APPENDIX G

MID-LINE BUOY ASSESSMENT

Broadwater LNG Gas Pipeline Project: Evaluating Pipe Laying Alternatives and Environmental Consequences
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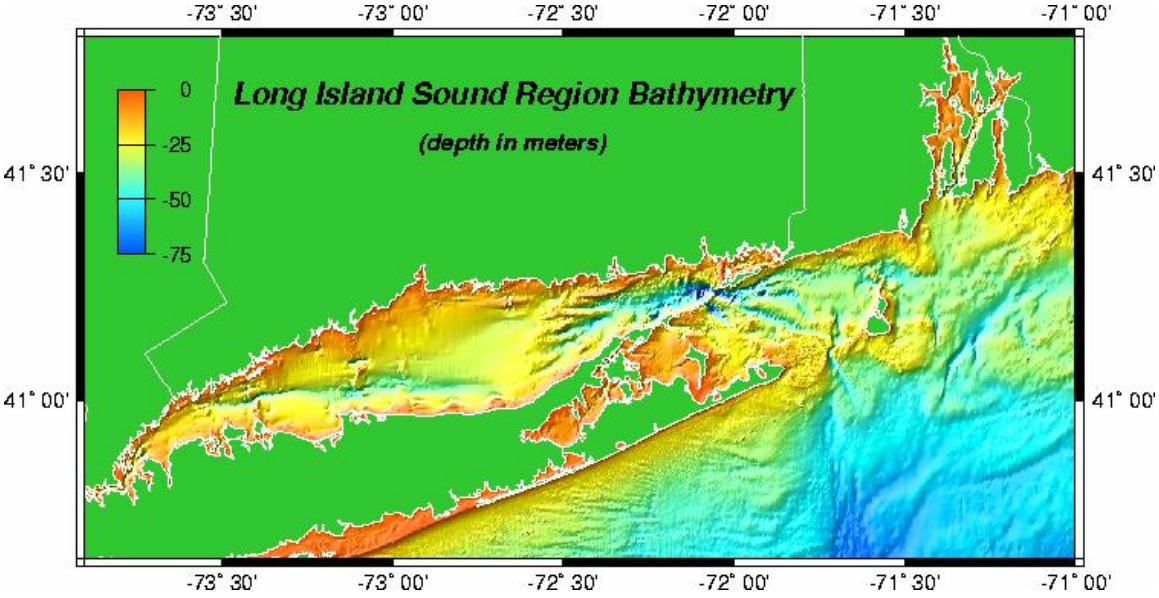


INTRODUCTION

The Broadwater LNG Project has been proposed in the middle of Long Island Sound. Part of the Project consists of a 21.7-mile-long, 30-inch-diameter submarine pipeline to connect the Broadwater LNG terminal to the existing IGTS pipeline in Long Island Sound. We evaluated the validity of the proposed anchoring impact estimates associated with pipeline construction, and assessed alternatives to the proposed anchoring methods that could potentially reduce impacts to the seafloor including use of a dynamically positioned (DP) laybarge and the use of mid-line buoys (MLBs) on anchor cables. This assessment is based on review of Broadwater's application (primarily Broadwater LNG 2006), and our evaluation of the post-construction monitoring results for the Gulfstream pipeline project (ENSR 2002). The Gulfstream post-construction monitoring was conducted following installation of the subsea Gulfstream pipeline using both a DP vessel and an anchored laybarge with and without the use of MLBs.

PROPOSED BROADWATER LNG PROJECT

Broadwater's proposal includes use of an 8-point mooring array for the pipeline laybarge with 3 anchor sets per mile and 3 passes of the laybarge along the pipeline route (one for laying pipe and two for plowing). Thus, there would be an estimated 1,562 anchor placements along the 21.7-mile pipeline during pipeline installation. The 8-point mooring array would occur within a 4,000 foot corridor centered on the pipeline. The following figure presents the proposed anchoring configuration.

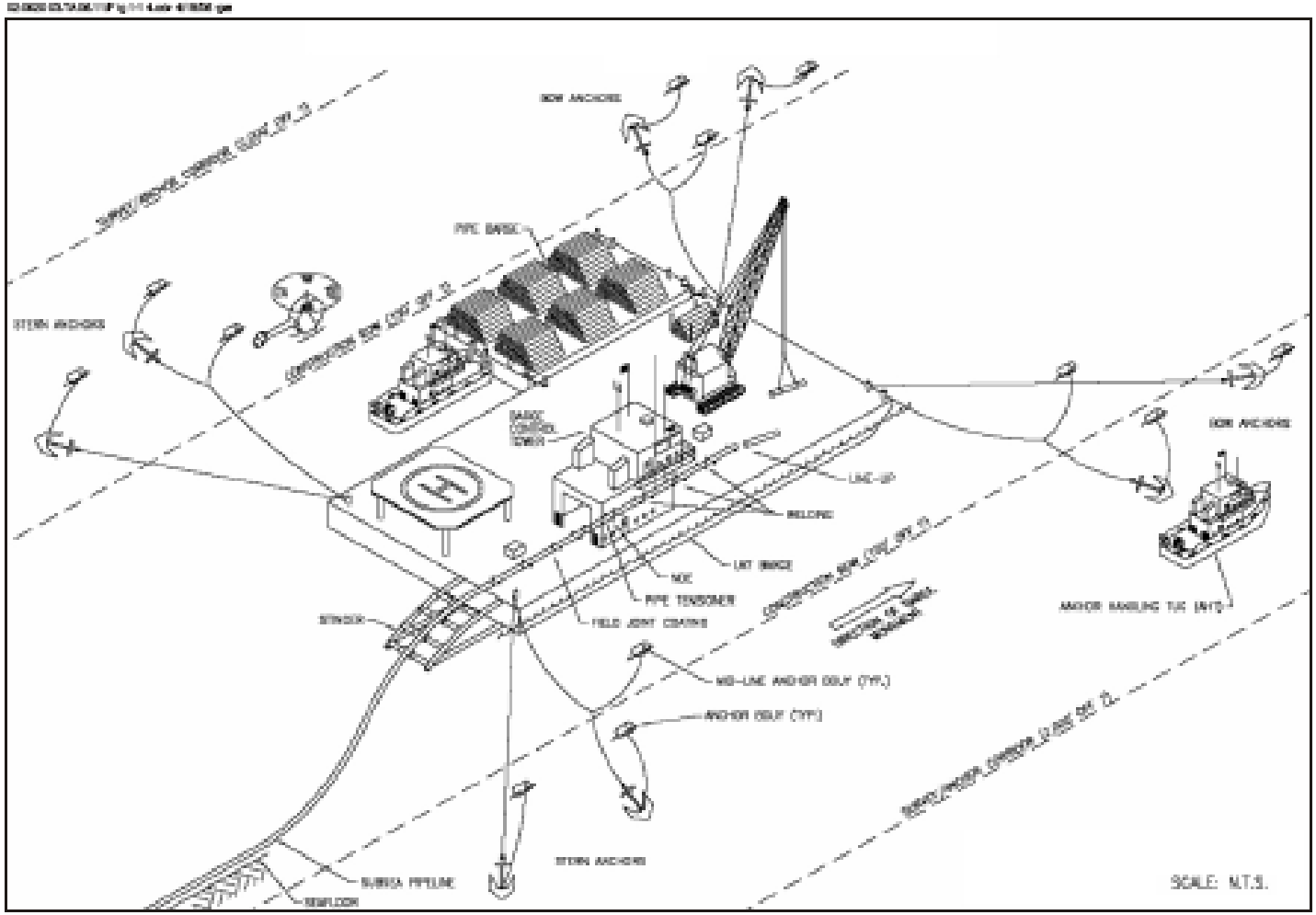
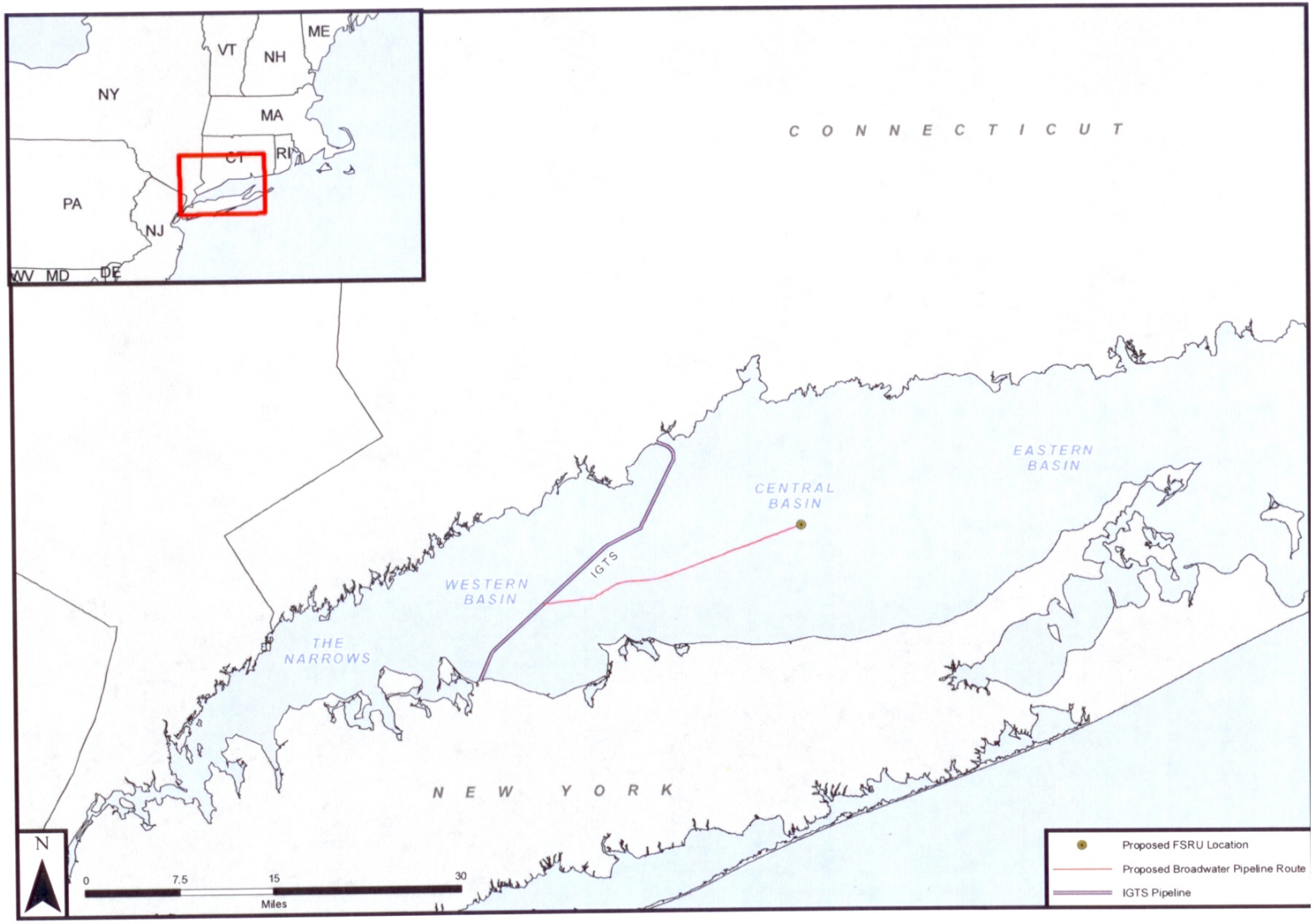


Figure 1-14 Typical Pipeline Lay Barge Spread (Rev 1)

Four anchors would be positioned off the sides of the laybarge (2 port and 2 starboard quarter anchors), and extend up to 2,000 feet from the laybarge. The remaining 4 anchors would include 2 bow anchors and 2 stern anchors, which would extend up to 2,500 feet from the laybarge. The laybarge would progress along the pipeline route as it deployed the pipe by winching in the bow cables and forward quarter cables, and releasing the tension on the stern and rear quarter cables. Approximately every 0.3 to 0.5 mile the anchors would be retrieved and redeployed. Bow and forward quarter anchors would be placed at approximately the maximum distance ahead of the laybarge, and the stern and rear quarter anchors would be placed relatively close to the laybarge. The process would be repeated as the lay barge proceeds along the path.

Potential anchoring impacts to the seafloor would include (1) the footprint of the anchor itself, (2) trenches created if the anchor fails to hold, and (3) anchor cable sweep. Cable sweep is caused by slack in anchor lines and the cables making contacting with the seafloor. When the cable is winched in or towed by the barge, it scrapes along the sea floor. Broadwater's proposed acreage impacts are summarized in Table 1 associated with the use of MLBs. The concept of MLBs is that they prevent most of the cable from making contact with the seafloor, thereby reducing the extent of cable sweep. Some cable sweep would likely still occur especially immediately adjacent to the anchor on the seafloor. Broadwater has currently proposed to use MLBs only on the quarter anchors (4), which they report would reduce seafloor impacts by 70 percent compared to not using MLBs on any anchor cables. FERC has included a requirement in the Draft Environmental Impact Statement for the Broadwater LNG Project to either use MLBs on all cables (including the bow and stern cables) or use a DP vessel (FERC 2006). Broadwater has reported that the use of MLBs on the bow and stern cables would reduce the extent of seafloor impacts associated with cable sweep by 49 percent compared to only using MLBs on the quarter cables. A DP vessel uses thrusters to move or maintain station and would not cause any anchoring impacts.

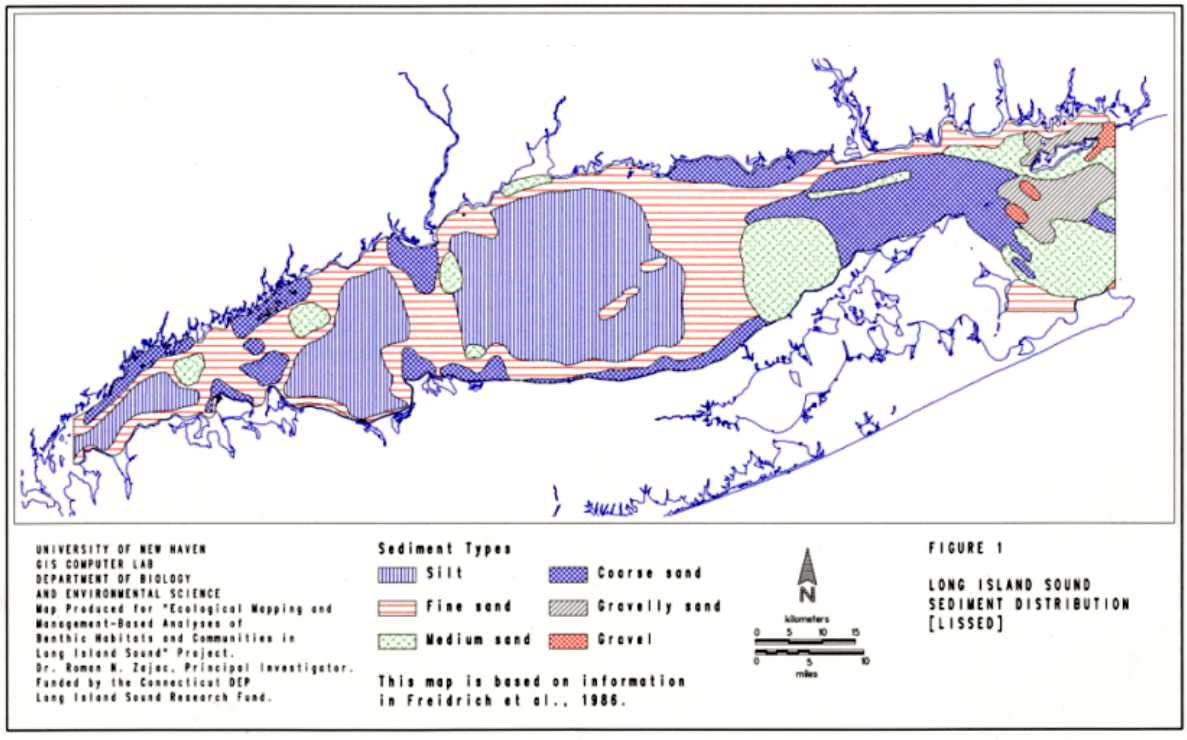
Broadwater has estimated that anchor footprints would total approximately 16.0 acres for the entire pipeline. According to the Gulfstream EIS, the footprint of a 22-ton anchor used in the industry is approximately 180 square feet (10 feet x 18 feet; FERC 2001). Thus, Broadwater's estimate appears to allow for the actual anchor footprint as well as some movement by the anchor during deployment and retrieval (averaging approximately 446 square feet assuming 1,562 anchor placements).



Proposed Broadwater gas pipeline (red) and IGTS pipeline (purple)

TABLE 1 Broadwater's Comparison of Anchor Cable Sweep Impact Areas			
Scenario	**Pipelay (acres)**	**Plowing (acres)**	**Total Acres**
No Mid-line Buoys	3,750	3,060	**6,810**
Mid-line Buoys on Quarter Anchor Cables	950	1,070	2,020
Mid-line Buoys on All Anchor Lines	359	672	1,031
Dynamically Positioned Laybarge	0	0	0

The seafloor in the Project area is generally sedimentary; sand and silt-clay are prominent (Knebel et al. 1999). The Stratford Shoal area is located along the pipeline route and is composed of gravel and cobble bottom type. Water depths along the proposed pipeline route range from about 58 to 130 feet. Depths are sufficient that thruster wash would not disturb the sea floor.



GULFSTREAM PIPELINE PROJECT

Gulfstream Natural Gas System, L.L.C. constructed a marine pipeline in 2001 to transport natural gas from Mississippi and Alabama across the Gulf of Mexico to Tampa Bay, Florida. During construction, specialized pipeline lowering and trenching technologies such as a submarine plow, careful placement of anchors, use of computer anchoring management system (CAMS) anchor

handling system, the deployment of mid-line buoys on construction barge anchor cables, and the use of a DP vessel to pull the trenching plow, where feasible, were employed to minimize disturbance. The anchored laybarges used either an 8- point or a 12-point mooring array with approximately 2 anchor sets per mile. According to the Gulfstream EIS, 22-ton anchors measuring approximately 10 feet by 18 feet were proposed on the Gulfstream project. For the portion of the pipeline route described below, water depths were generally 60 feet or greater and the seafloor was composed of both softbottom and hardbottom substrates.

Following construction, Gulfstream Natural Gas System conducted a comprehensive study comparing anchoring impacts to the seafloor with MLBs versus anchoring impacts without MLBs as reported in *An assessment of potential additional impacts associated with non-use of mid-line buoys during the OCS construction of the Gulfstream Natural Gas System* (ENSR 2002). Post-construction monitoring surveys were conducted using sidescan sonar, a remotely operated vehicle (ROV), and divers to assess the extent and magnitude of anchoring impacts in areas where MLBs were used compared to areas where MLBs were not used. The following discussion describes the seafloor impacts associated with DP vessels, MLBs, and anchors based on the Gulfstream project.

Dynamically Positioned Laybarge

During the Gulfstream project, DP vessels were used to plow the trench in the federal zone of jurisdiction in depths as shallow as 40 feet. There was no evidence that the thrusters on the DP vessels disturbed the seafloor.

Use of Mid-line Buoys

Post-construction surveys were conducted using sidescan sonar and ROV along portions of the pipeline where the anchors were deployed both with and without MLBs. Overall, the surveys included the 18.4 mile long pipeline section where MLBs were not employed (3,280 foot survey corridor) and 5.3 miles of pipeline route where MLBs were employed on all anchors for reference. The laybarge (LB-200) had a CAMS that compiled the anchor drops, lifts, the point where the cable touched the seafloor, and the area from the anchor to the point where the cable touched down.

Based on these surveys, the cable sweep footprints originating from the anchor crater were two to three feet wide and one foot deep, and the cable footprints narrowed as a function of distance from the anchor footprint. The typical cable footprint leading away from the anchor was 1 to 1.5 feet wide and 4 to 8 inches deep.

The length of the cable footprints on the seafloor averaged 2,310 feet when MLBs were used (range of 466 to 6,135 feet), and 3,176 feet when MLBs were not employed (range of 0 to 6,142 feet; Table 2). The cable sweep areas averaged 1,766 square feet when MLBs were deployed (0 to 9,213 square feet) and 3,401 square feet when MLBs were not deployed (0 to 9,231 feet). Thus, the use of MLBs reduced the length of the cable footprint by 27.3 percent and the impact area by 48 percent. The Gulfstream monitoring report concludes that use of MLBs significantly reduced cable sweeps.

TABLE 2
Cable sweep and anchor scar results from Gulfstream post-construction monitoring[a]

	Depth (ft)		Area (ft^2)		Length (ft)	
	No MLBs	With MLBs	No MLBs	With MLBs	No MLBs	With MLBs
Cable Sweep, range	N/A	N/A	0-9,213	233-4,601	0-6,142	466-6,135
Cable Sweep average	N/A	N/A	3,401	1,766	3,176	2,310
Anchor scar range	0-5	1-4	0-11,956	367-6,242	N/A	N/A
Anchor scar average	2.6	2.1	3,333	2,326	N/A	N/A

Notes:
[a] ENSR 2002

Anchors

According to the Gulfstream EIS, the LB 200 laybarge used anchors in the Tampa Bay region that were 10 feet by 18 feet wide (180 square feet), and weighed 22 tons. It was estimated prior to construction that the anchor would create an average footprint on the seafloor of 360 square feet. This is twice the actual anchor dimension, providing an extreme case scenario.

The Gulfstream monitoring report found anchor dragging averaged 3,333 square feet without MLBs and 2,326 square feet with MLBs. We were unable to define the cause of this large difference as it relates to the use of MLBs since MLBs do not directly reduce anchor dragging. However, this 30 percent reduction is likely associated with improved anchor handling methods along different portions of the pipeline route as well as possible differences in depth and substrate characteristics.

To further assess the actual size of seafloor impacts due to anchor footprints and anchor scars due to dragging, we assessed the sidescan sonar results for a nine-mile portion of the pipeline route (construction mile post 375 to mile post 386; map pages 36, 37, and 39). Of the 261 anchorings identified by sidescan along this portion of the pipeline route, the large majority (89.7 percent) of the depressions approximated the size of the anchors (footprint ranged from approximately 177 to 314 square feet). The anchor footprints were typically 2 to 3 feet deep. The remaining anchor locations (10.3 percent of the total) identified in the sidescan survey documented anchor scars where the anchors had apparently been dragged (Table 3). In instances where anchor dragging occurred, the impacts were relatively substantial. The average anchor scar was approximately 290 feet long and 24 feet wide totaling 6,960 square feet. MLBs were used on all anchor cables along this portion of the pipeline. Based on the findings of the Gulfstream monitoring report, the extent of seafloor impacts due to anchor dragging could possibly be approximately 70 percent greater if MLBs had not been used.

TABLE 3
Anchor impacts between mile post 375 to 386; Side scan sonar surveys (lay barge utilized 12 anchors, mid line buoys were used on all anchors)

Parameter	MP 375-379	MP 380-383	MP 383-386	Total/summary
Documented anchor drops	79	79	103	261
Detected anchor drops	82	39	79	200
Detected anchor scars	9	4	14	**27**
Total anchor scar length (ft)	3185	951	3683	7819
Minimum length (ft)	119	113	90	90
Maximum length (ft)	995	326	751	995
Average length (ft)	353.89	237.75	263.07	**289.59**
Std. dev.	283.73	92.55	178.17	209.43

EXPECTED ANCHORING IMPACTS ASSOCIATED WITH THE BROADWATER PROJECT

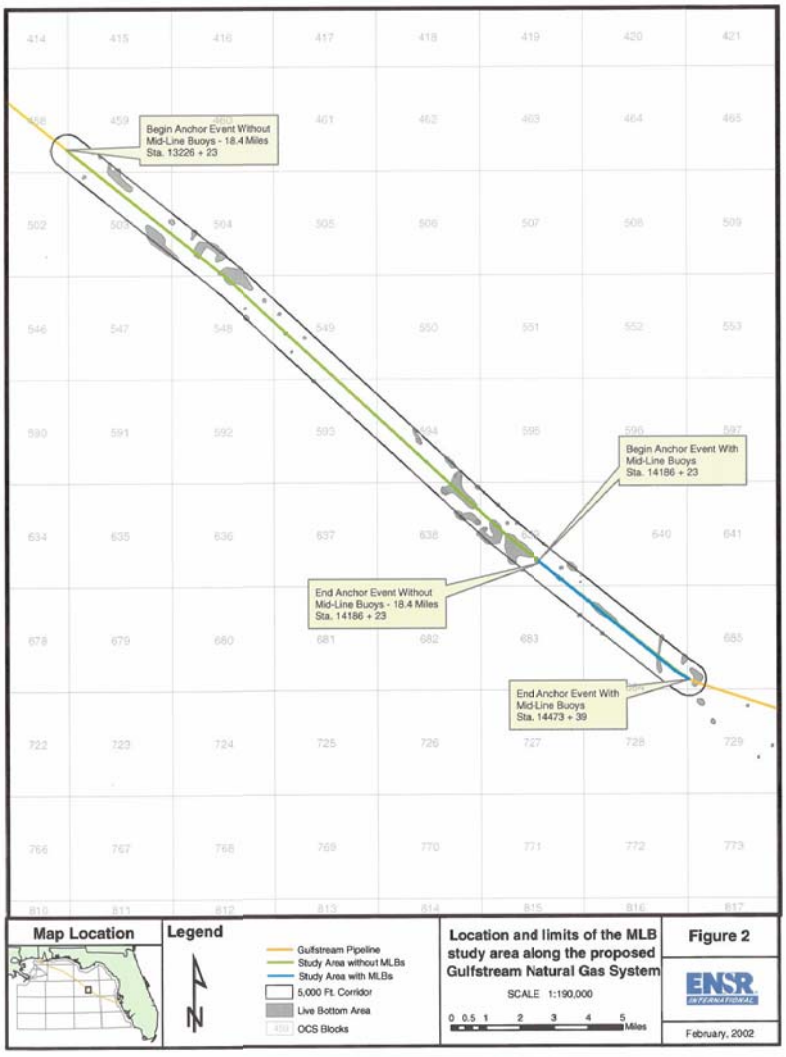
Based on the comparable construction equipment and methods, the results from the Gulfstream project can be used to identify the expected anchoring impacts during pipeline installation for the Broadwater LNG Project.

Dynamically Positioned Laybarge

A DP vessel to lay the pipeline and plow the trench would eliminate all anchor and cable impacts. A DP vessel could be operated in depths along the entire Broadwater pipeline route without sediment disturbance due to the thrusters. However it is doubtful that a DP laybarge is available for laying a 30-inch pipeline. A DP trenching ship may be available and should be considered because it would eliminate approximately 67 percent of the anchor and cable sweep impacts since two of the three passes would be associated with trenching.

Cable Sweep and Mid-line Buoys

Mid-line buoys were successfully employed on all anchor cables of the laybarge during the Gulfstream pipeline construction. The technology is feasible and would not be difficult to employ on the Broadwater project.


Begin Anchor Event Without Mid-Line Buoys - 18.4 Miles Sta. 13226 + 23
Begin Anchor Event With Mid-Line Buoys Sta. 14186 + 23
End Anchor Event Without Mid-Line Buoys - 18.4 Miles Sta. 14186 + 23
End Anchor Event With Mid-Line Buoys Sta. 14473 + 39
Map Location
Legend
Gulfstream Pipeline
Study Area without MLBs
Study Area with MLBs
5,000 Ft. Corridor
Live Bottom Area
OCS Blocks
Location and limits of the MLB study area along the proposed Gulfstream Natural Gas System
SCALE 1:190,000
0 0.5 1 2 3 4 5 Miles
Figure 2
ENSR INTERNATIONAL
February, 2002

Broadwater's estimated seafloor impacts associated with cable sweep with and without MLBs are significantly greater than would be expected based on the results of the Gulfstream post-construction surveys. On Gulfstream, cable sweep averaged 3,401 square feet per anchor without MLBs. With MLBs, the average area of cable sweep per anchor was 1,766 square feet with an average length of 2,310 feet. Thus with or without MLBs, the cable sweep acreage per anchor on Gulfstream was less than 0.1 acre. Broadwater estimated cable sweep would average approximately 4.4 acres per anchor without MLBs (assuming 1,562 anchors). With MLBs on all anchor cables, Broadwater has estimated that overall cable sweep would impact 1,031 acres. The expected acreage impacted due to cable sweep on Broadwater with MLBs would be a maximum of 63.3 acres based on the acreage per anchor results of the Gulfstream monitoring (1,766 square feet per anchor) and there being approximately 1,562 anchor deployments for Broadwater.

However, the expected cable sweep on the Broadwater Project would theoretically be substantially less than documented on the Gulfstream project based on the maximum length of the anchor cable proposed by Broadwater. On the Gulfstream project, cable footprints extended up to about 6,140 feet (with and without MLBs). On the Broadwater Project, the maximum amount of cable extended would average 2,250 feet (4 bow/stern cables would have a maximum extension of 2,500 feet and the 4 quarter cables would have a maximum extension of 2,000 feet). Using this maximum value for cable length contacting the seafloor (albeit impossible), the overall seafloor impact due to cable sweep during pipeline installation by Broadwater would be about 61.7 acres (based on impact per foot of cable from Gulfstream and 1,562 anchors for Broadwater). The post-construction monitoring on Gulfstream indicated that the use of MLBs on all anchor cables would reduce seafloor acreage impacts due to cable sweep by approximately 48 percent. Applying this reduction to the Broadwater Project results in an expected seafloor impact of 32.1 acres due to cable sweep if MLBs were used on all anchor cables.

Broadwater has stated that the use of MLBs would result in a maximum length of 600 feet of cable touching the seafloor, which, if true, would mean the expected area of cable sweep with MLBs on all anchor cables would be 16.4 acres for the Broadwater Project based on the average area impacted per foot of cable on the Gulfstream monitoring results.

Anchors

Broadwater proposed anchor footprints would total 16.0 acres during pipeline installation. This appears to be a valid, although slight overestimate, of the expected acreage of anchor footprints based on the results from the Gulfstream project and the approximate number of anchors on the Broadwater Project (1,562 anchors). A total impact of 16.0 acres would average 446 square feet per anchor. While Broadwater has not specified the anchor size, it is expected that the laybarge anchors would be comparable to those proposed during the Gulfstream project (anchor footprint of 180 square feet).

On Gulfstream, the documented anchor footprints on the seafloor were approximately one to two times the size of the anchor (177 to 314 square feet). Thus, the expected total acreage impacted by anchor footprints for Broadwater would be less than the 16 acres proposed by Broadwater (between 6.3 and 11.3 acres based on 1,562 anchors). However, approximately 10.3 percent of the Gulfstream anchors were apparently dragged creating anchor scars (averaging 6,960 square feet per dragging with MLBs, and possibly substantially more if MLBs were not used). If the problem with anchor dragging was comparable on Broadwater, this would result in an additional 25.7 acres of anchoring impacts during pipeline installation. Thus, the expected acreage impacts on the Broadwater Project should either account for additional acreage associated with potential

anchor dragging, or require that anchor management plans be developed to minimize potential impacts associated with cable sweep and anchor dragging.

TABLE 4
Summary of estimated impacts, Broadwater gas pipeline.

Impact	DP Plow and DEP Lay Barge	DP Plow and anchor system lay barge	No MLBs deployed	MLBs Deployed
Anchor footprints	0	4.3 to 7.6	11. 3	6.3
Anchor drags	0	17.4	25.7	25.7
Cable sweeps	0	21.1 to 41.7	61.7	31.2 (16.4*)
Total acres of disturbance	0	42.8 to 66.7	98.7	63.2 (48.4*)

Notes:

* 16.4 acres is an estimate from Broadwater, only 600 feet of cable would come in contact with the sea floor

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