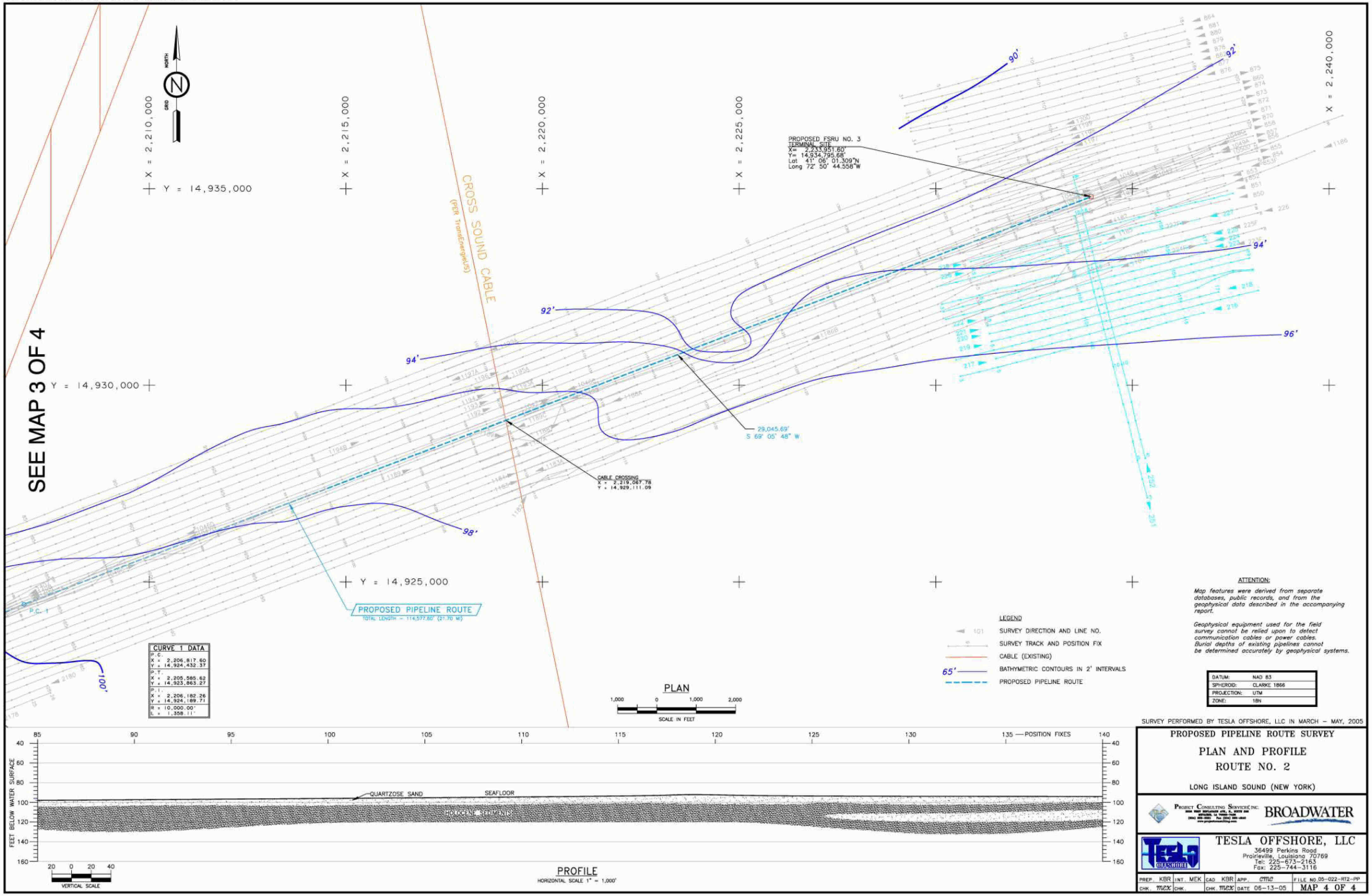
INT. MEK
CAD KBR
APP.
FILE NO. 05-022-RT2-PP
CHK.
DATE 06-13-05
MAP 2 OF 4



POSITION FIXES
FEET BELOW WATER SURFACE
SEAFLOOR
QUARTZOSE SAND
HOLOCENE SEDIMENTS
VERTICAL SCALE
PROFILE
HORIZONTAL SCALE 1" = 1,000'
SEE MAP 2 OF 4
SEE MAP 4 OF 4
NORTH
GRID
X = 2,175,000
X = 2,180,000
X = 2,185,000
X = 2,190,000
X = 2,195,000
X = 2,200,000
Y = 14,925,000
Y = 14,920,000
Y = 14,915,000
Y = 14,910,000
CURVE 3 DATA
P.C.
X = 2,197,663.07
Y = 14,920,794.24
P.T.
X = 2,196,100.68
Y = 14,920,339.25
P.I.
X = 2,196,863.30
Y = 14,920,630.52
R = 10,000.00'
L = 1,629.10'
CURVE 2 DATA
P.C.
X = 2,202,679.50
Y = 14,922,273.22
P.T.
X = 2,199,885.13
Y = 14,921,249.12
P.I.
X = 2,201,359.37
Y = 14,921,550.92
R = 10,000.00'
L = 2,987.21'
3,312.68'
S 61° 18' 55" W
PROBABLE CABLE CROSSING
X = 2,202,634.40
Y = 14,922,248.69
2,268.14'
S 78° 25' 50" W
PROBABLE LOCATION OF AT&T CABLE
BASED ON SIDE SCAN SONAR DATA
AT&T CABLE CORRIDOR
PROPOSED PIPELINE ROUTE
TOTAL LENGTH ~ 114,577.60' (21.70 MI)
22,547.43'
S 69° 05' 48" W
FLAG ATLANTIC 1 NORTH CABLE
PLAN
SCALE IN FEET
LEGEND
SURVEY DIRECTION AND LINE NO.
SURVEY TRACK AND POSITION FIX
CABLE (EXISTING)
BATHYMETRIC CONTOURS IN 2' INTERVALS
PROPOSED PIPELINE ROUTE
ATTENTION:
Map features were derived from separate databases, public records, and from the geophysical data described in the accompanying report.
Geophysical equipment used for the field survey cannot be relied upon to detect communication cables or power cables. Burial depths of existing pipelines cannot be determined accurately by geophysical systems.
DATUM: NAD 83
SPHEROID: CLARKE 1866
PROJECTION: UTM
ZONE: 18N
SURVEY PERFORMED BY TESLA OFFSHORE, LLC IN MARCH – MAY, 2005
PROPOSED PIPELINE ROUTE SURVEY
PLAN AND PROFILE
ROUTE NO. 2
LONG ISLAND SOUND (NEW YORK)
PROJECT CONSULTING SERVICES, INC.
BROADWATER
TESLA OFFSHORE, LLC
36499 Perkins Road
Prairieville, Louisiana 70769
Tel: 225-673-2163
Fax: 225-744-3116
PREP. KBR INT. MEK CAD KBR APP. cmc FILE NO. 05-022-RT2-PP
CHK. mex CHK. CHK. mex DATE 06-13-05 MAP 3 OF 4


SEE MAP 3 OF 4
NORTH
GRID
X = 2,210,000
X = 2,215,000
X = 2,220,000
X = 2,225,000
X = 2,240,000
Y = 14,935,000
Y = 14,930,000
Y = 14,925,000
CROSS SOUND CABLE
(PER TransEnergieUS)
PROPOSED FSRU NO. 3 TERMINAL SITE
X= 2,233,951.60'
Y= 14,934,795.68'
Lat 41° 06' 01.309"N
Long 72° 50' 44.558"W
29,045.69'
S 69° 05' 48" W
CABLE CROSSING
X = 2,219,067.78
Y = 14,929,111.09
PROPOSED PIPELINE ROUTE
TOTAL LENGTH = 114,577.60' (21.70 MI)
P.C. 1
90'
92'
94'
96'
98'
100'
CURVE 1 DATA
P.C.
X = 2,206,817.60
Y = 14,924,432.37
P.T.
X = 2,205,585.62
Y = 14,923,863.27
P.I.
X = 2,206,182.26
Y = 14,924,189.71
R = 10,000.00'
L = 1,358.11'
PLAN
1,000 0 1,000 2,000
SCALE IN FEET
LEGEND
SURVEY DIRECTION AND LINE NO.
SURVEY TRACK AND POSITION FIX
CABLE (EXISTING)
65' BATHYMETRIC CONTOURS IN 2' INTERVALS
PROPOSED PIPELINE ROUTE
ATTENTION:
Map features were derived from separate databases, public records, and from the geophysical data described in the accompanying report.
Geophysical equipment used for the field survey cannot be relied upon to detect communication cables or power cables. Burial depths of existing pipelines cannot be determined accurately by geophysical systems.
DATUM: NAD 83
SPHEROID: CLARKE 1866
PROJECTION: UTM
ZONE: 18N
SURVEY PERFORMED BY TESLA OFFSHORE, LLC IN MARCH – MAY, 2005
85 90 95 100 105 110 115 120 125 130 135 140
POSITION FIXES
FEET BELOW WATER SURFACE
40 60 80 100 120 140 160
QUARTZOSE SAND
SEAFLOOR
HOLOCENE SEDIMENTS
20 0 20 40
VERTICAL SCALE
PROFILE
HORIZONTAL SCALE 1" = 1,000'
PROPOSED PIPELINE ROUTE SURVEY
PLAN AND PROFILE
ROUTE NO. 2
LONG ISLAND SOUND (NEW YORK)
PROJECT CONSULTING SERVICES, INC.
BROADWATER
TESLA OFFSHORE, LLC
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Fax: 225-744-3116
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APP. cmc
FILE NO. 05-022-RT2-PP
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CHK. mex
DATE 05-13-05
MAP 4 OF 4

6.2.2 Geology

The land-based geology of New York and Connecticut has little bearing on the Project other than the extension of bedrock formations into the Sound, potential faults, and potential seismic activity. The following is a summary of the geology along the shore of Long Island and Connecticut in the vicinity of the proposed location of the Project.

The proposed pipeline route lies within the Atlantic Coastal Plain (ACP) physiographic province, which stretches from Cape Cod south to the Yucatan Peninsula. The ACP is characterized as a flat, low-lying seaward-thickening wedge of Cretaceous-age and younger sediments that gently slope toward the sea. The ACP is part of a continuous surface that extends offshore, the underwater section of which comprises the continental shelf (Isachsen et al. 1991).

Long Island Sound lies at the contact boundary between crystalline Piedmont rock and the Cretaceous ACP strata (Williams 1981). Paleozoic-age crystalline bedrock underlies Long Island at depths to several hundred feet and rises toward Connecticut. The Upper Cretaceous-age Monmouth Group, Matawan Group, and Magothy formation sedimentary strata that overlie the bedrock surface are thin along the northern coast but thicken southward under the Sound and underlie the Long Island mainland. This assemblage of units is comprised of semi-consolidated coastal deposits of quartzose sand interbedded with silt and clay. The same bedrock surface that underlies Long Island forms nearly the entire mainland of Connecticut.

Installation of the stationary tower structure will require the placement of piles to ensure structural stability. The piles will be driven beneath the seabed floor to approximately 230 feet (70 m), depending on existing sediment and geological conditions. This estimated depth is based on a seabed anticipated to consist of silt and clay, and does not include bedrock drilling and installation. This depth is anticipated to be sufficient to provide stability for the mooring tower structure. Installation of these piles will not have any impact on the geologic structure underlying the Sound. Deep exploratory borings will be conducted in the later part of 2008 to assess the existing conditions underlying the Sound and to determine the actual depth to which the piles will be installed. The geotechnical investigation, to be carried out at the detailed design stage, will sample to a depth of 260 feet (80 m) and take samples at 5-foot (1.5-m) intervals. Data collected as part of this investigation will form the basis of detailed pile design, depth, driveability analysis, and process.

Most of the Long Island coast consists of glacial outwash (sand and gravel deposited by meltwater streams in front of the end moraine) and is marked by a sinuous ridge or terminal moraine comprised of till, gravel, sand, and clay that extends throughout western Long Island and across Staten Island. Although this and other glacial features were originally deposited on the land surface, rising sea level caused by the melting glaciers has since modified the moraines by wave action. On most of Long Island, Cretaceous deposits of up to 1,000 feet (305 m) underlie the glacial cover material. Surficial geology in the Northport, New York, area consists of glacial till ranging from 30 to 90 feet (9 to

27 m) thick. The till in this area was deposited adjacent to ice and is less well sorted and more permeable than commonly observed in till.

The Connecticut coast of Long Island Sound is highly irregular, with numerous embayments, nearshore islands, and coarse-grained sandpits and beaches. The coast is very rocky, dominated by Paleozoic-age crystalline bedrock and glacial debris. The bedrock surface of Connecticut has been deeply scoured by numerous glacial episodes, and many of the river valleys were greatly deepened and widened over time.

6.2.3 Mineral Resources

Based on a review of United States Geological Survey (USGS) and other geologic and nautical maps of the area, there are no known mining operations in the Sound. The USGS surface sediment location map for the Long Island Sound (*see* Figure 6-4) indicates that the bottom subsurface sediments in the Project area are generally sand and silt except for gravel sands and possibly bedrock at Stratford Shoal.

6.3 GEOLOGICAL HAZARDS

Potential geological hazards generally include ground failure caused by unstable soils (liquefaction), karst terrain (unexpected formation of sinkholes), seismicity (earthquakes), volcanism, or consequences of human activities (e.g., mining, blasting/construction, etc.). Problems associated with soil instability, human activities, karst terrain, and volcanism are not of concern for this Project. Therefore, the relevant potential geologic hazard for this Project is seismicity.

6.3.1 Seismicity

Earthquake activity is common in the eastern United States, although the likelihood of a damaging earthquake occurring in the Project area over the life of the Project is very low. As previously stated, the proposed pipeline route traverses the ACP physiographic province, which stretches from Cape Cod south to the Yucatan Peninsula. The ACP is a region of generally low seismicity marked by several distinct areas of higher activity. These higher activity areas can be correlated to unique specific structures or zones that are not found in the Project area and are not typical of the entire ACP. The largest earthquakes in the province found outside of these specific high activity zones have been Intensity VII on the modified Mercali scale (Stover and Coffman 1993). Most of these quakes had an intensity of less than V on the modified Mercali scale, where I is the least intensive (not felt except by very few under especially favorable conditions); VI is in the middle of the intensity scale (felt by all, heavy furniture is moved and, in a few instances, fallen plaster occurs); and XII is the most intensive (severe damage—lines of sight are distorted and objects are thrown in the air).

Earthquake intensities are measured using either the modified Mercali scale or the Richter scale. The Mercali scale measures the results of an earthquake, such as the shaking and damage that people actually feel and see. The Richter scale measures the magnitude of energy released in an earthquake by measuring the size of the seismic

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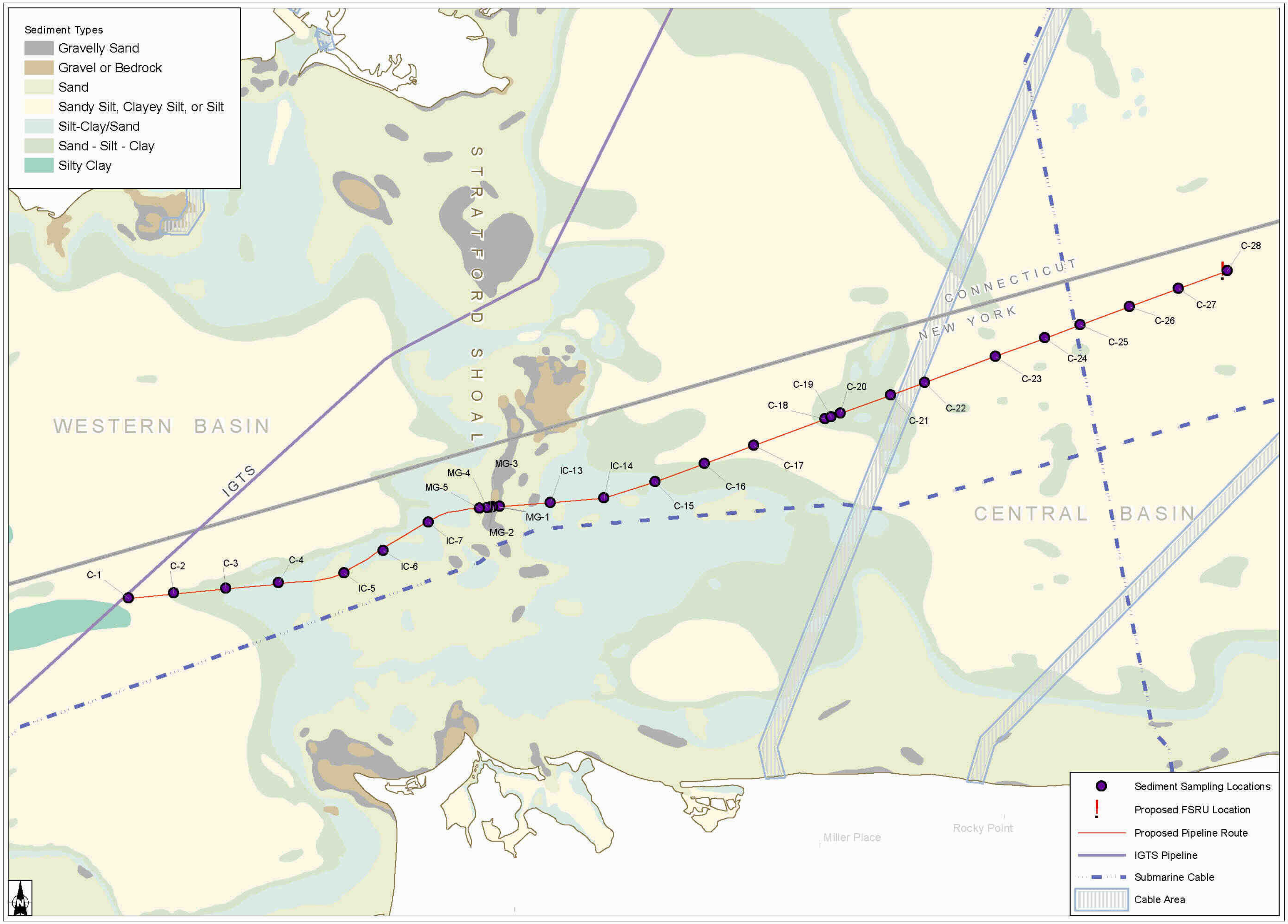

Source: U.S. Geological Survey Open-File Report OFR 00-304, 2000;
Broadwater Surveys conducted in April/May 2005.

0 2 4 8
Miles

Figure 6-4 Distribution of Sediment Types in the Project Area waves. Mercali numbers do not correspond directly to Richter numbers. The following is a comparison of the Mercali scale versus the Richter scale:

- Mercali I to V = Richter < 5.5
- Mercali VI and VII = Richter 5.5 - 6.1
- Mercali VIII and IX = Richter 6.2 - 6.9
- Mercali X = Richter 7.0 - 7.3
- Mercali XI = Richter 7.4 - 7.9
- Mercali XII = Richter > 8.0

According to the USGS (1996) ground-shaking map showing hazards from earthquakes (*see* Figures 6-5 and 6-6), Long Island Sound has a very low ground-shaking hazard. Ground shaking is expressed as a percentage of the force of gravity (%g). Figure 6-5 shows contours of the percentage of the force of gravity that has a 10% chance of being exceeded in any given 50-year period. For the 10% probability, the %g across the Sound from west (New York City area) to east (tip of Long Island) ranges from 6%g to 3%g, respectively. The FSRU is located near the 4%g border, while the pipeline will traverse the 4%g to 5%g zones. This means that there is a 10% chance that ground shaking with a force of 4%g to 5%g (which is very low) would occur at some point within a given 50-year period. For the 2% probability, the %g across the Sound from west (New York City area) to east (tip of Long Island) ranges from 20%g to 9%g, respectively. The FSRU is located in the 12 to 14%g range, while the pipeline will traverse the 12 to 18%g range. This means that there is a 2% chance that ground shaking with a force of 12 to 18%g would occur at some point within a given 50-year period.

For comparison purposes, a 2%g quake equates to an earthquake intensity of about IV on the modified Mercali scale (capable of rattling objects), and a 10%g to 20%g quake equates to an intensity of about VII (capable of breaking furniture and causing bricks to fall from buildings) (Kafka 2004).

According to the USGS Professional Paper 1527, Seismicity of the United States 1568 - 1989 (Stover and Coffman 1993), only three earthquakes with magnitudes > 4.5 (Richter scale) or an intensity > VI (Mercali scale) have originated in southeastern New York State or southern Connecticut since 1900. Through contacts with local experts, Broadwater has identified the presence of a feature within the Sound, the Branford Structure, also referred to as the Eastern Border Fault, which has been active since glacial retreat, and has recorded activity on a micro-seismic scale (DeBoer 2005). The tectonic/seismic lineament extends from east of Branford, Connecticut, to offshore of Bridgeport in an east-northeast direction. It is onshore until New Haven, and then dives below the post-glacial deposits of the Sound. Recent slippage has been identified in a wetland north of Branford. Figure 6-7 presents the general location of fault in relation to

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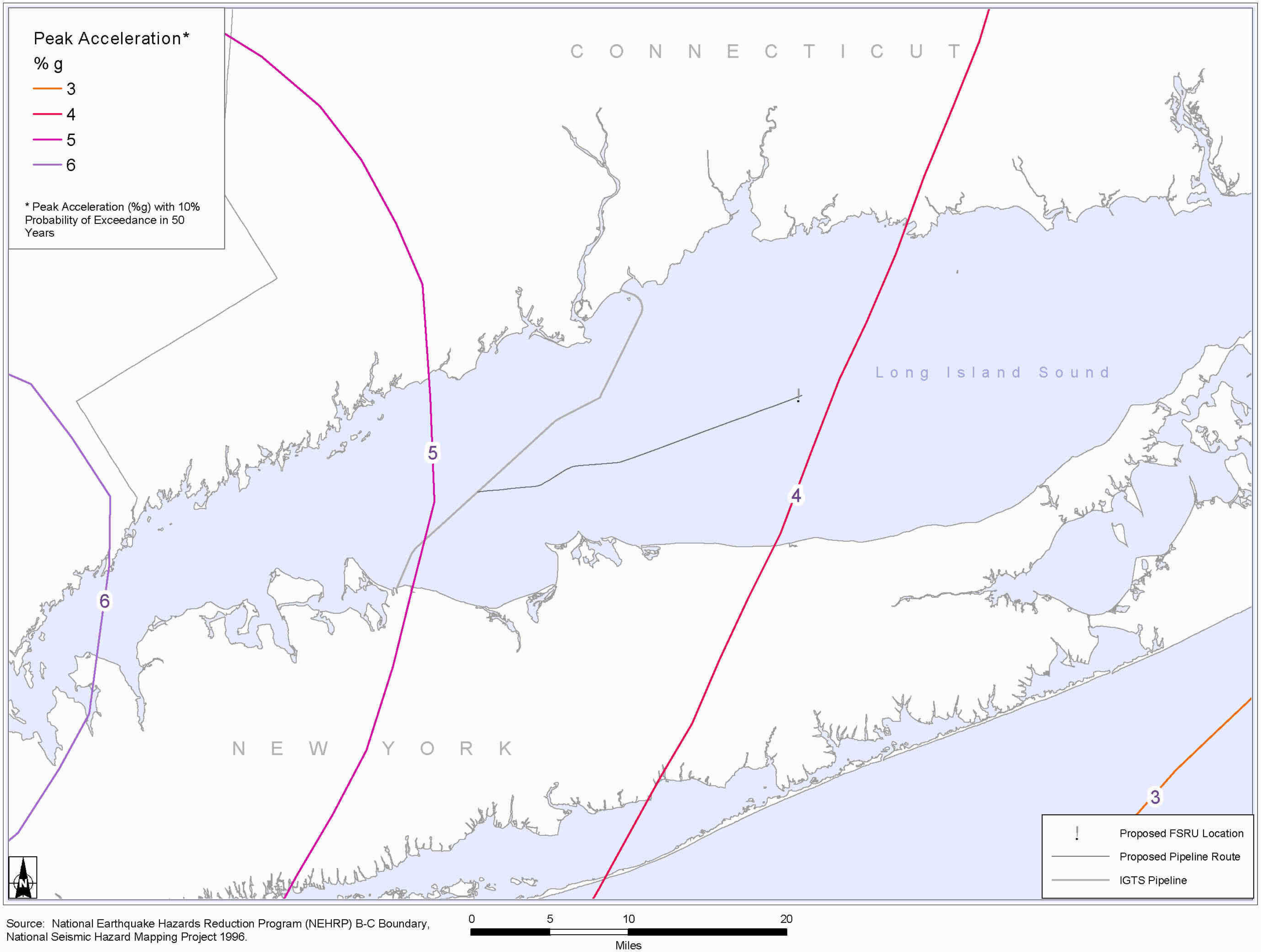
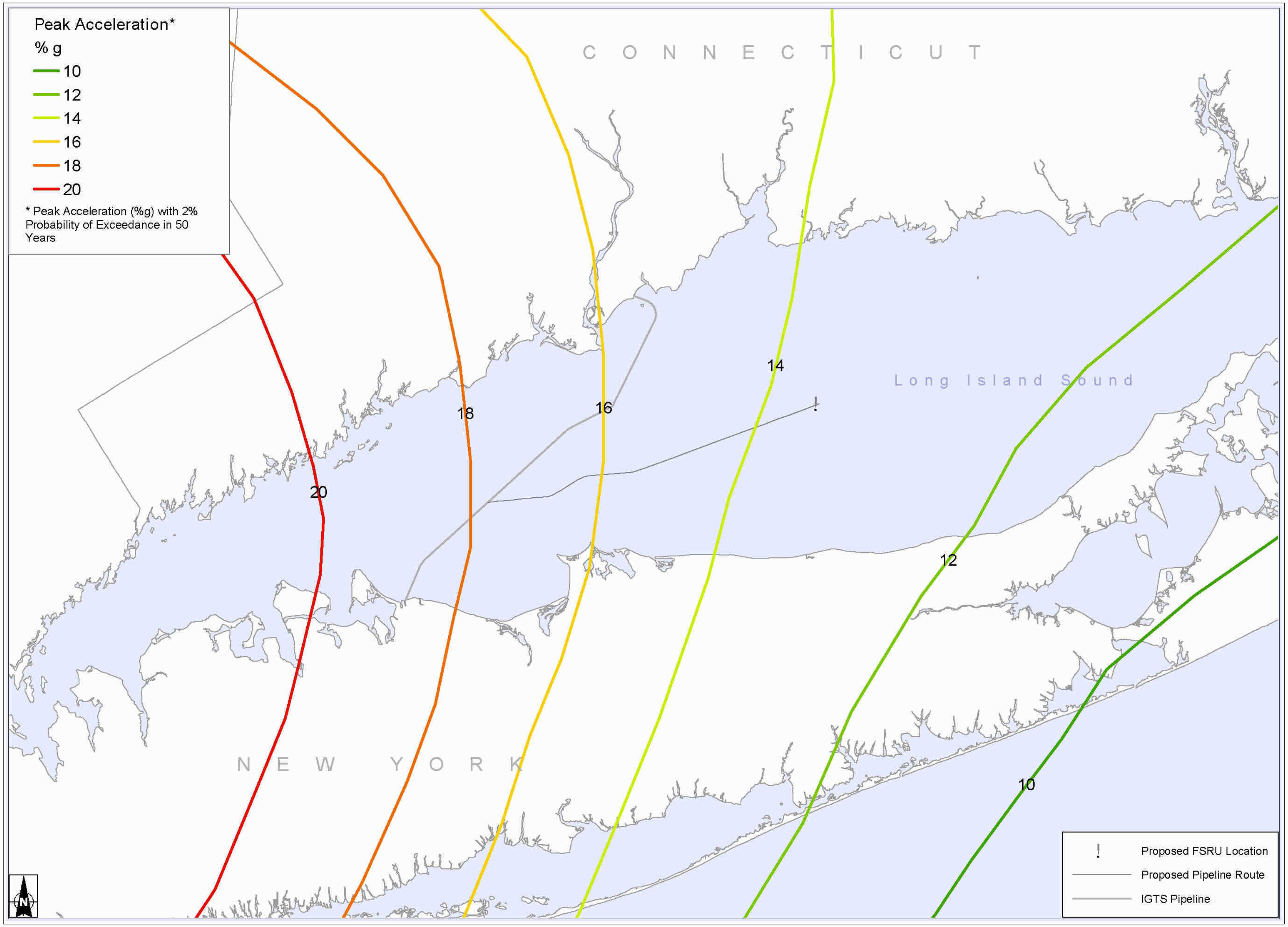


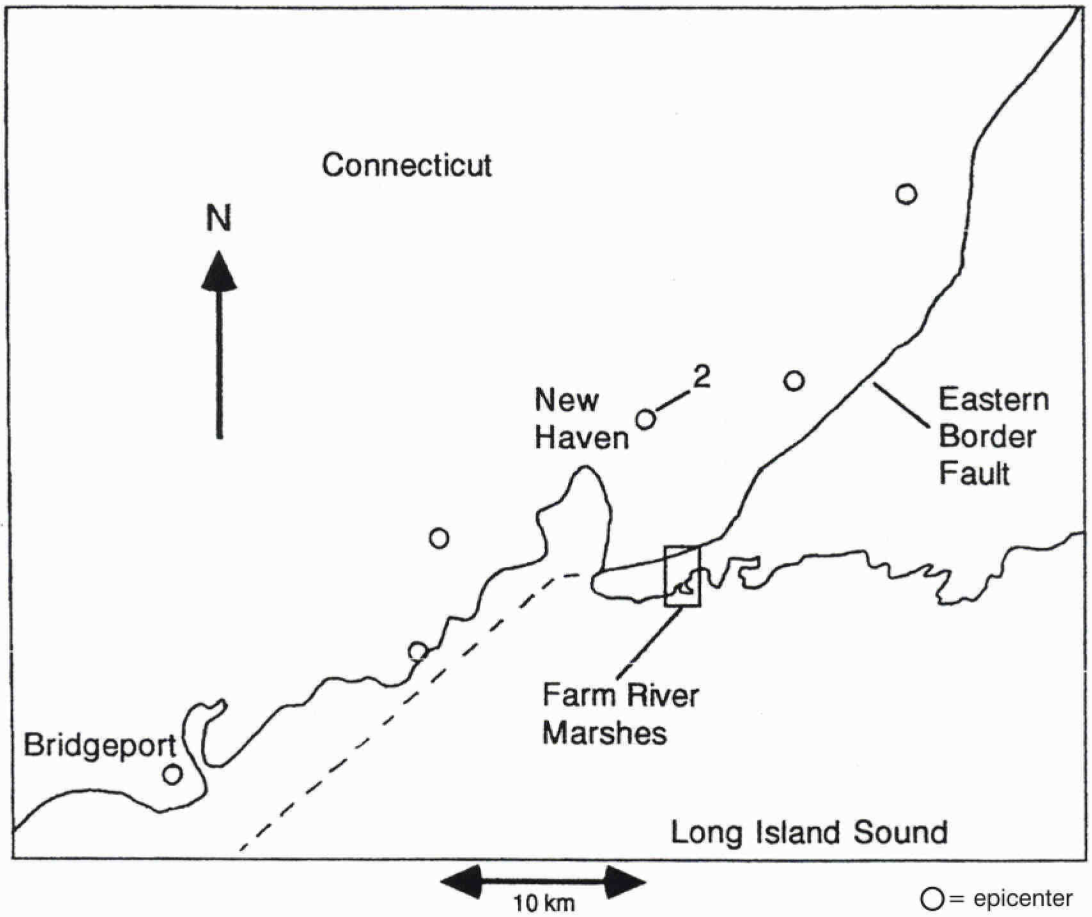
Source: National Earthquake Hazards Reduction Program (NEHRP) B-C Boundary, National Seismic Hazard Mapping Project 1996.

Figure 6-5 Ground-Shaking Hazard Map with 10% Probability



Source: National Earthquake Hazards Reduction Program (NEHRP) B-C Boundary, National Seismic Hazard Mapping Project 1996.

Figure 6-6 Ground-Shaking Hazard Map with 2% Probability



Source: Thompson 1999.

Figure 6-7 Earthquakes Spatially Associated with the Eastern Border Fault

Long Island Sound. The approximate location of the fault in relation to the Project is presented on Figure 6-8. Specific data regarding the earthquakes associated with the fault are presented in Table 6-1.

Table 6-1 Earthquake Epicenters Associated with the Eastern Border Fault

Date	North Latitude	West Longitude	Magnitude (Richter Scale)	Location
10/24/80	41.32	72.87	2.8	Fairhaven, CT
10/25/80	41.33	72.88	2.7	Fairhaven, CT
8/17/81	41.32	72.73	0.8	Totoket Mt., N. Brantford, CT
2/25/82	41.17	73.13	1.1	Lordship, CT
8/2/88	41.34	72.79	2	Tilcon Quarry, N. Brantford, CT

Table 6-1 Earthquake Epicenters Associated with the Eastern Border Fault

Date	North Latitude	West Longitude	Magnitude (Richter Scale)	Location
4/26/89	41.22	73	1.5	Woodmont, CT
4/27/89	41.27	72.99	2.8	West Haven, CT

Source: Thompson, 1999.

The fault is of a relatively young age and exhibits large offsets. Seven micro-earthquakes were noted in the 1980s, with magnitudes ranging from 0.8 and 2.8. The epicenters of these seven events also are indicated on Figure 6-7. With the magnitudes of these micro-earthquakes all less than 3, which is well within the design capacity of pipelines, it is not anticipated that this fault will have any impact on the operations of the Project. The estimated relationship of the Eastern Border Fault to the Project area is presented on Figure 6-8. Although no definitive data could be located regarding the exact orientation and position of the fault within Long Island Sound, this figure indicates that the Eastern Border Fault would not traverse Broadwater, but in fact likely underlies the existing IGTS system. The largest earthquake in the area dates back to 1791 with a magnitude of 4.1, which caused disturbance along Long Island (DeBoer 2005).

In 1974, a 3.8 magnitude, VI intensity earthquake occurred in Wappingers Falls (Dutchess County) that toppled a bookcase and broke a few windows in the area. In 1983, a 3.0 magnitude, VI intensity earthquake occurred in Lagrangeville (Dutchess County) that caused slight damage to property in two towns, Lagrangeville and Pawling. In 1985, a 4.0 magnitude, VI intensity earthquake occurred near Beach Hill (Westchester County) that caused light damage (broken windows and cracked plaster/drywall) at a few towns in New York, Connecticut, and New Jersey. All three earthquakes are classified as possibly causing minor damage to poorly built buildings (e.g., cracked plaster), but likely would not be capable of damaging a pipeline system.

In addition, according to the USGS Earthquake Hazards program, there is only a 3% to 6% probability of an earthquake with a magnitude >4.75 (Richter scale) occurring within a 50-year period in the Project area (*see* Figure 6-9). The probability increases to the west toward New York City and decreases to the east toward the tip of Long Island. The probability also decreases significantly with higher magnitudes (i.e., a quake with a magnitude of a >7.01 [Richter scale] has a probability of only 0.1% to 0.5% in the Project area [*see* Figure 6-10]). It is reasonable to assume that an intensity VII event could occur anywhere within the Project area, although the likelihood of such an event at any given point is extremely small. In general, pipeline systems have been demonstrated to be capable of withstanding earthquakes of up to intensity VII with little damage (FERC 2000). Therefore, based on this information, the likelihood of a damaging earthquake occurring in the Project area over the life of the Project is very low.

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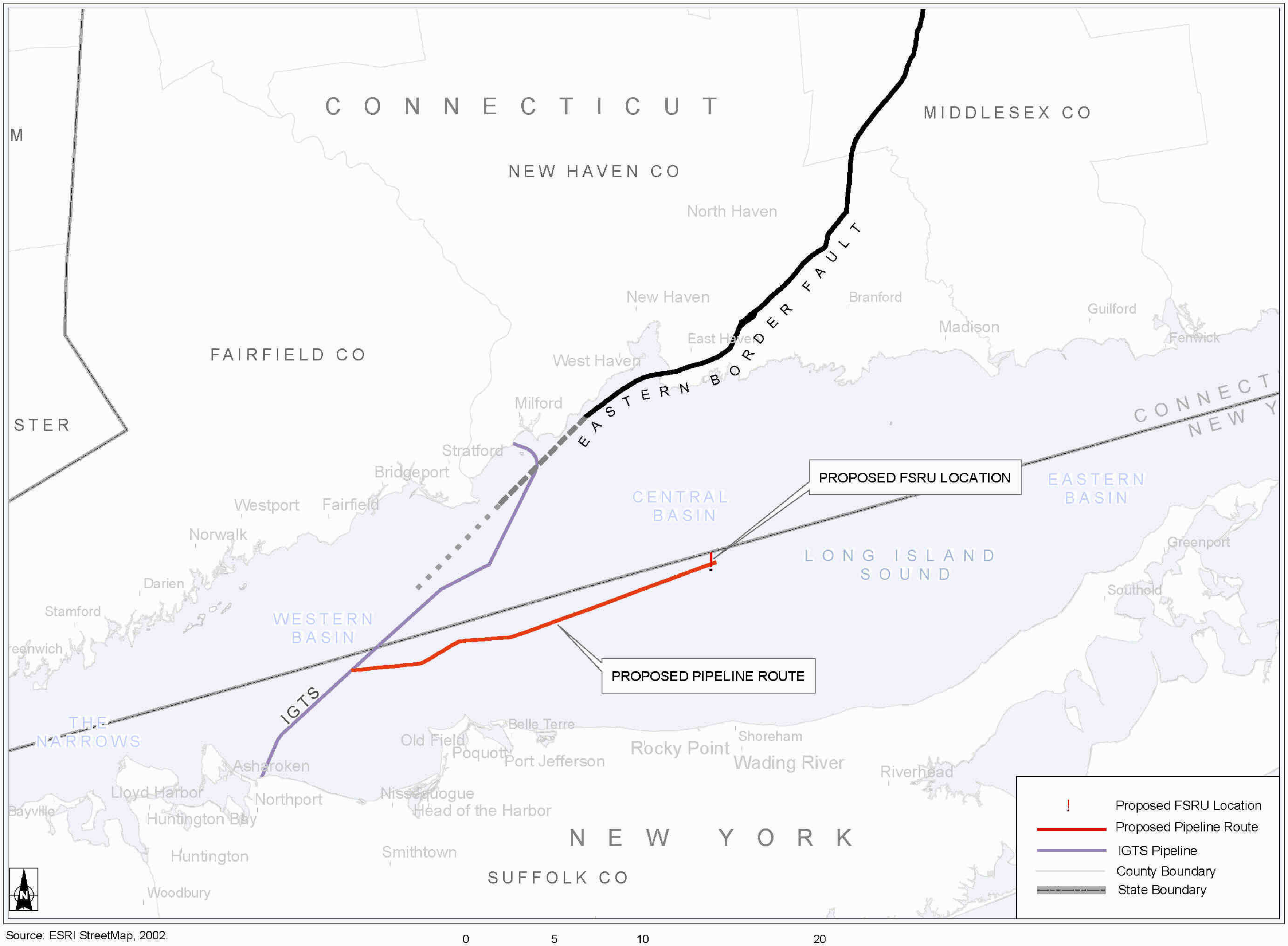

Source: ESRI StreetMap, 2002.

Figure 6-8 Eastern Border Fault and Proposed Broadwater Project Location

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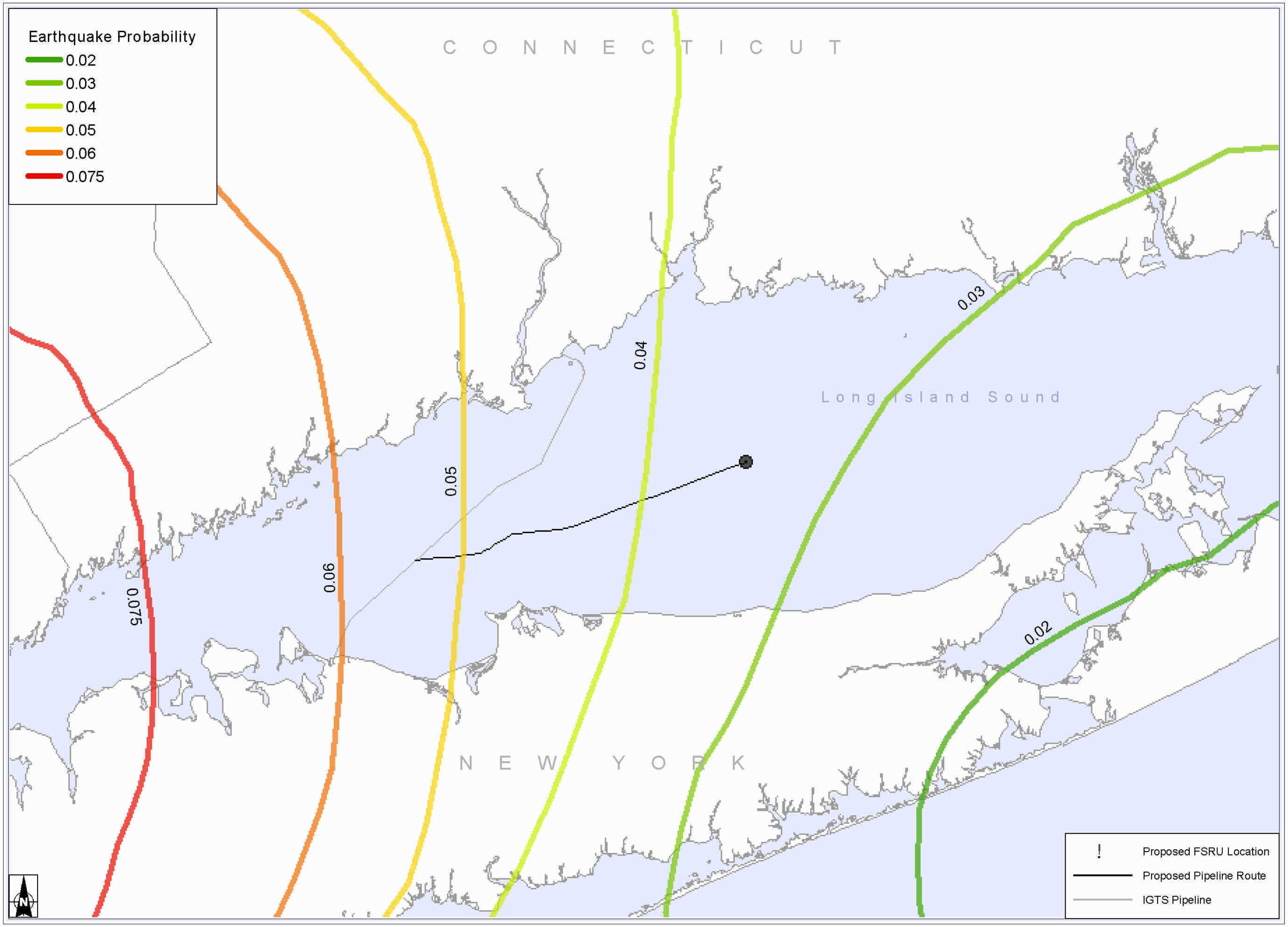

Source: National Earthquake Hazards Reduction Program (NEHRP) B-C Boundary, National Seismic Hazard Mapping Project 1996.

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Miles

Figure 6-9 Earthquake Probability - Magnitude (Richter Scale) > 4.75

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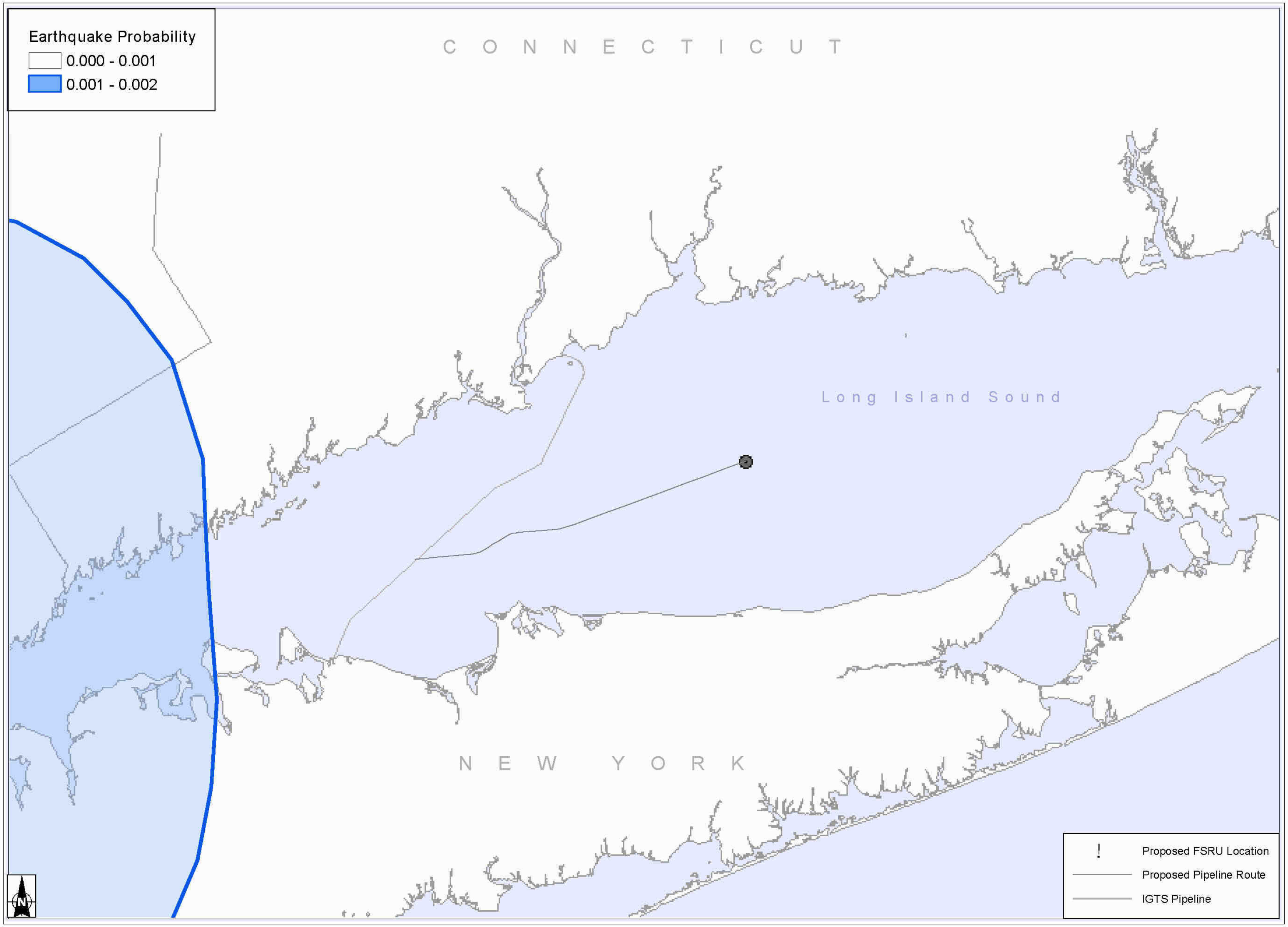

Source: National Earthquake Hazards Reduction Program (NEHRP) B-C Boundary, National Seismic Hazard Mapping Project 1996.

0 5 10 20
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Figure 6-10 Earthquake Probability - Magnitude (Richter Scale) > 7.01

6.4 BLASTING

The sediments toward the eastern and western extents of the proposed pipeline appear to be composed primarily of silty sands and silty clays. Existing resource mapping of the Stratford Shoal indicates the potential presence of bedrock, which could potentially require blasting in conjunction with pipeline installation. The Stratford Shoal is an area of shallow, hard material located in the middle of Long Island Sound, straddling the New York/Connecticut border.

An extensive geophysical and geotechnical investigation was conducted within the Project area in spring 2005. Vibratory core sampling across Stratford Shoal identified the presence of very hard subsurface material resulting in core refusal. Refusal of this nature is potentially indicative of bedrock or glacial till. In-field investigation of the cores collected at the shoal indicated the presence of large cobbles, which likely contributed to core refusal. However, additional geotechnical investigations of Stratford Shoal demonstrated the ability to insert a 1-inch-diameter solid steel probe through the upper portion of the surface sediment, to the required depth for pipeline installation. The presence of this unconsolidated material in the upper soil horizon indicates that bedrock is not present near the surface and that pipeline installation could be performed using conventional installation technology and would not require blasting. Based on the results of this investigation, blasting will not be required for installation of any portions of the Project. If adequate burial depth cannot be achieved during construction, Broadwater will utilize concrete mats to provide adequate pipeline protection.

6.5 PALEONTOLOGICAL RESOURCES

There are no areas of paleontological significance in the vicinity of the proposed pipeline Project area (FERC 2000, 2001). The geologic units underlying the proposed Project are comprised mainly of igneous or metamorphosed bedrock and glacial deposits, limiting the possibility of encountering geologic units containing paleontologic specimens.

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