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LEBOEUF, LAMB, GREENE & MACRAE LLP

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LOS ANGELES
PITTSBURGH
SAN FRANCISCO

1875 CONNECTICUT AVE., N.W.
SUITE 1200
WASHINGTON, D.C. 20009-5728
(202) 986-8000
FACSIMILE: (202) 986-8102

E-MAIL ADDRESS: LAWRENCE.ACKER@LLGM.COM
WRITER'S DIRECT DIAL: (202) 986-8016

LONDON
A MULTINATIONAL PARTNERSHIP
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March 19, 2007

BY ELECTRONIC FILING

Philis Posey, Acting Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Re: Broadwater Energy LLC, Docket Nos. CP06-54-000
Broadwater Pipeline LLC, Docket Nos. CP06-55-000 & CP06-56-000

Dear Ms. Posey:

Pursuant to the Environmental Information Request issued on February 8, 2007 ("EIR"), enclosed for filing in the referenced proceedings are the responses of Broadwater Energy LLC and Broadwater Pipeline LLC (collectively, "Broadwater") to EIR Nos. 2, 4, 7, 15, 18, 21, 23, 24, and 25. This filing supplements Broadwater's February 28, 2007 submission, in which Broadwater filed responses to EIR Nos. 1, 5, 6, 8, 9, 11, 14, 16, 19, and 20.

The response to EIR No. 17 will be filed on March 20, 2007.

Broadwater anticipates providing its remaining responses to EIR Nos. 3, 10, 12, 13, and 22 on or before March 26, 2007.

Please do not hesitate to contact me with any questions regarding this submission.

Respectfully submitted,

/s/ Lawrence G. Acker

Lawrence G. Acker

Counsel to Broadwater Energy LLC & Broadwater Pipeline LLC

Enclosure

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FERC 3-2

Request:

Provide a refined air dispersion analysis that incorporates protocol accepted by pertinent agencies including NYSDEC. Specifically, evaluate impacts for stationary sources and mobile emissions (LNG carriers, support vessels, etc.) originating within the moored safety zone for different operating modes (stationary sources, stationary sources and hotelling, and stationary and unloading sources). Results from this modeling should be compared to significant impact levels as well as compared to the NAAQS.

Response:

A revised air dispersion modeling protocol was submitted to NYSDEC and USEPA Region 2 on March 13, 2007. The revised protocol addresses comments provided by both agencies that resulted from review of previous protocols. Major issues addressed in the revised protocol include use of an overwater meteorological data set for calendar year 2006 that meets the 90% raw data recovery acceptability threshold and a proposed approach to addressing overwater mixing height in the modeling data.

It is currently anticipated that NYSDEC and USEPA will complete review of the revised protocol by March 28, 2007. At that time, comments will be addressed and the protocol will be finalized for agency acceptance. Modeling will commence after notification of acceptance from the agencies. The dispersion analysis conducted in accordance with the accepted protocol will then be provided to FERC.

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EIR 3-4

Request:

Provide a detailed description documenting how the project would demonstrate conformance with the applicable State Implementation Plan in accordance with Title 40 CFR Part 51.858. The documentation should address each regulatory criterion listed in Part 51.858; provide a detailed explanation as to whether or not the project would meet each requirement; and, for each criterion satisfied, provide all supporting information on how the project would comply.

Response:

See attached.

Broadwater General Conformity Applicability Analysis

1.0 Project Description

Broadwater Energy, a joint venture between TCPL USA LNG, Inc., and Shell Broadwater Holdings LLC (Broadwater), has filed 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) regasification facility (the Project) 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 Project will be located approximately 9 miles from Long Island in Long Island Sound, in approximately 90 feet of water and offshore of Riverhead, Suffolk County, New York. 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 natural gas pipeline system via an interconnection to the IGTS pipeline.

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 FSRU will be designed with a net temporary 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.

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.

The Project is located within AQCR 43 (New Jersey-New York-Connecticut Interstate Area Quality Control Region). This AQCR is also known as the New York-Northern New Jersey-Long Island, NY-NJ-CT area. The portion of this area which is located in New York State is designated moderate nonattainment for the 8-hour ozone standard. Previously the AQCR was designated severe nonattainment for the 1-hour ozone standard and New York State continues to apply control programs addressing the 1-hour ozone standard as more protective of air quality. This area is designated as nonattainment for the $PM_{2.5}$ standard, effective April 5, 2005. These nonattainment designations result in the regulation of oxides of nitrogen (NO_x), volatile organic compounds (VOCs) and $PM_{2.5}$ (and specified $PM_{2.5}$ precursors) which may trigger the General Conformity requirements established by the United State Environmental Protection Agency (USEPA). This area is designated attainment for all other criteria pollutants.

2.0 General Conformity – Regulatory Background

Section 176(c) of the Federal Clean Air Act (CAA) provides that Federal agencies cannot engage, support, or provide financial assistance for licensing, permitting, or approving any project unless the project conforms to the applicable State Implementation Plan (SIP). A SIP is a compilation of a state's air quality control plans and rules, approved by the USEPA. The State and USEPA's goals are to eliminate or reduce the severity and number of violations of National Ambient Air Quality Standards (NAAQS) and achieve expeditious attainment of these standards.

Pursuant to CAA Section 176(c) requirements, the USEPA promulgated Title 40 of the Code of Federal Regulations (CFR) Part 51 (40 CFR § 51) Subpart W and 40 CFR § 93 Subpart B, "Determining Conformity of General Federal Actions to State or Federal Implementation Plans" (see Volume 58 of the Federal Register [FR], November 30, 1993 (58 FR 63214)). These regulations, commonly referred to as the General Conformity Rule, apply to all Federal actions except for those Federal actions which are excluded from review (e.g., stationary source emissions) or related to transportation plans, programs, and projects under Title 23 U.S. Code or the Federal Transit Act, which are subject to Transportation Conformity. 40 CFR Part 51 Subpart W applies in states where the state has an approved SIP revision adopting General Conformity regulations; 40 CFR Part 93 Subpart B applies in states where the state does not have an approved SIP revision adopting General Conformity regulations.

In New York State, the New York State Department of Environmental Conservation (NYSDEC) has not promulgated a rule incorporating Federal General Conformity regulations by reference or establishing its own General Conformity regulations. Therefore, the New York SIP does not contain an USEPA-approved SIP revision incorporating General Conformity. Although a proposed New York State General Conformity rule (Part 241) was slated for development in the NYSDEC January 2006 regulatory agenda, the rule has not been developed. NYSDEC has indicated the development of this rule will likely be taken off of the regulatory agenda for 2007. As

specified in 40 CFR Part 93, Subpart B, if a State has not developed its own General Conformity rule or formally adopted the Federal General Conformity rule, then the provisions in 40 CFR Part 93 Subpart B apply. It should be noted that General Conformity provisions in 40 CFR Part 93, Subpart B are identical to those in 40 CFR Part 51 Subpart W.

2.1 General Conformity Requirements

The General Conformity Rule is used to determine if Federal actions[1] meet the requirements of the CAA and the applicable SIP by ensuring that air emissions related to the action do not:

- Cause or contribute to new violations of a NAAQS;
- Increase the frequency or severity of any existing violation of a NAAQS; or
- Delay timely attainment of a NAAQS or interim emission reduction.

A Federal action is subject to the General Conformity Rule if it is not classified as an exempt activity, as listed in 40 CFR Part 93, Subpart B and if the total direct and indirect emissions of a pollutant (or its precursors), for which the area is classified as nonattainment or a maintenance area, equal or exceed (1) emission thresholds established in the General Conformity regulations or (2) 10% of the total emissions budget for the entire nonattainment or maintenance area. If emissions are less than these criteria levels, then the Federal action is presumed to conform to the SIP.

Conformity regulatory criterion are listed in 40 CFR § 93.158 (note that the criterion listed here are the same as listed in 40 CFR § 51.858). An action will be determined to conform to the applicable SIP if, for each pollutant that exceeds the rates in 40 CFR Part 93.153(b), or otherwise requires a conformity determination due to the total of direct and indirect emissions from the action, the action meets the requirements of paragraph (c) of § 93.158.

The lead Federal agency for the Project is FERC and, as such, FERC will prepare the environmental impact statement (EIS) for the Project and the General Conformity determination. The Project would be located in an area designated nonattainment for ozone and $PM_{2.5}$. Therefore, in accordance with 40 CFR §§ 93.153 and 93.158, emissions of ozone precursor compounds nitrogen oxide NO_x and VOC and $PM_{2.5}$ and $PM_{2.5}$ precursor compounds (sulfur dioxide [SO_2] and NO_x) are analyzed in a General Conformity analysis.

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[1] The General Conformity Rule defines a Federal action as any activity engaged in by a department, agency, or instrumentality of the Federal government or any activity that a department, agency, or instrumentality of the Federal government supports in any way, provides financial assistance for, licenses, permits, or approves. The General Conformity Rule applies only to Federal actions in locations designated as nonattainment or maintenance areas for any criteria air pollutant under 40 CFR Part 81, "Designation of Areas for Air Quality Planning Purposes."

2.2 New York State SIP

The current New York State SIP contains provisions for control programs for ozone under the 1-hour standard, total suspended particulate, SO_2 and carbon monoxide. The provisions currently included in the SIP for total suspended particulate (a maintenance plan for the Niagara Frontier Air Quality Control Region), SO_2 (two provisions specific to the Lovett Generating Station) and carbon monoxide (provisions for an oxygenated gasoline program and control period associated with a Downtown Brooklyn maintenance plan and an Onondaga County maintenance plan) are not applicable to the Project.

The current New York State SIP provisions for attaining the 1-hour ozone standard contain control programs focused on motor vehicle emissions, certain specific industrial categories and stationary source programs for NO_x and VOC control. The SIP provisions for motor vehicles and the industrial categories listed are not applicable to Broadwater. The only current provision in the SIP potentially governing Broadwater in regard to General Conformity is the New York SIP for Ozone - Phase II Alternative Attainment Demonstration; however the projected emission budget in this latter SIP extends only to 2007. This SIP has been approved by the USEPA to attain the 1-hour ozone NAAQS. In accordance with a recent decision of the United States Court of Appeals, the 1-hour ozone standard and the CAA requirements for nonattainment SIPs under the 1-hour standard remain in effect.[2]

NYSDEC is in process of developing its SIP for the attainment of the 8-hour ozone NAAQS. Historically, exceedance of the 1-hour and 8-hour ozone NAAQS have been found to occur between May 1 and September 30 in the nonattainment area. A combination of ozone precursor emissions and meteorological conditions during this period can cause formation of ozone. Thus, control programs in New York State are aimed at controlling emissions of ozone precursors (NO_x and VOCs) during this period each year.

There are no SIP provisions currently addressing $PM_{2.5}$ nonattainment since areas within New York State have not previously been designated with respect to the $PM_{2.5}$ standard. NYSDEC is in the process of developing its control strategy and SIP for $PM_{2.5}$. In addition to existing and new stationary source control programs, other national air quality programs that are likely to be relied upon in New York State's upcoming SIPs for ozone and $PM_{2.5}$ include new regulations for nonroad diesel engine emissions (engine emission standards and sulfur-in-fuel limits).

3.0 Project Emissions

Emissions will occur during two phases of the Project: construction and operation. Construction emissions will not occur simultaneously with operations emissions. Construction emissions will occur in calendar years 2009 and 2010, followed by operations emissions that include a facility shakedown period followed by commencement of regasification operations.

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[2] *South Coast Air Quality Management District v. EPA*, 2006 U.S. App. Lexis 31451, (D.C. Cir. Dec. 22, 2006 (SCAQMD Decision). It is possible that EPA may seek reconsideration of this decision.

3.1 Construction Emissions

Construction emissions will occur from construction of offshore facilities in New York State waters. Although onshore facilities in New York State will be utilized as well, temporary onshore facilities used during construction for the milling, concrete coating and temporary storage of pipeline will be existing facilities located outside the Project area. Temporary use of dock, office and warehouse space for construction contractors will utilize existing facilities.

Offshore construction activities will consist of pipeline installation, the installation and hook up of the mooring tower and FSRU towing. The FSRU will be constructed in a shipyard away from the Project site and towed to the site. Thus, the primary sources of emissions during construction activities will be the marine construction vessels used to install the pipeline and FSRU. Ships of various sizes, ranging from small day-use workboats to large supply vessels, pipeline construction vessels and ocean-going tug boats, will be used. Emission estimates from construction activities are based on the anticipated duration of use of each vessel type during the construction period, the vessels' engine characteristics and duty cycles, and emission factors. The construction emission estimate includes emissions from towing the FSRU while in New York State waters to its mooring location.

Construction is anticipated to occur during winter months only over a two-year period (2009 and 2010). A spreadsheet emission estimate tool provided by the U.S. Department of the Interior, Minerals Management Service, developed specifically for estimating construction in the marine environment, was used to estimate construction-related emissions. The emission estimate requires the use of a detailed construction schedule, inventory of vessel types, quantity and duration of use, and emission factors. Emission estimates for construction activity are presented in Table 1; the detailed construction emission estimate study is provided in Appendix A.

Table 1 Estimated Emissions from Construction Activities

Year	$PM_{10}/PM_{2.5}$ (tpy)	SO_2 (tpy)	NO_X[1,2] (tpy)	Ozone Control Period NO_X (tons)	VOCs[1] (tpy)	Ozone Control Period VOCs (tons)
1	10	26	213	0	11	0
2	22	67	538	0	24	0
Annual General Conformity *de minimis*	100[2]	100[2]	100 25[3]	n/a	50 25[3]	n/a

(1) Assumes that *de minimis* thresholds proposed by USEPA for a moderate ozone nonattainment area are applicable. The *de minimis* threshold for NO_x under the USEPA's $PM_{2.5}$ *De Minimis* Emission Levels for General Conformity Applicability (see FR Vol. 71, No. 65 April 5, 2006) is equal to 100 tpy, which is the same as the *de minimis* threshold proposed by USEPA for moderate ozone nonattainment.

(2) USEPA's $PM_{2.5}$ *De Minimis* Emission Levels for General Conformity Applicability (see FR Vol. 71, No. 65 April 5, 2006) sets *de minimis* levels for direct $PM_{2.5}$ and $PM_{2.5}$ precursor compounds (SO2 and NO_x) at 100 tpy. However, the final rule allows a State or USEPA to make a finding that VOC and/or ammonia are $PM_{2.5}$ precursors and to make a finding that NO_x is not a $PM_{2.5}$ precursor.

(3) Assumes that the *de minimis* thresholds for the 1-hour ozone nonattainment area continue to apply.

3.2 Operational Emissions Not Subject To Permitting

The FSRU is subject to major nonattainment New Source Review (NSR) for NOx under New York's 1-hour ozone nonattainment program. The SCAQMD Decision reinstated New York's SIP for the 1-hour ozone standard. Accordingly, Broadwater's FSRU NOx emissions are subject to requirements for permitting under the Clean Air Act and are excluded from General Conformity pursuant to 40 CFR 93.153(d)(1).

Emissions will be produced by LNG carriers during transit to and from the FSRU and by support vessel operation during routine operation of the FSRU. Vessels associated with routine operation of the FSRU include the LNG carrier and tug boats which will escort and assist the LNG carriers while approaching, positioning, docking, and leaving the FSRU. The final location of the permanent on-shore facility has not been chosen. Broadwater has identified locations in Greenport NY and Port Jefferson NY (both in Suffolk County) that can provide the needed facilities. Permanent on-shore facilities will utilize existing office space, warehouse and docks. The permanent onshore facility will not construct any new stationary emission sources or compression facilities. Small supply vessels will deliver supplies for use on the FSRU from the onshore facility.

Emissions for the LNG carriers are calculated for the complete delivery cycle beginning at the location at which the vessel enters New York State waters, as it travels inbound to the FSRU, unloads LNG at the FSRU, and as it travels outbound until it reaches the boundary of New York State waters. The United States Coast Guard (USCG) provides recommendations with respect to LNG carrier routes in the Waterways Suitability Report (USCG 2006).

Tug boats will be used to assist an LNG carrier during its operation in the vicinity of the FSRU. The tugs are used to aid in making turns and positioning the LNG carrier alongside the FSRU. In addition, tug boats will typically meet the inbound LNG carrier at the Race during transit into Long Island Sound, escort it to the FSRU, and escort the outbound LNG carrier out to the Race after it delivers its LNG cargo. The number of tug boats required for these operations will vary depending on the size of the LNG carrier and USCG requirements. For the purposes of this emission analysis, Broadwater has assumed that three tug boats will assist the LNG carrier while berthing to the FSRU and two escort tugs will travel with the LNG carrier inbound and outbound through Long Island Sound. One supply vessel will typically visit the FSRU per each LNG delivery. Based on LNG deliveries from a conventional LNG carrier with a cargo capacity of 140,000 m^3, 118 supply vessel trips will be made to the FSRU annually.

A summary of reasonably foreseeable direct and indirect emissions not subject to permitting during normal operation of the Project is presented in Table 2.

Table 2 Operational Emission Summary for General Conformity

	Annual NO_x (tpy)	Ozone Control Period NO_x (tons)	Annual VOC (tpy)	Ozone Control Period VOC (tons)	$PM_{10}/PM_{2.5}$ (tpy)	SO_2 (tpy)
LNG Carrier Hoteling and Unloading[1]	22	9.3	0.3	0.1	8	172
Carrier Transit and Support Tugs	438	185	19	8.0	28	282
FSRU[5]	0	0	18	7.5	48	4
Total	460	194	37.3	15.6	84	458
Annual General Conformity *De minimis*	100[2] 25[4]	n/a	50[2] 25[4]	n/a	100[3]	100[3]

(1) All LNG carrier emissions associated with LNG unloading and LNG carrier hoteling while at the FSRU are included in the General Conformity determination.

(2) Assumes that *de minimis* thresholds proposed by USEPA for a moderate ozone nonattainment area are applicable. The *de minimis* threshold for NO_x under the USEPA's $PM_{2.5}$ *De Minimis* Emission Levels for General Conformity Applicability (see Vol. 75, No. 65 April 5, 2006) is equal to 100 tpy, which is the same as the *de minimis* threshold for moderate ozone nonattainment.

(3) USEPA's $PM_{2.5}$ De Minimis Emission Levels for General Conformity Applicability (see FR Vol. 71, No. 65 April 5, 2006) sets *de minimis* levels for direct $PM_{2.5}$ and $PM_{2.5}$ precursor compounds at 100 tpy. By default, SO2 and NO_x emissions are considered $PM_{2.5}$ precursor compounds and ammonia and VOC are not. The final rule allows a State or USEPA to make a finding that VOC and/or ammonia are $PM_{2.5}$ precursors and to make a finding that NO_x is not a $PM_{2.5}$ precursor.

(4) Assumes that the *de minimis* thresholds for the 1-hour ozone nonattainment area continue to apply.

(5) FSRU NOx emissions are subject to major nonattainment NSR and are therefore excluded from General Conformity.

4.0 General Conformity Applicability

Reasonably foreseeable emissions from direct and indirect sources associated with the construction and operation of the Project not subject to air permitting under the CAA NSR and/or Prevention of Significant Deterioration (PSD) requirements are considered in this analysis. The reasonably foreseeable emissions include the ozone-forming pollutants NO_x and VOCs because the Project area is in nonattainment for the 1 and 8-hour NAAQS. Direct FSRU emissions of VOCs are below the major source permitting

threshold and are therefore aggregated with vessel and other emissions subject to General Conformity.

Suffolk County also is designated nonattainment for $PM_{2.5}$; thus, in accordance with USEPA's General Conformity regulations, direct emissions of $PM_{2.5}$ and emissions of $PM_{2.5}$ precursor compounds (NO_x, and SO_2) are compared to General Conformity *de minimis* thresholds defined in the final rule (FR Vol. 71, No. 65). The final $PM_{2.5}$ De Minimis General Conformity rule does not require VOC and ammonia emissions to be included as $PM_{2.5}$ precursor emission but does allow a state and USEPA to determine if VOC and ammonia emissions should be controlled as $PM_{2.5}$ precursors. The final rule includes NO_x emissions as a $PM_{2.5}$ precursor but also allows a state or USEPA to not include NO_x as a precursor if the state and USEPA find that NO_x emissions from sources in the state do not significantly contribute to the $PM_{2.5}$ nonattainment area. At this time, New York State and USEPA have not provided a determination whether VOC, ammonia and NO_x will be regulated as $PM_{2.5}$ precursors. As a result, it is assumed NO_x and SO_2 are considered $PM_{2.5}$ precursor emissions as prescribed by the rule, while VOC and ammonia emissions are not $PM_{2.5}$ precursor emissions.

Construction-related emissions are not covered by New York's nonattainment NSR program (i.e., subject to offset requirements) and are therefore evaluated under the General Conformity Rule. Construction-related emissions occur in calendar years prior to commencement of FSRU operations. No other Project-related emissions will occur simultaneously with construction-related emissions. Since the region is in nonattainment for ozone, emissions of NO_x and VOCs are compared to General Conformity *de minimis* thresholds for the 1 and 8-hour ozone standards.

The NO_x emissions shown in Table 1 are above the General Conformity *de minimis* threshold of 100 tpy proposed under the 8-hour ozone standard and 25 tpy under the 1-hour standard for each year of construction. Assuming that New York State and USEPA will not exclude NO_x emissions as a precursor for $PM_{2.5}$, the full amount of the NO_x emissions during the two-year construction period are subject to mitigation under General Conformity. However, with construction scheduled to occur outside of the ozone control period (May 1 through September 30), construction emissions will not have any bearing on control period ozone concentrations or violations of the 1 or 8-hour ozone NAAQS.

Direct construction emissions of $PM_{2.5}$ will be less than the *de minimis* threshold. Of the $PM_{2.5}$ precursor compounds (NO_x and SO_2), only NO_x would exceed a *de minimis* threshold. This conclusion is based on the assumption that New York State and USEPA will not exclude NO_x emissions as a precursor for $PM_{2.5}$. Thus, NO_x emissions from construction activities in 2009 and 2010 may need to be further mitigated under General Conformity. Conversely, emissions of VOC, $PM_{2.5}$ and SO_2 during each year of the two-year construction period are estimated to be below the *de minimis* threshold for applicability of the General Conformity rule. Therefore, a General Conformity determination is not required for these pollutants.

De minimis thresholds for ozone and $PM_{2.5}$, and corresponding emissions associated with the operation of the Project, are shown in Table 2. Vessel activity during operation of the

facility is shown to result in annual NO_x and SO_2 emissions above the *de minimis* thresholds for these pollutants. Operational emissions of VOC from vessels and the FSRU in the aggregate exceed the *de minimis* threshold for VOC under the 1-hour ozone NAAQS and are subject to General Conformity. Direct emissions of $PM_{2.5}$ are below the *de minimis* threshold. Thus NO_x, VOC, and SO_2 emissions in each year of operation will require a General Conformity determination.

4.1 New York State SIP

The current New York 1-hour ozone SIP applicable to Broadwater is the "New York State Implementation Plan for Ozone Phase II Alternative Attainment Demonstration." Within the attainment demonstration is a projection of emissions from the source category "Other Non-Road Emissions." This category includes aircraft, locomotives and marine vessels. Emissions are shown broken out by these three categories by County for planning years 2002, 2005 and 2007. In light of the recent SQAMD court decision, NYSDEC will need to keep the 1-hour ozone SIP in effect and prepare reasonable further progress (RFP) updates until attaining the 1-hour NAAQS.

New York State is in process of developing a SIP to address 8-hour ozone nonattainment; the SIP is due to USEPA in June 2007. As of January 2007, NYSDEC is finalizing the baseline emission inventory budget to be used as the basis for the 8-hour ozone SIP emission budget projections. One of the source groups in New York's SIP emission inventory is marine vessels. NYSDEC based the marine vessel baseline emission inventory for the 8-hour ozone standard on the "Starcrest" Report (Port Authority NY NJ 2003). This marine vessel emission inventory is a comprehensive evaluation of marine vessel emissions in the waters surrounding the New York City Metropolitan area, including Long Island Sound. Broadwater's marine vessel emission inventory was developed using the same emission factors as used in the Starcrest report.

New York State is also beginning the process of developing SIP provisions to address $PM_{2.5}$ nonattainment. The $PM_{2.5}$ SIP is due April 2008. At this time, these SIP provisions are not available for review. Broadwater may have to address control of $PM_{2.5}$ precursor emissions under a $PM_{2.5}$ SIP depending on the content of control programs New York State structures into its SIP provision for $PM_{2.5}$ nonattainment.

During the development of SIPs for ozone and $PM_{2.5}$, it is likely that New York will include the emission reduction benefits provided by new emission standards for marine vessel engines and the fuel sulfur limitations of the nonroad diesel fuel rule in the projected emission budgets.

5.0 General Conformity Determination

In accordance with the SCAQMD Decision, New York's 1-hour SIP remains in effect and is subject to RFP under the CAA. As discussed in section 4.1, New York State is currently developing an ozone SIP to address attainment of the 8-hour ozone standard by 2009. Thus, at this time, a final ozone SIP applicable in 2009 and beyond is not available. Similarly, New York State is beginning the process of developing a SIP to

address $PM_{2.5}$ nonattainment in the State's nonattainment areas including the project location. The $PM_{2.5}$ SIP is due three years after nonattainment designations are final; therefore the New York $PM_{2.5}$ SIP is due in April 2008 (see FR Vol. 70, No. 210 November 1, 2005).

5.1 Consistency With Relevant SIP Requirements

Broadwater will be constructed and will operate in conformance with the New York SIP under the 1-hour ozone standard, insofar as it applies in the future. Broadwater anticipates that measures undertaken in conformance with the 1-hour ozone SIP will similarly conform under the 8-hour SIP. As noted above, New York State has not finalized SIP requirements beyond calendar year 2007. However, it is reasonable to assume that marine vessel engine standards and nonroad fuel sulfur requirements will be incorporated into future New York SIPs for attainment of the ozone standard and attainment of the $PM_{2.5}$ standard.

Broadwater is committed to meeting the requirements and being consistent with the relevant SIPs. Broadwater-owned vessels will comply with applicable marine vessel engine standards and nonroad fuel sulfur requirements. Owners and/or operators of other vessels such as LNG carrier or tug boats will have an independent obligation to comply with marine vessel-related requirements. Broadwater will continue to follow development of the New York ozone and $PM_{2.5}$ SIPs and work with NYSDEC to be consistent with requirements in those SIPs.

5.2 Emission Budgets/Attainment Demonstration

The current emission budget contained in the New York SIP is applicable to attaining the 1-hour ozone standard and, under the SCAQMD Decision, is subject to RFP requirements. Thus future updates to the 1-hour emissions budgets are required. The New York SIP emission budget to demonstrate attainment of the 8-hour ozone standard is under development.

New York State does not have an emission budget in place to address $PM_{2.5}$ nonattainment; $PM_{2.5}$ nonattainment designations are the result of relatively recent promulgation of the $PM_{2.5}$ air quality standard; thus, this is the first time that New York State has received a designation under the $PM_{2.5}$ standard. New York will also begin development in 2007 of a SIP emission budget to demonstrate attainment of the $PM_{2.5}$ standard.

Given the status of development of SIP budget components that affect Broadwater, Broadwater has initiated discussion with NYSDEC regarding General Conformity and the Project's emissions that are subject to General Conformity. Project emission data have been submitted to NYSDEC and are being evaluated by NYSDEC for incorporation into the SIP emission budget for the relevant ozone SIPs. NYSDEC has indicated they are also considering using the ozone SIP emission source inventory and budgets for the $PM_{2.5}$ SIP that will be developed in 2007. Broadwater intends to continue discussions

with NYSDEC regarding incorporation of project emissions into the emission inventory budgets as the ozone and $PM_{2.5}$ SIPs are developed.

5.3 Project Emissions Mitigation/Offsetting

As lead federal agency for the Project, FERC conducts the full General Conformity determination parallel to its preparation of the EIS. FERC will utilize emission estimates prepared for this General Conformity analysis (which is similar to emission estimates already provided in Resource Report 9) in its General Conformity determination. The magnitude and potential impact of the emissions will be evaluated, and a determination will be made regarding whether mitigation is necessary.

Several options to demonstrate conformity are available, as provided for in 40 CFR Part 93.158:

- the project can comply with the control measures and regulations included in the applicable SIP(s); and, the total direct and indirect emissions subject to conformity are specifically identified and accounted for in the SIP's attainment demonstration; or
- the State commits to revise its SIP to accommodate the emissions from the Project; or
- for any criteria pollutant except ozone, the total emissions subject to conformity are evaluated through an area-wide and/or local air quality modeling analysis demonstrating that the project does not cause or contribute to any new NAAQS violation or increase the frequency or severity of any existing NAAQS violation in any area; or,
- emissions from the Project are mitigated so that there is no net increase in emissions.

During the development phase of a new SIP, as is underway in New York State with respect to the 8-hour ozone attainment and $PM_{2.5}$ attainment demonstration SIPs, General Conformity can be demonstrated by incorporating projected emissions for the Project into the inventory. Likewise, insofar as the 1-hour ozone standard continues to apply during the relevant time period for the Project, emissions for the Project can be incorporated into the RFP inventory for the 1-hour standard. If attainment is demonstrated and the SIP is approved by USEPA with the emission budget containing a project's emissions, then General Conformity is demonstrated.

Upon the determinations concerning the budgets, Broadwater will continue to coordinate with FERC, NYSDEC, and USEPA to satisfy the applicable General Conformity requirements. For example, with respect to construction emissions, as stated earlier, construction emissions will occur over a two year period but will not occur during the ozone control period within those years. Thus, construction activities will not contribute to ozone precursor (NO_x) emissions during the May 1 through September 30 ozone control period as long as construction occurs as planned. This mitigation measure

contributes to the current 1-hour ozone SIP's goal of reducing ozone control period ozone precursor emissions by limiting construction activities to the non-ozone control period. This approach will also serve a similar role with respect to the goals of the 8-hour ozone SIP, when approved. A similar mitigation measure was used by the New York Harbor dredging project for its first year of emissions, i.e., emissions of NO_x and VOC will occur outside of the ozone control period and therefore will not contribute to ozone precursor emissions during the control period. Broadwater will confirm that this mitigation measure is sufficient for the purpose of satisfying General Conformity requirements to construction and related activities. If Broadwater is required to demonstrate conformity through mitigation, Broadwater will coordinate with NYSDEC and the USEPA and provide all appropriate documents necessary to support the emission reductions associated with these mitigation efforts.

6.0 Additional Considerations

Broadwater introduces a reliable source of new natural gas to the region, offering a compelling solution to the ever-growing demands in the Long Island, New York City, greater New York City metropolitan and Southern Connecticut markets for a competitively priced, reliable and cleaner burning fuel supply. This supply, which will be used by the residences and businesses, municipal governments, commerce, schools and hospitals in the target markets, will encourage patterns of development that enhance Long Island coastal communities and enable existing coal-and oil-fired electric generating facilities to repower using clean-burning and cost-effective natural gas. The end result will be increased energy reliability and regional power generation and reduced impacts on the natural resources that so greatly contribute to the character of Long Island's coastal communities.

7.0 Conclusion

Documentation supporting conformity with the applicable New York State SIPs in accordance with 40 C.F.R § 93.158 is not yet available. Broadwater will continue to work with NYSDEC and, as necessary, USEPA to develop this documentation. Broadwater will undertake such actions as necessary to demonstrate General Conformity for the Project.

8.0 References

Code of Federal Regulations, Title 40, Part 51, Subpart W, "Determining Conformity of General Federal Actions to State or Federal Implementation Plans." July 1, 2006.

Code of Federal Regulations, Title 40, Part 93, Subpart B, "Determining Conformity of General Federal Actions to State or Federal Implementation Plans." July 1, 2006.

FR Vol. 70, No. 91, May 12, 2005, "Rule to Reduce Interstate Transport of Fine Particulate Matter and Ozone (Clean Air Interstate Rule)."

FR Vol. 70, No. 210, November 1, 2005, "Proposed Rule to Implement the Fine Particle National Ambient Air Quality Standards."

FR Vol. 71, No. 65 April 5, 2006, "$PM_{2.5}$ De Minimis Emission Levels for General Conformity Applicability."

6 NYCRR Part 204, Title 6 New York Code Rules and Regulations Part 204, NO_x Budget Trading Program.

Port Authority NY NJ, 2003, "The New York, Northern New Jersey, Long Island Nonattainment Area Commercial Marine Vessel Emissions Inventory, Volume 3 – Appendices F and G," Starcrest Consulting Group LLC.

USCG, September 2006, U.S. Coast Guard Captain of the Port Long Island Sound Waterways Suitability Report for the Proposed Broadwater Liquefied Natural Gas Facility. United States Department of Homeland Security.

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EIR 3-7

Request:

Provide the construction criteria emissions associated with alternative pipeline installation using a dynamically positioned laybarge.

Response:

In order to respond to this request, Broadwater reviewed the current status of the dynamically positioned (DP) laybarge fleet that could potentially act as the laybarge to install the Broadwater pipeline onto the seabed, and/or act as the bury barge to pull the post-lay subsea plow to lower the pipeline.

In Broadwater's response to the FERC's October 19, 2005 Environmental Information Request regarding Draft Resource Reports Nos. 5, 6 and 7 (response filed by Broadwater on January 12, 2006), for item 30 regarding pipeline construction methods, Broadwater stated that of the four existing (worldwide) DP vessels and one proposed DP vessel with the technical capacity to install (trench and lower) the pipeline, only Global Industries' DLB Hercules could perform the required work under U.S. law. Broadwater has determined that the DLB Hercules is no longer qualified to act as a bury barge in U.S. waters. Thus, Broadwater would only be able to use a DP vessel to lay the pipe on the seafloor; and trenching and lowering would have to be performed by a conventional cable and anchor-propelled laybarge.

Broadwater has prepared its response (emission estimates) based on the following:

- A suitable DP laybarge (e.g., the Panamanian-flagged AllSeas Solitaire) is used to lay the pipeline, including a "pull section" procedure required for the relatively shallow waters of the Stratford Shoal (see the pull section description at the end of this response); and
- A suitable conventional cable and anchor-propelled bury barge is used to pull the post-lay subsea plow and continuously lower the pipeline for its entire 21.7 mile length as per Broadwater's proposed construction plan.

The spreadsheet emission installation tool provided by the U.S. Department of the Interior, Minerals Management Service, was used to estimate the construction emissions presented in Table 7-1, below. For comparison purposes Broadwater has retained the previous emissions estimates for construction with conventional laybarge and bury barge alternatives prepared in response to the FERC's Environmental Information Request issued March 31, 2006, No. EIR 5, Table EIR5-2 "Comparison of Pipeline Construction Emissions" as filed by Broadwater on April 20, 2006.

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Table 7-1 Comparison of Pipeline Construction Emissions

Scenario		Emitted Substance (tons)				
		SOx	NOx	PM	CO	VOC
Construction with conventional laybarge and bury barge	No Midline Buoys	92	740	32	161	36
	Midline Buoys on Quarter Anchor Lines	95	761	33	166	36
	Midline Buoys on All Anchor Lines	97	783	34	170	36
DP Laybarge Alternative: • Pipelay by DP laybarge • Lowering by conventional bury barge with midline buoys on all anchor lines		294	2,256	75	492	79

Stratford Shoal Pull Section Procedure for DP Laybarge

There will be an approximately 3,000 foot long section of the Stratford Shoal that cannot be installed as a continuous lay operation by a DP laybarge due to the reduced water depths.

Owners and operators of suitably sized DP laybarges have advised Broadwater that a minimum working water depth of 65 feet is needed in order to maintain station (position) and hold the heavy pipeline (600 to 800 pounds per foot) at the necessary constant tension in an "S" lay configuration between the vessel and the seabed without threatening the structural integrity of the pipeline. This is not an issue for a conventional laybarge holding station with cables and anchors.

The minimum water depth across the Stratford Shoal is 54 feet occurring at about MP 14.5. Therefore, a DP laybarge cannot install the pipeline in continuous lay operation across the Stratford Shoal, and it will be necessary to use a procedure that will include the pulling of a section of the pipeline across the shallow area. This operation would be supported by a stationary pull barge with a linear line pulling winch set up on one side of the Shoal. The pull barge with its 6 to 8 cables and anchors to hold the barge on station would "pull" a continuous pipe section across the shallow section of the Shoal from the DP laybarge set up on the other side.

The pull section procedure, described more fully in Table 7-1, below, is estimated to require approximately 6 days. The delay impact of this procedure on the overall construction schedule should be alleviated by better productivity during continuous pipe lay operations by the DP laybarge compared to a conventional laybarge with mid-line buoys, and it is estimated that the total duration of pipe lay operations will be same as for

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the alternative of a pipe lay by a conventional cable and anchor-propelled laybarge with mid-line buoys.

Table 7-2 describes the pull section procedure required for the DP laybarge to install the pipeline across the Stratford Shoal.

Table 7-2 Stratford Shoal Pull Section Procedure for DP Laybarge

Step	Description
1.	The DP laybarge sets up on the east side of the Stratford Shoal at a distance approximately 2,000 feet from the mid point of the 3,000 foot pull section;
2.	The pull barge sets up on the west side of the Stratford Shoal at a distance approximately 2,000 feet from the mid point of the 3,000 foot pull section;
3.	A pull cable is run the 7,000 feet (1.33 miles) from the pull barge to the DP laybarge and the cable is attached to a pull-head welded to the end of the pipeline being fabricated on the laybarge;
4.	The pull barge pulls the pipeline one joint at a time as new joints are added to the pipeline onboard the DP laybarge. The process continues until the pull barge has pulled sufficient pipe so that the pull-head has reached the pre-determined target box on the west side of the Stratford Shoal;
5.	The pull-head is anchored in place, the pull cable is released, and the pull barge demobilizes;
6.	The DP laybarge initiates continuous pipelay operations from MP 14.1 progressing eastward along the pipeline route to the pipe lay down location near the YMS at MP 0;
7.	After lay down of the pipeline near the YMS, the laybarge relocates to the west side of the Stratford Shoal and back up to where the pull-head is located;
8.	The laybarge lifts the pull head to the stern of the barge and recovers the pipeline by backing up the barge until the pull head is in the line-up station at the bow of barge. The pull head is then removed, the welding face re-beveled and a new joint of pipe added; and
9.	The laybarge initiates continuous pipe lay operations progressing westward to near the proposed hot-tap on the existing IGTS pipeline at MP 21.7, thus completing a single continuous pipeline installed on the seabed between MP 0 and MP 21.7 ready for lowering by post-lay subsea plow.

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EIR 3-15

Request:

Define the specific type of copper-based paint that would be used on the FSRU and mooring structure, and provide Material Safety Data Sheets. Identify the expected duration of effectiveness, and the potential for increases in sediment concentrations due to paint flaking, especially associated with periodic hull cleaning. Describe the potential to completely avoid the use of any anti-fouling paint on the FSRU, or minimizing potential impacts by using non-copper based anti-fouling paints, or reducing amount of anti-fouling paint applied to the FSRU and YMS.

Response:

The type of anti-fouling paint to be considered for the FSRU Hull is a self-polishing copolymer copper acrylate based coating. Material Safety Data Sheets and test results for copper leaching release rates for typical products are attached. The expected duration of effectiveness is proportional to the coating thickness and the polishing rate. As presented in Resource Report 13, Broadwater anticipates an initial application thickness of 100 microns. For comparison purposes, in typical marine applications, a 300 microns thickness of copper acrylate anti-fouling is suitable for a five year interval between re-coating based on an average 5 micron per month polishing rate. Because the FSRU will largely be non-mobile (with the exception of weathervaning around the mooring tower) copper would be expected to leach at a rate less than a vessel that is underway, since much of the leaching results from the water/hull friction that is generated at higher speeds when a vessel is in transit. Therefore, the anti-fouling coating would be anticipated to function effectively for approximately 1 to 2 years after the installation of the FSRU in the Sound, and then be considered largely depleted. The antifouling paint is required to provide adequate protection to the FSRU during its construction in a foreign port to prevent fouling that could inadvertently be transported with the FSRU into Long Island Sound. Broadwater does not propose an additional coating once the FSRU is in place and operational. Beyond the period of time that the anti-fouling paint is effective, all anti-fouling maintenance would be completed through physical scrubbing of the hull.

There are marine coating products in the market that are silicone based. These non-fouling coating systems work by making the surface of the structure too smooth for marine growth to adhere to, and where any fouling does take place it is quite easily removed. Based on in-service feedback, in general, silicone based coatings are effective for periods of between seven and ten years.

Corrosion protection of the underwater part of the Yoke Mooring System will be based on the use of sacrificial anodes. The structure will not be coated. In way of the splash zone, corrosion protection will be based on a combination of increased thickness of critical structural members and the application of solvent free amine cured glass epoxy of

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1mm thickness. Therefore, Broadwater does not intend to apply anti-fouling coatings to the Yoke Mooring Structure.

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EIR 3-18

Request:

Identify the target geologic stratum needed to secure the YMS pilings. Describe any potential depth limitations related to the maximum achievable length for the piles.

Response:

The predicted geotechnical profile at the project location is based on the seismic reflection profiles available for the site. Based on the geological and geotechnical information available, the bedrock is considered at about 130m below the seabed. The upper 66 ft (20 m) of sediment and soil are likely to be soft/loose Holocene deposits, providing little pile capacity. The Lower Glacial Lake deposits, located from about 98 ft (30 m) to 427 ft (130 m) below the seabed, are composed primarily of silt and clay and likely to be firm to very stiff. Therefore, based on the predicted soil profile, the YMS piles will be likely to terminate in this Lower Glacial Lake deposits. The pile tip penetration may be limited to about 197 ft (60 m) to 230 ft (70 m) below seabed to mitigate piling refusal risks. Soil investigation will be conducted during the detailed design phase to provide detailed site-specific geotechnical information for the YMS piling design including length.

EIR 3-21

Request:

If post-construction monitoring indicates that active backfilling was not successful according to the terms agreed to in the backfill plan (created with interagency coordination), what measures would be taken to further address the seafloor disturbance impacts incurred during construction of the pipeline and mooring structure?

Response:

Broadwater has proposed natural backfilling of the pipeline trench, except in identified locations such as the first two-mile section of the pipeline, to minimize cable sweep along the pipeline route. Active backfilling with native substrate would require an additional pass with a bury barge pulling a backfill plow. Broadwater estimates that seafloor impact would be increased from 1,246.5 acres to 1,513.7 acres, including an increase from 1,031 acres to 1,293 acres attributed to anchor cable sweep assuming the use mid-line buoys on all anchor cables (as recommended by the DEIS). If the first two miles were to be actively backfilled with native substrate (if an acceptable design) the total seafloor impact would increase to approximately 1,533 acres, with 1,312 acres attributed to anchor cable sweep.

During construction the progress of the backfilling operation will be closely monitored using a specialist Survey/ROV vessel. The Survey/ROV vessel will perform surveys along and across the pipeline corridor to ensure that the results of the backfilling operations are known as soon as possible after the backfill plow passes. The results of the survey will be compared to the surveys performed before and after pipelay operations and after the pipe has been lowered and is at its final position in the trench. These comparisons will allow the Engineer to evaluate the depth of cover over the pipeline, the elevation of the materials replaced into the trench and confirmation that the spoil banks adjacent to the pipeline trench have been substantially leveled. Keeping in mind that some spoil material will be lost due to sediment dispersion and transport during pipeline lowering and storage, the success of the backfilling operation will be measured by a review of the overall length of pipeline and the amount of residual native substrate available for backfilling. If sections of the line have a depth of cover deficiency and rectification is required, then work will be completed before the contractor demobilizes. Isolated sites can be rectified with rock, concrete mats, or sand bags. Extended sections may require the placement of imported fill (e.g. sand and/or a sand/gravel/rock mixture) using the Tremie System.

Post-construction monitoring of the status of backfill will be undertaken at intervals to be determined in coordination with federal and state resource agencies. Similar to post-construction monitoring, a specialist Survey/ROV vessel will complete a scan of the pipeline route. If this survey indicates loss of cover a risk assessment will be completed

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involving the affected federal and state resource agencies to determine the optimum strategy considering, among other things, public safety and environmental factors. If remedial actions are recommended, the repair will be planned in detail and scheduled along with regular maintenance activities. As for the case of remediation during construction, operational remediation for isolated sites can be completed with rock, concrete mats, or sand bags. Extended sections may require the placement of imported fill.

FERC 3-23

Request:

Provide an updated discussion of potential noise impacts associated with construction, especially pile-driving methods. The discussion should include a tabular summary of the magnitude, intensity, extent, frequency, and duration of underwater noise at ¼-mile intervals from the noise source as it relates to noise limits for other recent pile-driving projects in a marine environment. Describe potential physical and behavioral impacts of construction noise on marine resources, and identify any additional mitigation measures that could be implemented to avoid or minimize potential impacts.

Response:

Three additional key reports/literature reviews support conclusions drawn in Broadwater's Resource Report 3 (Fish, Wildlife and Vegetation). The first literature review by Mardi Hastings and Arthur Popper provides a comprehensive summary and critical review of what is known about the effects of sound (including those from pile driving activities) on fishes and also identifies studies needed to address areas of uncertainty relative to measurement of pile driving sounds and the response of fishes to such sounds. A copy of this complete publication is provided as an attachment to this response (Hastings and Popper (2005)). A second recently issued White Paper by Popper et al. (2006) titled *Interim Criteria for Injury of Fish Exposed to Pile Driving Operations: A White Paper* presents science-based, *interim* noise exposure criteria for the onset of direct physical injury in fish exposed to the impact sound associated with pile driving. This White Paper is also provided as an attachment to this response (Popper White Paper (2006)). The final document referenced is the FEIS/EIR prepared by the USCG on the Neptune LNG Deepwater Port License Application (Docket USCG-2005-22611), published on November 3, 2006.

Very little is known about the key variables that control the physical interaction of sound with marine resources and possible effects on these organisms. There are no relevant data from exposure to pile driving. Exposure to explosives (reviewed in Hastings and Popper (2005)) provides some suggestion (albeit, without suitable controls) that the larger fish are less subject to killing by explosives than are smaller fish. However, relevance of this observation to pile driving or other sounds is not known. There are also reasons to suggest that the likely degree of damage from sound exposure is not related per se to the distance of the organism from the sound source such as a pile driving operation, but to the received level and duration of the sound exposure. Several studies and modeling efforts have been performed to quantify sound exposure from pile driving operations and its resulting effects which are discussed below. Most importantly, it is noted that since

pile driving sounds travel through both the water and the substrate at different speeds, it is possible that there is some coherence of sound from the two pathways at some point distant from the source, resulting in a higher sound level at greater distances from the source (*see* discussion in Hastings and Popper (2005)). However, the degree of this affect depends on the nature of the substrate into which the pile is being driven.

Noise Characteristics of Pile Driving Operations in Marine Environments

In order to determine the noise characteristics of pile driving operations in the marine environment, modeling efforts have been undertaken for other offshore LNG facilities to compute the frequency and range-dependent sound transmission that is expected at a given location, depth and season of interest for such as event. Modeling efforts for the Neptune LNG Deepwater Port (DWP) off the coast of Boston, Massachusetts were utilized as a comparable analysis due to its location in northeast waters and proximity to several sensitive marine resources and critical whale habitats. This facility is located in waters approximately 240 feet (80 m) deep, which is slightly deeper than the proposed Broadwater facility that will be located in waters 60-130 feet (18-40 m) deep. However, the analysis for the Neptune facility evaluated three different received sound depths of surface, 150 feet (50 m) and bottom. The surface and 150 feet (50 m) modeling results were used as representative sound exposure scenarios for the Broadwater evaluation.

For the Neptune LNG facility, pile driving was modeled for a steel pile approximately 72" in diameters and 15 to 20 m long. This is potentially a shorter pile length than those expected to be used for the proposed Broadwater facility, but represents a similar diameter. Therefore the force from the hammer used in the operations is expected to be comparable, but may be used for a longer time period to install the piles at the Broadwater facility due to their increased length. The model assumed the use of a hydraulic hammer with a blow rate of 32 BPM with a broadband source energy level of 205.9 dB re 1 μPa^2s. From that, source levels at 1 m were estimated assuming a pulse length of 100ms, using the following formula:

SPL_{rms}(dB re 1 μPa@1m) = SEL (dB re 1 μPa^2s) – 10 Log T where T = 100ms

The model results based on these calculations were presented in 10 dB contours surrounding the sound source. The average range the modeled sound traveled was also calculated in a sector type analysis and was bounded by land formations (Cape Ann and Cape Cod) to the north and south to avoid interference by the coastline which is similar to the location of the Broadwater facility in Long Island Sound which is bounded by Connecticut to the north and Long Island to the south. The area represented within each contour interval at the surface and depth of 50 m is presented in Table 1 and 2 below, respectively.

Table 1 – Noise Characteristics from Pile Driving Sound Levels Received at the Surface

Contour Interval (dB)	Area Inside (km^2)	Average Range from Sound Source (km)
90	7,591	67.7
100	5,354	51.7
110	3,352	37.8
120	1,843	26.3
130	756	15.5
140	224	8.4
150	28	3.0
160	2	0.8
170	0	0.2

Table 2 – Noise Characteristics from Pile Driving Sound Levels Received at 50 m Depth

Contour Interval (dB)	Area Inside (km^2)	Average Range from Sound Source (km)
90	9,117	67.1
100	6,318	63.0
110	4,110	44.1
12	2,276	29.9
130	1,012	17.5
140	319	9.6
150	52	4.1
160	5	1.3
170	1	0.5

These modeling results show that sound exposure levels >170 db will not be experienced at a distance greater than 0.5 km (500 m) from the pile driving operation and with levels below the 180 dB threshold value established by NOAA Fisheries/NMFS, significant potential injury to marine resources resulting from physical harm is not expected. Popper et. al's (2006) white paper (provided as *Attachment 2*) further questions the validity of the currently used 180 dB threshold, suggesting that this threshold does not have scientific justification and concluded that, based upon the best available science, and using conservative estimates, it is reasonable and appropriate at this point to use a combined *interim* single strike criterion for pile driving received level exposure; an SEL of 187 dB re: 1 µPa2 •sec and a peak sound pressure of 208 dB re: 1 µPapeak as measured 10 m from the source.

Effects of Sound on Fish

Hastings and Popper (2005) describes what is known about the effects of pile driving sound on fishes and identifies studies needed to address areas of uncertainty relative to

measurement of pile driving sound and the response of fishes to such sounds. Hastings and Popper (2005) also discussed the effects of other types of sounds on fish, with the understanding that one must be exceedingly cautious in extrapolating between sounds produced by pile driving and sounds produced by other human-generated sources such as SONAR and seismic air guns.

The monitoring data evaluated in the summary paper shows that sound pressure levels do not necessarily decrease monotonically with increasing distance from the sound source which is a key factor in evaluating the impacts to fishes. The data on the effects of pile driving on fishes is limited and not at all conclusive. There is limited observational anecdote that pile driving can potentially kill fishes of several different species if they are very close enough to the sound source, although these studies were never quantitative and only relied on observations of dead fish that came to the surface and not fish that died but were carried away by currents or fell to the bottom. There is an equally small body of evidence that fishes further from the sound source are not likely to be killed, although as pointed out by Hastings and Popper, most of the work on effects of pile driving on fish have major scientific flaws including lack of scientific controls, poor experimental design, and very suspect data analysis (*see* Hastings and Popper (2005) for critical review of these studies).

Hastings and Popper (2005) evaluated several studies performed that in part describe some aspect of the potential physical and behavioral impacts of pile driving operations on fishes. Potential physical impacts that have been noted but not proven from pile driving operations include death, hemorrhage from the eyes, metabolic changes, cellular damage, and rupture of swim bladders. In most all cases, these studies were not subject to peer review, and as pointed out by Hastings and Popper, they are generally faulty with respect to controls, experimental design, statistics, and data analysis.

Hastings and Popper (2005) also evaluated a number of other studies that examined effects of other types of sounds on fish. Many of these studies are in the peer review literature, and while few in number, provide some insight into effects of sounds on fish. Only in studies where fish were exposed to extended periods of very intense sound was there evidence of damage to the sensory receptor cells of the inner ear, while only in studies using explosives were there damage to other organ systems (and even these studies are equivocal). Perhaps the most relevant study was one by Popper et al. (2005) who demonstrated that there was no damage to fish of several species after exposure to high intensity seismic air guns. Two species did show a temporary affect on hearing sensitivity, but otherwise there were no physical effects and all fish survived. While the air guns are somewhat different in signal rise times than pile driving signals, these are the closest controlled data to any pile driving operation.

The overall results from the Hastings and Popper (2005) review of non pile driving sounds on fish suggest that fish species studied survive exposure to intense sounds with little physical damage. At the same time, the authors point out that it is hard to extrapolate between species, and that there are so few data that broad generalizations about effects of sound on fish are not possible.

It is important to note that several of the studies reporting these physical and behavioral impacts have been highly criticized for flaws in study design, treatment of control groups and inappropriate fish pathology and histology techniques which further compromise the reported results and their use as an indicator of impacts from actual pile driving operations. In addition, no studies have examined the presence or absence of longer-term effects of exposure to pile driving sounds and studies have not examined the non-mortality response of fishes outside of the immediate impact zone of the pile driving operation or to repeated noise exposures over an extended time period. Moreover, there are no data to indicate the effects of intermittent stimuli, such as pile driving. A critical question concerns the nature of any cumulative effect of pile driving when fish are exposed to multiple strikes, and if there is recovery from any effect if there is a longer interval between strikes.

Effects of Sound on Marine Mammals

Most research conducted on the effects of sound on marine mammals has focused on pulsed sound sources associated with airguns and offshore oil and gas exploration. Little information is available on the impact of pile driving operations as pulsed sound sources, but the effects that are likely to exist include masking effects, disturbance effects, hearing impairment, and non-auditory physiological effects.

Masking effects have not been shown to be significant for marine mammals since the pulsed noise produced during pile driving is discontinuous and some whale species such as sperm whales have been shown to continue calling in the presence of seismic pulses and their calls can be heard between pulses. It should also be noted that due to the enclosed nature of Long Island Sound, the occurrence of marine mammals is largely restricted to the pinneped and cetacean species described in the DEIS. While whale species are known to occur in the ocean waters off of Long Island , they are rarely seen in the Sound.

Disturbance effects have been observed through behavioral reactions in whales and vary depending on the sound source level, type of whale, and the activity the whale is engaged in when the sounds were heard. Most baleen whales have shown some form of displacement from strong pulsed sounds. However, this displacement was temporary and only lasted a short time. Among toothed whales, responses have been shown to be highly variable and under some circumstances, species will avoid pulsed noises when received sound levels exceed 180 dB (Wursig et al. 2000; Akamatsu et al. 1993). It is not known whether pulsed sounds have long-term behavioral impacts related to reproduction, distribution or habitat use, but studies of Gray whales along the west coast of North America indicate that there may not be long term impacts since whales continue to migrate annually in this area despite increased ship traffic and developed oil fields which are a large source for prolonged noise exposure.

Hearing impairment or loss has been a very difficult outcome to study or quantify in marine mammals. But temporary hearing loss has been reported for toothed whales exposed to pulsed sounds (Ridgway et al 1997) and bottlenose dolphins and beluga whales exposed to pulsed sounds have shown signs of hearing loss (Schlundt et al. 2000).

Hearing loss or impairment was generally observed at levels of 192-201 dB and 75 kHz. These values were not associated with permanent hearing loss since hearing thresholds and ability returned to normal after the studies were completed.

The most difficult outcome to quantify is non-auditory physiological effects. Very little known about the potential for pulsed sounds such as those associated with pile driving causing physiological effects in marine mammals. The limited data available shows that if they occur, it is limited to short distances from the sound source. The minimal studies that have been performed show responses in beluga whales with increased levels of norepinephrine, epinephrine, and dopamine and bottlenose dolphins showed increased levels of aldosterone and a decrease on monocyte counts when exposed to pulsed sounds. However, these data are not considered meaningful or conclusive since they do not provide a baseline to draw quantitative predictions for impacts to all species of whales or dolphins.

Mitigative Measures

A small amount of information is available on measures that have been investigated to mitigate for pulsed noise associated with pile driving operations. Limited data suggests that mitigating devices such as air curtains can significantly reduce the amplitude of pile driving signals. In addition, pile driving operations can be initiated slowly and include a ramp-up period of slowly increasing the power which may allow marine mammals that are disturbed to move further away before full noise levels are experienced. However, Broadwater notes that there are few if any data to show this as effective. Safety zones can also be set-up around the pile driving operation which can be visually monitored for sensitive marine mammal species. If these species are spotted, operations can be halted until they leave the area. Broadwater has taken these measures into account as well as the timing of the installation which will occur in October when sensitive species are less likely to be present in Long Island Sound. Operations will also only occur in daylight hours when species such as sensitive marine mammals can be visually detected and operations altered to minimize impacts.

Conclusions

The modeling information and data for fish and marine mammals presented above further supports the conclusions in Resource Report 3 which stated that in areas where subsurface noise levels reach a peak of 180 dB, injury or mortality of marine resources may occur. But these levels are not expected beyond the immediate vicinity of the pile driving operation and are temporary since these impacts occur during pile installation. As presented in Table 3-11 in Resource Report 3, the maximum distance that a 180 dB level may be experienced by marine resources is 2,953 feet (900 m) from the actual hammer operation. As further discussed in the Popper White Paper (2006), this sound level may in fact be quite conservative. In addition, modeling data for this operation at a similar LNG facility shows that levels at 170 dB will only be experienced at 0.2 and 0.5 km (200-500 m) from the actual hammer. Therefore, available literature and modeling evidence supports the conclusion that pile-driving operations associated with the Broadwater facility would not have a significant negative and/or long-term impact on the marine resources of Long Island Sound. Broadwater recognizes the concerns raised by NOAA Fisheries and others regarding potential impacts resulting from pile-driving activities. As

stated above, however, there is relatively little scientific literature available that provides definitive science as to the exact sound levels which can cause significant damage to fish and marine mammals in close proximity to pile-driving activities. Broadwater is committed to continuing a dialogue with the scientific community and NOAA fisheries to develop adequate mitigation measures, as appropriate to minimize demonstrable impacts resulting from pile-driving activities associated with the Project.

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Effects of Sound on Fish

by

Mardi C. Hastings,[1] Ph.D.

&

Arthur N. Popper,[1] Ph.D.

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Jones & Stokes
2600 V Street
Sacramento, CA 95818

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Summary

A. Effects of Pile-Driving Sound on Fish

The purpose of this report is to describe what is known about the effects of sound (including those from pile driving activities) on fishes and to identify studies needed to address areas of uncertainty relative to measurement of sound and the response of fishes. *Exposure to sound* is defined to include both the received level and duration of the signal.

The emphasis of this report is on the *known* effects of sound *received* by fishes. The effects are known if both the received sound and its elicited effect are well defined. Detailed source characteristics of various types of piles and detailed analyses of the effectiveness of various sound attenuation technologies (e.g., bubble curtains) are beyond the scope of this report.

The results in the peer-reviewed and gray literature on the effects of sound on fishes are variable and, as yet, give no clear-cut "rules" as to what sounds will affect fish and how they will be affected. A limited number of quantitative and qualitative studies and observations show mortality related to pile driving and also provide some data pertaining to the effects of sound on fishes. Results based on sound signals other than pile driving indicate that *some* exposures to sound will cause a change in the hearing capabilities of *some* test fish species or actually damage the sensory structures of the inner ear. There is also a very limited body of evidence that leads to the suggestion that exposure to sound has the potential for affecting other aspects of the physiology of fish, and that these effects may range from the macro (destruction of the swim bladder) to the cellular and molecular.

Data from explosive blast studies, while not directly comparable to pile driving, indicate that very fast, high-level acoustic exposures can cause physical damage and/or mortally wound fishes. There is also reason to believe that lesser effects might also occur, but these have not been well documented. Just as in investigations testing the effects of sound, however, the number of species studied in tests of the effects of explosives is very limited, and there have been no investigations to determine whether blasts that do not kill fish have had any impact on short- or long-term hearing loss, or on other aspects of physiology (e.g., cell membrane permeability, metabolic rate, stress), and/or behavior (e.g., feeding or reproductive behavior, movement from preferred home sites).

While these earlier studies provide a preliminary indication of the potential impact of pile driving on fishes, there are no peer-reviewed studies that examine the effects of pile driving on fish hearing, and there are only a few non-peer-reviewed reports about effects on non-sensory structures.[2] While we are able to use available data as a very preliminary indication of the kinds of effects that might be encountered as a result of pile driving, only additional well-controlled studies of behavioral and physiological responses to pile driving or to signals specifically

[2] In the course of conducting this review, the authors reviewed numerous reports and publications provided by the Fisheries Hydroacoustics Working Group and other colleagues. We are grateful for having many important reports and papers brought to our attention and many of these have been incorporated into this report. At the same time, we have elected to not include a number of reports and papers provided to us because we did not see them as being relevant to the subject and/or scope of this report.

designed to have the same acoustic characteristics as pile driving sounds, will provide clear scientific support of any criteria that are to be established.

B. Areas of Uncertainty and Studies Needed

To date, there are few data for fish on the effects of exposure to sound from pile driving, and these only appear in the gray literature (e.g., Anderson 1990; Feist 1992; Bonar 1995; Shin 1995; Caltrans 2001, 2004; Abbott and Bing-Sawyer 2002; Nedwell et al. 2003; Abbott 2004). Although these studies provide some information about exposures to pile-driving sounds, there is little that can be definitively concluded from them. By way of example, there are data and general observations of mortality and some injury to fishes that are close to the source where the level of sound is very high. Additionally, there are observations based on the numbers of fish that come to the surface dead after pile driving that suggest that there is less (or no) mortality at greater distances from the source (where the received level of sound would be lower than close to the pile). Finally, experimental cage studies also suggest that fishes further from the pile have little or no mortality and/or damage (e.g., Caltrans 2001, 2004; Abbott and Bing-Sawyer 2002; Nedwell et al. 2003; Abbott 2004; Marty 2004).

It does appear, however, that the degree of damage is *not* related directly to the distance of the fish from the pile, but to the received level and duration of the sound exposure. Because monitoring data show that sound pressure levels do not necessarily decrease monotonically with increasing distance from the pile, it is imperative that received sound levels be measured in future studies in order to develop exposure metrics that correlate with mortality and different types of damage observed in fish exposed to pile driving. The only study we are aware of to date (Caltrans 2004) that was intended to measure the differential in survival between fish exposed to pile driving with a bubble curtain attenuation device turned on and those exposed with the bubbles turned off, was not able to show a statistical difference in survival between the two conditions because the sample sizes were too small. Though in a study using an explosive sound souce, Keevin et al. (1997) showed that use of a bubble curtain significantly reduced mortality of caged bluegill (*Lepomis macrochirus*) during demolition of a dam and locks on the Mississippi River.

It is also very difficult to extrapolate to pile driving from studies using other types of signals (e.g., pure tones, air guns) because such signals are not analyzed or described in a format that can be interpreted in terms of a pile-driving signal (e.g., acoustic energy flux or acoustic intensity over time). Moreover, signals used in other studies often differ markedly from those emitted by pile driving in terms of duration, rise and fall times, and frequency content (e.g., Yelverton et al. 1975; Hastings et al. 1996; McCauley et al. 2003). Thus, specific signal components that affect fish may be very different in, for example, a study that uses continuous white noise vs. a study that uses impact sound exposures such as generated during pile driving.

The authors of this report conclude that it is imperative to initiate studies that start with very basic questions about the effects on fishes from exposure to pile driving sound. Table 1 (page 6) gives an overview of the types of studies that need to be accomplished to better understand the issues of pile driving and the biological effects caused by such signals. Note that

this table is presented in much greater detail in Section V of this report (Table 5, page 49), and summarized in Figure 9 (page 73).

It is important to note, as discussed in detail in Section V (page 42), that the body of scientific and commercial data currently available is inadequate for the purpose of developing more than the most preliminary scientifically supportable criteria that will protect fish from exposure to pile driving sound. As a consequence, such criteria are not proposed in this report. Instead, the information from earlier blast and pure tone studies has been used to develop recommendations for interim guidance to address physical injury and mortality and damage to auditory sensory cells, while recognizing the need for well-controlled studies to provide clear direction for development of scientifically supported criteria. It is critical to note, however, that *the interim guidance developed must be used with the utmost caution*, and that such guidance should not be used for any other signal than pile driving. The interim guidance recommended for pile driving is *only* applicable to that source and not for other sources such as air guns or sonars because it is based on results of effects studies that had received signals with temporal and spectral characteristics similar to those of pile driving signals.

Table 1: Outline of studies to investigate pile driving and its effects on fishes.
Characteristics of pile driving
Define acoustic dose for exposure to pile driving sound – Develop ways to express exposure to pile driving sounds in terms of total energy received over time and degree of temporal variation, and to define the acoustic particle velocity within the sound field.
Structural acoustic analysis of piles – Develop structural acoustics models of piles to investigate how their physical characteristics affect the radiated sound and how modifications to piles could alter the sounds received by fish. Acoustic analysis could also indicate how best to describe the waveform and how it is affected by pile material, geometry and size, hammer type, and environmental factors such as water temperature, depth, and substrate. These studies could lead to a better ability to develop attenuation of sounds produced during pile driving by modifying structural material, attenuation technologies, etc., especially if they are linked to modeling of the underwater sound propagation as described below.
Characteristics of underwater sound field – Develop underwater sound propagation models for locations of interest and integrate with pile structural acoustics models to estimate received levels of sound pressure and particle velocity in the vicinity of pile driving operations and define zones of impact on fishes. Verify with field measurements of underwater sound pressure measurements.
Effects on fishes
Hearing capabilities of Pacific Coast fishes – Determine hearing capabilities (using Auditory Brainstem Response [see Glossary, page 61]) of representative species.[3]

[3] All studies involve what are called in this report "representative species." These are defined as species that serve as models for fishes in the region of question – in this case, the Pacific Coast. Species for study need to be selected to represent differences in: (a) habitat; (b) presumed hearing capabilities (e.g., hearing specialists vs. non-specialists; (c) ear structure and connections of the ear to peripheral structures such as an air bubble; (d) swim bladder presence/absence, biomechanical properties, and connection to the gut; (e) bony fish vs. non-bony fish (including elasmobranchs); (f) fish size/mass; and (g) other comparable factors. A minimum set of fishes should be defined so as to have the fewest possible studies and yet represent as many of the parameters for the fishes of the area of question as possible.

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Interim Criteria for Injury of Fish Exposed to Pile Driving Operations: A White Paper

Arthur N. Popper
Department of Biology, University of Maryland, College Park, MD 20742

Thomas J. Carlson
Pacific Northwest National Laboratory, Battelle Portland, MSIN: BPO, 620 SW 5th Avenue, Suite 810, Portland, OR 97204-1423

Anthony D. Hawkins
Loughine Ltd, Kincraig, Blairs, Aberdeen, AB12 5YT, United Kingdom

Brandon L. Southall
NOAA Ocean Acoustics Program, National Marine Fisheries Service, Office of Science and Technology, 1315 East West Hwy, SSMC III #12539, Silver Spring, MD 20910-6233

Roger L. Gentry
ProScience Consulting, LLC, Dickerson MD 20842

Summary

This paper presents science-based, *interim* noise exposure criteria for the onset of direct physical injury in fish exposed to the impact sound associated with pile driving. This paper provides an objective, scientific assessment of pile driving exposures which are injurious to fish. It does not explicitly consider policies of regulatory agencies which are based on mandated legal requirements and consequently result in the application of sometimes limited information for management decisions. The authors recognize that fish may respond to pile driving without experiencing injury, but the paper does not directly address behavioral responses of fishes or other sub-injurious auditory effects in setting interim criteria, largely due to the absence of underlying information.

The interim criteria presented here are based on the best science available at the time of writing. We have used professional judgment and, for the most part, the existing, peer-reviewed literature, to make conservative decisions where data are lacking, or present a range of options. That is, in the face of uncertainty criteria are set at exposures somewhat lower than the present peer-reviewed literature suggest may be the levels that would result in the onset of injury. A dual criteria approach is developed which includes an interim single-strike criterion for Sound Exposure Level (SEL) combined with an interim criterion for Peak Sound Pressure Level. Possible applications of SEL metrics to account for the accumulation of exposure energy across multiple exposures are discussed, although it is pointed out that the available data supporting multiple strike criteria are highly limited. The assumptions on which the criteria developed here are based are listed in an Appendix along with suggestions for the research that is needed to test the assumptions. Because of the high likelihood that this research will call for modifications of the interim criteria, the criteria presented must be clearly understood to be provisional and part of

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an iterative, self-correcting process that, along with policy guidelines, will continue to evolve for decades as new data become available.

Introduction: approach to exposure criteria

The initial approach to linking biological consequences with impulsive sound exposure has focused on the sources of the sound because that is how information is presented in the peer-reviewed literature. The major sources of impulsive sound are explosions, seismic devices, and percussive pile driving. However, any impulsive signal can exhibit a wide range of characteristics as described using various metrics that may include, among others, peak pressure, rise time, duration, and spectral composition. Overlap of impulse characteristics between sources is a fact. It is possible for seismic sound impulses to have key characteristics, such as peak pressure, that are very similar to percussive pile driving sound or to explosions. This is true because of the wide range in the characteristics of sources and the rapid modulation of the composition of impulsive sound signals as they propagate, particularly in shallow water.

In terms of biological consequences, it is not the source of the energy that affects exposed fish that is important. Instead, it is the received exposure conditions, attributable to the particular characteristics of a signal of interest, the specific environment in which the sound is produced, and the physical orientation of source and receiver. Also of importance may be factors such as the rise time of the signal, the number of exposures of an animal to a particular signal, the time between each exposure, and the physiological accumulation of effects.

The mapping function of ultimate interest to science is between metrics such as peak pressure and rise time for both sound impulse pressure and particle motion, and also biological consequences of effects such as barotrauma or hearing loss. The objective of scientific investigation is to describe the mapping functions between biological consequence and impulsive sound characteristics. In such a mapping, impulsive sound characteristics will be grouped as data vectors similar to the familiar (X,Y) coordinates that identify a point in a plane. These data vectors, instead of identifying the location of a point, will map to the biological consequences of impulsive sound exposure, which will most likely be probabilistic in nature, for that particular impulsive sound data vector. This paper presents the initial step in this process by proposing a science-based data-driven approach that consists of two impulsive sound metrics that map to the boarders of a biological response space that is poorly understood.

Scope and Purpose

Fish species are sometimes injured or killed by the impact sounds generated by percussive pile driving. Their hearing may also be affected or their behavior altered. The specific effects of pile driving on fish depend on a wide range of factors including the type of pile, type of hammer, fish species, environmental setting, and many other factors. The fish species affected depend on the location of the operation, and the habitat, which varies from rivers to reefs on the continental shelf. Ultimately, noise exposure criteria for fish are needed for the onset of injury, behavioral disturbance, and possibly other auditory effects such as noise interference with hearing (masking) or temporary loss of hearing (temporary threshold shift -

TTS). Unfortunately, available data are currently too sparse to set clear-cut science-based criteria for behavioral disturbance of fish or auditory masking from pile driving. Therefore, only criteria for the onset of direct physical injury from exposure to pile strikes are presented in this paper.

Sounds from Percussive Pile Driving

The sounds from percussive pile driving result from the impact of the hard surface of the hammer with that of the pile (See Hastings and Popper, 2005, for a fuller description of the sounds from pile driving and associated acoustics). The sounds are short, sharp and often very high in amplitude. They are repeated, usually at intervals greater than one second, for some minutes and sometimes for some hours. Figure 1 shows typical sound pressure impulses from a single strike at different locations within a harbor area. The individual impulses may vary in their characteristics and amplitude even at one location within a sequence, as the driven pile encounters different substrates. Moreover, the shape and amplitude of the impulse varies as the sound travels through different pathways to different locations. The impulses are generally shorter than one second, have a steep rise-time (although this may change with distance from the source), and may reach a sufficiently high level to result in non-linear effects in the water and in fish tissues. Because of their brevity and sharpness they have a wide frequency spectrum, and any monitoring or recording equipment must reflect this.

To fully describe the characteristics of the sounds it is necessary to look at those features which may create damage to the tissues and organs of fish. Particularly at risk are the gas-filled swim bladder and surrounding tissues as they expand and contract with passage of a pressure wave. In addition, the ear of fish may be vulnerable to extreme pressures and motions. Sound characteristics currently believed to be most germane to assessing damage to fish include:

- The peak pressure excursion, including the negative and positive peaks.
- The accumulation of energy over time within a single impulse, including not only the direct signal, but also the signal as received via multipaths (e.g., due to surface reflections and/or transmission through the substrate).
- The "sharpness" of the sound (*e.g.*, ratio of peak to rms pressure, or "crest factor") and its rise time.
- The repetition of the sound and accumulation of energy over multiple exposures - receipt of further sound impulses before organs and tissues have recovered from the impact of the first.
- The particle motion stimulus associated with the sound.

Metrics

As indicated, it is not yet clear which aspect(s) of a signal are relevant when considering how a sound may impact a fish. In order to provide some understanding of the possible metrics for describing sound characteristics relevant to potential injury, a number of such metrics are discussed below.

Peak Sound Pressure Level

The peak SPL is the maximum excursion of pressure within the sound. The maximum excursion may take place within a single cycle of sound, but the highest positive peak and the lowest negative peak may be separated in time within the sound impulse. The peak pressure will determine whether the swim bladder and ear are subjected to extreme mechanical stress. Currently the peak SPL is often the only measurement utilized to evaluate the impact of pile driving.

Accumulation of Energy with Time

The time over which energy is applied to a tissue or organ may affect the degree of damage which is inflicted. With a continuous signal a measurement of the root mean square (rms) sound pressure is an appropriate metric. With a sound impulse, however, a metric must be chosen which adequately describes the potential for damage of pulses of different lengths and energy distribution; that is, which measures the acoustic energy in the transient. The sound exposure level (SEL) is one such metric. The SEL is defined as that level which, lasting for one second, has the same acoustic energy as the transient and is expressed as dB re: $1\mu Pa^2 \bullet sec$.

Formally, the SEL is measured over a stated time interval. Ten times the base-10 logarithm of a given time integral of squared instantaneous sound pressure is divided by the product of the squared reference sound pressure and the reference duration of 1 sec. The time interval over which the sound is measured must be long enough to include most of the sound source's acoustic energy.

Note that in the context of this paper the SEL is used to compare impulses, or short single event sounds. SEL may also be used to examine and compare continuous sounds which fluctuate in level and there is evidence from the mammalian hearing literature that total energy measures are relevant in describing cumulative fatiguing effects under certain conditions (*e.g.*, Ward, 1997; Hamernik *et al.*, 2003). The relevance of these observations to physical injury in fish is unknown, however. At this time, these and other significant limitations in available data preclude a definitive assessment of whether or how SEL should be used to account for the repetition of impulse exposures. While it is likely that in certain situations, the SEL of multiple strikes may be a meaningful metric in describing exposure dose and assessing effects, there are numerous variables such as the additive effects of multiple signals on physiology and hearing that are not at all understood for fish.

Sound "Sharpness"

A number of studies have shown that the presence of a strong transient within a sound correlates with increased damage to the ears of mammals. There are well documented increases in auditory damage with pulsed as opposed to non-pulsed sounds, or with "sharp" sounds as opposed to "dull" sounds. Pile driving may generate sharp transients where the peak SPL and conventional SEL metrics may not, alone, be sufficient to describe the stimulus in terms of the damage it may cause. As discussed below, explosives have an even sharper rise time. Price (1983) has shown that a rifle shot may have a more damaging effect upon the mammalian auditory system than a cannon shot of higher SEL. Based on measured spectral differences, Price predicted that rifle impulses would cause permanent threshold shifts at approximately 9 dB lower peak pressures than cannon impulses. This threshold shift was later confirmed by experiment.

After studying a large number of chinchillas during exposure to high level continuous non-Gaussian noise, Hamernik *et al* (2003) concluded that the statistical metric, kurtosis, in conjunction with an energy metric, can identify hazardous exposure conditions not identified by conventional energy based metrics alone. Formally, the kurtosis (β) of the sample distribution is the ratio of the fourth-order central moment to the squared second-order central moment of the distribution. Kurtosis is sensitive to the various parameters that define a complex noise such as the levels and durations of the transients, temporal structure of the noise, the numerical relationship between peak and rms pressure ("crest factor"), as well as to the duration of the noise sample over which β is computed. The crest factor itself is often monitored as a potential cause of damage in mechanical systems exposed to a continuous sound.

For impact sounds, the rise time (the time taken for the impulse to reach its peak pressure), or other metrics, may be more appropriate for measuring the sharpness of onset than kurtosis or crest factor. Accordingly, reduction of the sharpness of the impact sounds from pile driving may play a significant role in the reduction of damage. However, one issue with pile driving is the variation from strike to strike of rise times, and the lack of any data on the effect of rise time differences on fish.

Sound Repetition

If another impulse is experienced before an organism has fully recovered from the effect of an initial impulse, then cumulative effects may occur, leading to greater risk of injury. The SEL may or may not be an appropriate metric for measuring repetitive impact sounds in this context as the period of silence between impulses will dominate the measurement. In the present state of knowledge the impulse repetition rate may be the most suitable metric, but it is not possible to use this metric at this point since nothing is known about cumulative effects, and thus repetition rate, on fish. As discussed in the Appendix, these are areas that are critical components of future research.

Particle Motion

Sound consists of two mechanical effects. As well as the change in the pressure above and below the hydrostatic pressure – the sound pressure – which is normally monitored there is also a back and forth motion of the component particles of the medium, of the order of nanometers, which can be expressed as the particle velocity, particle displacement or particle acceleration. Particle motion is aligned along a particular direction and is therefore a vector quantity.

Many species of fish are sensitive to particle motion in addition to, or instead of, sound pressure (Popper *et al*., 2003). In these fishes it is not yet clear whether high levels of particle motion may damage the auditory system. There is no experimental evidence on this point, although it is evident that particle motion is the important stimulus in considering behavioral responses of many species of fish, particularly when they are close to the source. In these species, pressure waves may also remain a source of injury to the fish, even though the auditory system may be relatively insensitive to sound pressure.

Setting Criteria for Damage

Only recently has impact sound been managed with the intent of mitigating adverse effects on fish. The interim noise exposure criterion which the relevant regulatory authority in the U.S. NOAA's National Marine Fisheries Service has set in managing pile driving is a peak sound pressure of 180 dB re: 1 μPa_{peak} (meaning the sound pressure level at the instant of maximum absolute pressure). While it appears that this value is often cited (e.g.,, http://mapping.orr.noaa.gov/website/portal/pies/piledriving.html), the scientific basis for this value is obscure, if not completely absent (see discussion in Hastings and Popper, 2005). It is an oversimplification that has likely resulted from regulators trying to apply a single exposure criterion for exceedingly wide-ranging exposure conditions.

Recent research (Popper *et al*. 2005) indicates that for seismic impulses, 180 dB re: 1 μPa_{peak} is considerably lower than the sound pressure levels that could cause actual injury in three taxonomically diverse species of fish. Furthermore, application of the peak pressure criterion on its own fails to account for the temporal characteristics of the single impulse (the rise time and the variation in peak or rms pressure within the impulse) and the cumulative effects upon the animal of multiple strikes from pile driving (note that the peak pressure units contain no reference to time). For these reasons it is critical to consider that a series of metrics should be examined for setting protective criterion.

Hastings and Popper (2005) reviewed all pertinent peer-reviewed and unpublished papers on noise exposure of fish through early 2005. They proposed the use of SEL to replace peak Sound Pressure Level in pile driving criteria. After deliberation and discussion, we of this paper have concluded that while SEL is an important criterion, it too has drawbacks and uncertainties when used exclusively. Instead, we advocate using both SEL and peak SPL simultaneously to describe the characteristics of a single impulsive sound. This combination is likely to account for those impulsive sound characteristics implicated in injury to fish better than either metric

alone.

At the same time, we want to point out that the addition of SEL to the current criteria must be considered provisional. Future research may very likely show that other metrics, either alone or in combination, may provide even better indices of injury than the present choice. Kryter (1985), ANSI (1986), and Hamernik *et al.* (2003) review all the metrics that have been found to correlate with physical injury to humans and other animals. Of these, kurtosis or another metric describing the sharpness of the impulse seem particularly promising for future investigation in fish (see Appendix). Particle motion may also be a relevant parameter especially where behavioral responses are being considered, or where fish lack swim bladders. It is also necessary to consider the effects of repetition of the impulse and/or the rise time of the signal. However, selection of additional, or alternative, metrics can only take place after considerably more research on the effects of sound on fishes. Indeed, there are no studies either in the peer-reviewed or unpublished literature that have even attempted to examine these alternative metrics in studies of the effects of sound on fishes.

In the dual criterion approach adopted here, the SEL value limits the total acoustic energy fish may experience within a single impulsive sound, while the peak sound pressure level protects fish from an especially strong excursion in pressure within the sound impulse. In practice, we recommend that both SEL and peak pressure are measured during pile driving operations and that neither criterion should be exceeded. We note the likely relevance of some means of accounting for the cumulative effects of multiple exposures and the fact that peak pressure fails entirely in this regard.

Selecting Values for the Criteria from the Available Data

The following discussion proposes that interim criteria for pile driving be set at an SEL level of 187 dB re: 1 $\mu Pa^2 \cdot sec$ *and* a peak sound pressure level of 208 dB re: 1 μPa_{peak} in any single strike. The scientific basis for this suggestion is presented below. Note that only one of the studies cited (Caltrans, 2004) used pile driving stimuli. This raises the question of how valid it is to use data from other sources to set criteria for pile driving. The signals produced by explosives and seismic devices have different rise and decay times and higher peak pressures than signals generated by pile driving. Waveforms from dynamite explosions (Yelverton *et al.* 1975) typically have peak pressures several orders of magnitude above that of pile driving signals (see Hastings and Popper, Appendix I, for a fuller discussion) and faster rise times. Thus, the effects of explosives (and possibly seismic activity) are likely to have a greater effect on fish than pile driving signals, and the use of data from these sources to set criteria for pile strikes would be conservative.

In an attempt to select initial interim criteria, we are only able to use four studies for guidance on effects of sound impulses on fish (Yelverton *et al.* 1975; Caltrans, 2004; Popper *et al.*, 2005; Popper *et al.*, in prep.). The one (unpublished) study that considered pile driving itself, Caltrans (2004) reported that there was no damage to steelhead and shiner surfperch when exposed to multiple pile driving strikes that ranged from 158 to 182 dB (re 1 μPa^2-s) at distances of 23 to 314 meters from the pile. This study showed no statistically significant mortality (i.e.

different than control groups) for SEL's as high as 181 dB (re 1 μPa^2-s) for surfperch and SEL's as high as 182 dB (re 1 μPa^2-s) for steelhead.

In a study investigating the effects of explosives on fish, Yelverton *et al.* (1975 – reviewed in detail in Hastings and Popper, 2005) predicted the likelihood of mortality on fish of different sizes for single explosions. These data were converted by Hastings and Popper (2005) to exposure in terms of SEL (Fig. 2, from Figure 8 of Hastings and Popper, 2005). In Figure 2, the lower curve suggests that the "no injury" level for the very smallest fish (0.01 g) occurs at 193 dB re: 1 μPa^2•sec. Impulsive sound with SEL below this level has not been found to injure fish, and SEL's above it pose a risk of injury proportional to their level above 193 dB.

Based upon these data, a doubling in exposure would be required to cause an estimated 50% mortality for these small fish (upper curve in Fig. 2). Since the stimulus used by Yelverton *et al.* (1975) was impulsive and had considerable similarity to the stimulus from pile driving (Hastings and Popper, 2005), these values provide some guidance as to potential effects of single strikes of pile driving.

At the same time, since the stimulus in the figure does differ from a pile driving signal, we suggest that a more conservative value is needed for the initial SEL interim criterion. Therefore, we have reduced the levels from Yelverton *et al.* (1975) by an additional 6 dB, resulting in an energy level that is one-fourth that of the value derived from Yelverton (each 3 dB decrease in energy is ½ of the higher value). The resultant criterion becomes 187 dB re: 1 μPa^2•sec (over a 1-second period) received level for an impulsive sound.

The conservative nature of this value is supported by a recent peer-reviewed study. Popper *et al.* (2005) found no effect on the behavior or physiology of salmonids exposed to seismic air-guns at an SEL of 180 dB re: 1 μPa^2•s, and only temporary threshold shift (TTS) in two other species. TTS is defined as a reversible physiological fatigue and not injury (Ward, 1997). Fish, like mammals, show complete recovery from TTS and return to normal hearing. The Popper *et al.* (2005) study leads to the suggestion that an SEL somewhat higher than 187 dB would still be conservative as a criterion for injury from seismic impulses.

In addition, Popper and colleagues (in prep.) exposed fish to low frequency sonar for 324 seconds, with an SEL of 188.5 dB re: 1 μPa^2•s. This long-duration exposure caused some TTS but no injury to two species of fish (including rainbow trout as a surrogate for endangered salmon), but not to a third.

The above data, along with an evaluation of the peer and unpublished literature (reviewed in Hastings and Popper, 2005) also demonstrate that there is absolutely no scientific justification for establishing a peak pressure criterion for injury of 180 dB re: 1 μPa_{peak} for low frequency signals. Indeed, a more reasonable value is likely to be in the range of 205-215 dB re: 1 μPa_{peak} for continuous sounds. This is supported by findings of Popper et al. (2005) who showed that TTS onset (physiological fatigue and not damage) in three species of fish exposed to seismic air-gun pulses occurred within the range of 205-210 dB re: 1 μPa_{peak}. Moreover, the peak pressures recorded in the Caltrans (2004) study which showed no damage to fish at SEL's of over 181 dB re: 1 μPa^2•s had peak levels in this same range. We recognize that pile driving sounds have

different characteristics than the seismic signals, making direct comparisons less than optimal. Using the combined information and acknowledging the differences in stimulus parameters, we propose a value of 208 dB re: 1 μPa_{peak} (*i.e.*, from the low end of the range) as the interim peak pressure criterion for injury to fish from pile strikes.

The suggestion that these values are conservative is also supported by research on barotrauma which has shown that changes in overpressure less than 0.4 times acclimation pressure at rates of change in pressure on the order of 150 Pa-sec^{-1} do not cause injury to tested species and sizes of physoclistous or physostomous fish (Cada 1990). The 208 dB re: 1 μPa_{peak} criterion is equal to a peak overpressure of 25.1 kPa which would be approximately 0.25 times the acclimation pressure for fish located at the water surface. The criterion becomes increasingly conservative with depth as the overpressure becomes a smaller fraction of acclimation pressure.

Finally, it is important to appreciate the reasoning behind using an exposure over a single pile driving pulse in making decisions on interim criteria *at this time*. There are no data on cumulative effects of pile driving (or any anthropogenic stimulus) on fish, nor is it known whether there is recovery from any effects of pile driving in the intervals between strikes. At the same time, when considering cumulative effects it is not correct to just add the amount of signal to which the animal is exposed since the cumulative effect must include any recovery that takes place in the animal between stimuli (Chen *et al.,* 1999). Thus, if the signals are far apart there is likely to be more recovery from each stimulus exposure than if the stimuli are close together.

Since nothing is known about cumulative effects of pile driving, it is difficult to know whether the effects of sequential strikes are in fact cumulative and, if so, what the relevant factors of exposure relative to damage and recovery are. It is well known that auditory systems show some recovery from trauma over even short periods of time (e.g., Chen *et al*., 1999). As a consequence, if one strike is quickly followed by a second, there may be a cumulative effect since there may be no time for recovery from the first strike. However, if the second strike follows the first by some greater period, the affected system may show some or complete recovery from the effects of the first strike. At this point, we know nothing of the accumulation of effects resulting from strikes that are variably spaced in time. Consequently, predicting the cumulative effects of multiple pile strike exposures remains speculative. It is clear that future research, as discussed in the appendix, will be needed to add the very important variables of multiple strikes and inter-strike intervals into subsequent exposure criteria.

While the SEL criterion given here is for a single strike, we recognize the importance of accounting for the energy contained in multiple exposures. Explicit research on this matter will inform subsequent criteria, but currently it is possible only to suggest some reasonable, and admittedly undocumented, means of approximating SEL summation. For instance, it is likely important that SEL be calculated only during the actual exposure period (including the multi-path energy from each strike) rather than including the silent intervals between strikes. Additionally, a cumulative SEL for multiple exposures, which could be assessed relative to the single strike SEL criterion, should very likely only be determined for conditions in which inter-strike intervals are on the order of seconds rather than minutes or hours.

Additional Issues

An additional issue to consider is the point at which the signals are measured for determination when the criteria are exceeded. The ideal situation is to use received level of the signal as the criterion since this is the actual signal detected by the animal. However, since regulators deal with animals at a wide range of distance from a source, it is impossible to stipulate that recordings be done at every conceivable fish location. At the same time, it is not possible to set criteria as signal levels at the source since these are often difficult (or dangerous) to measure, and the signals at this point are very complex. Thus, it is our recommendation is that a single distance from the source be selected as the point at which measurements are made to determine whether signals exceed criteria. Based on current procedures, we suggest that this distance be 10 meters from the source.

A final issue is a recognition that fish behave differently, and that criteria will ultimately have to be based on fish behavior in addition to sound levels. Some fishes are active swimmers and could be expected to swim through, or away from, areas of highest signal level with exposure to very few pile driving impulses. Other fish tend to be resident in areas and would not move away from impinging sounds, and thus would be exposed to signals for the duration of the pile driving activity. The effects of pile driving on the latter fishes is potentially much greater than upon the former.

Conclusions

Based upon the best available science, and using conservative estimates, we conclude that it is reasonable and appropriate at this point to use a combined *interim* single strike criterion for pile driving received level exposure; an SEL of 187 dB re: 1 $\mu Pa^2 \cdot sec$ and a peak sound pressure of 208 dB re: 1 μPa_{peak} as measured 10 m from the source. We have considered the important issue of cumulative effects of multiple exposures, but emphasize the current absence of any empirical information which would allow cumulative effects to be taken into account. Our expectation is that our interim criteria will change as we obtain more data on effects of pile driving and other sounds on fishes. However, since these values, based upon current data, are *conservative*, they are far more realistic than the value of 180 dB re: 1 μPa_{peak} which is currently in use, and for which there is no scientific justification.

Appendix: Assumptions and Research Needed to Test them

Assumptions

In proposing the interim criteria, we make a number of conservative assumptions about pile driving and the behavior of fish during exposure to the pile driving sound. However, there are few or no data to indicate whether these assumptions are valid, and any deviation from these assumptions will result in lesser effects on fish.

1. Fish have no avoidance reactions nor are they carried by water currents or otherwise affect a change in position (i.e. their position relative to the sound source is static) that would alter their exposure from strike to strike throughout a pile driving operation. They will experience the same received level from every strike required to drive a pile. This is possibly a conservative assumption because it has not been shown, and is probably unlikely, that many fish will remain static during driving of a pile, although how far they can/move between strikes is an open question, and will depend upon the normal "fright behavior" of fish and their swimming speed. They are probably likely to change orientation, actively move away from the area of highest ensonification, or be transported by flow through the more intense regions of the sound field. But, since few data now exist, the conservative approach is to assume that none will move.

2. At a given range, the received level is the same at all depths in the water column and the sound field does not change with the angle of the fish from the pile. Therefore exposure varies as a function of range but not depth or direction from the pile. Sound propagation models for piles are not well developed, particularly for the shallow water environments common to most pile driving work. Sound propagation models developed for other impulsive sound sources, such as explosions and seismic devices, indicate that the sound fields generated by such devices can vary with depth and angle from the source, particularly for shallow water environments.

3. Fish susceptibility to pile strikes in the form of barotrauma is uniform at all depths. This assumption is known to be false. Indeed, the risk of barotrauma is known to decrease as the acclimation depth of exposed fish increases and the overpressure in the sound impulse remains constant. However, the data are currently insufficient to set criteria for all species of interest that incorporate depth of exposure.

4. The SEL criterion is based on exposure of fish weighing 0.01 g, and assumes that such fish are present at every pile driving operation at any season of the year. This is a conservative assumption because in most cases only fish larger than 0.01 g are present, and fish susceptibility to impulsive sound decreases with size (see Fig. 2, upper line).

5. The SEL criterion assumes that sound impulses generated by pile driving strikes have the same potential for injury as the sound impulses generated by explosions (explosions were used as the basis for the initial 193 dB re: 1 $\mu Pa^2 \cdot sec$ estimates of a safe SEL). However, comparison of sound impulses from pile driving and those from explosions show that the latter have a faster rise time, higher peak pressure, and a different frequency spectrum.

6. The pressure criterion uses TTS to define effects, which is conservative given that TTS is considered to be physiological fatigue from which there is complete recovery (Ward, 1997) and permanent threshold shift (PTS) is considered to be injury. TTS and PTS are likely produced by different mechanisms (Liberman and Dodds. 1987; Nordmann *et al.*. 1999). At present, data are insufficient to estimate PTS onset from TTS onset in fish, so TTS is used as a general proxy for injury (very highly conservative).

Recommendations for Research

This document proposes the first round of interim criteria for impulsive sound. To refine these criteria, determine more accurate SEL and peak pressure levels, and determine whether metrics other than these would better index injury to fish, a long-term series of studies is needed. The following list outlines the needed studies. Additional studies are presented in Hastings and Popper (2005).

1. Studies are needed that expose fish to simulated pile driving sound impulses while independently varying pressure and particle motion. Fish should be tested levels up to and exceeding the proposed injury criteria for both peak pressure and SEL.

2. Studies are needed that examine cumulative effects of sound exposure on fish. Factors to be considered include cumulative effects of multiple strikes and the effects of different inter-strike intervals on cumulative effects. In other words, is it appropriate to define a criterion based on one strike or many strikes, and if on many strikes, how many and over what period of time?

3. Studies are required to examine the effect of the temporal characteristics of single impulses, including the rise time, in causing injury or hearing loss in fish. Questions need to be asked regarding effects of different rise times on the trauma imposed upon fish, as well as potential temporary effects such as hearing loss.

4. Hardware and software should be acquired or developed so that operators can monitor pile driving signals in SEL in near real time for both single strike and multiple strike exposures. Ultimately, operators may need to measure particle motion as well.

5. A study should be instituted to investigate the behavioral reactions of non-restrained fish to actual pile driving using visual or acoustic detection methods. This project would test the key assumption that fish have no avoidance behavior.

6. The results of this behavioral study should be incorporated into a model, such as the Acoustic Integration Model (AIM), that models accumulated acoustic exposure for simulated fish moving through an ensonified water column.

7. Data are required to determine which approaches (SEL, Kurtosis, peak pressure, something else) are the best descriptors of effects on fish. These should be considered in terms of effects on behavior, hearing, and barotraumas, It should be recognized that different measures may best describe different impacts on fish.

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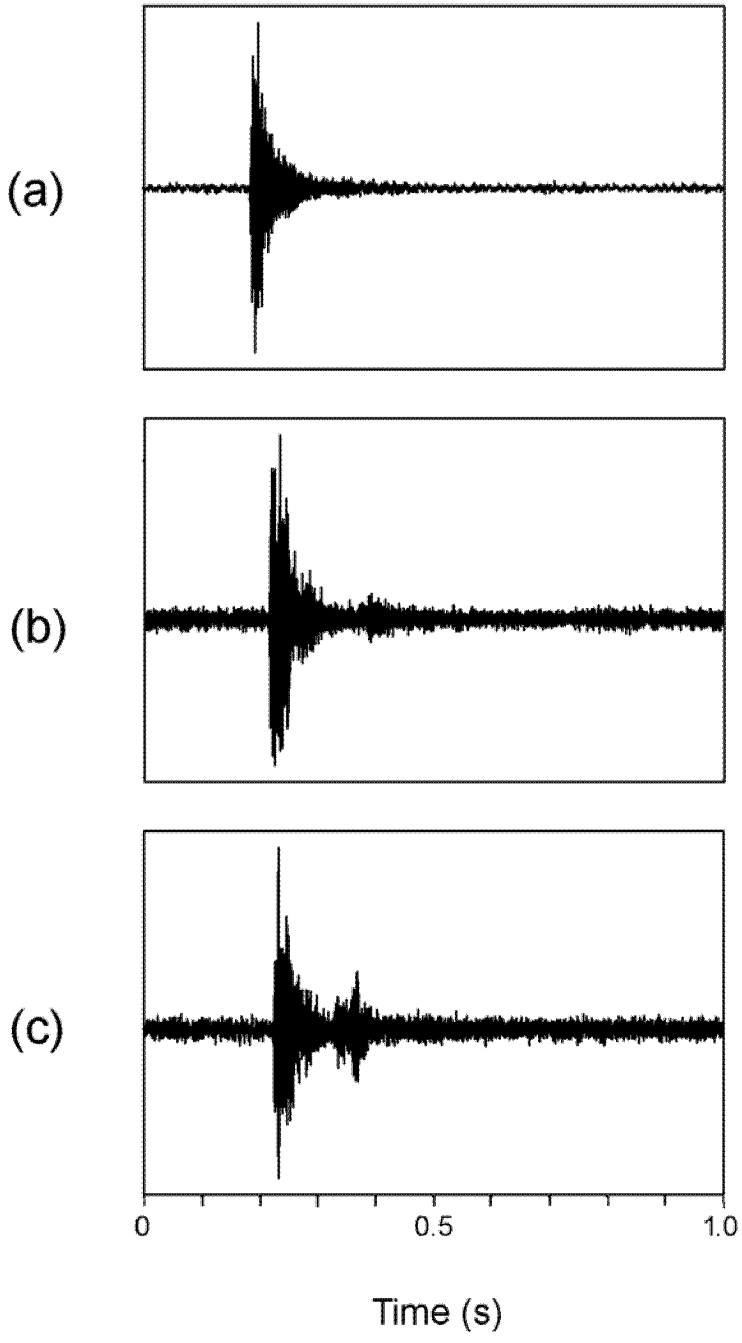

Figure 1. Three impulses from percussive pile driving obtained at different locations in a shallow water environment. a) at 189m, b) at 552m and c) at 906m. Note the short duration, sharp onset, and uneven distribution of energy over time

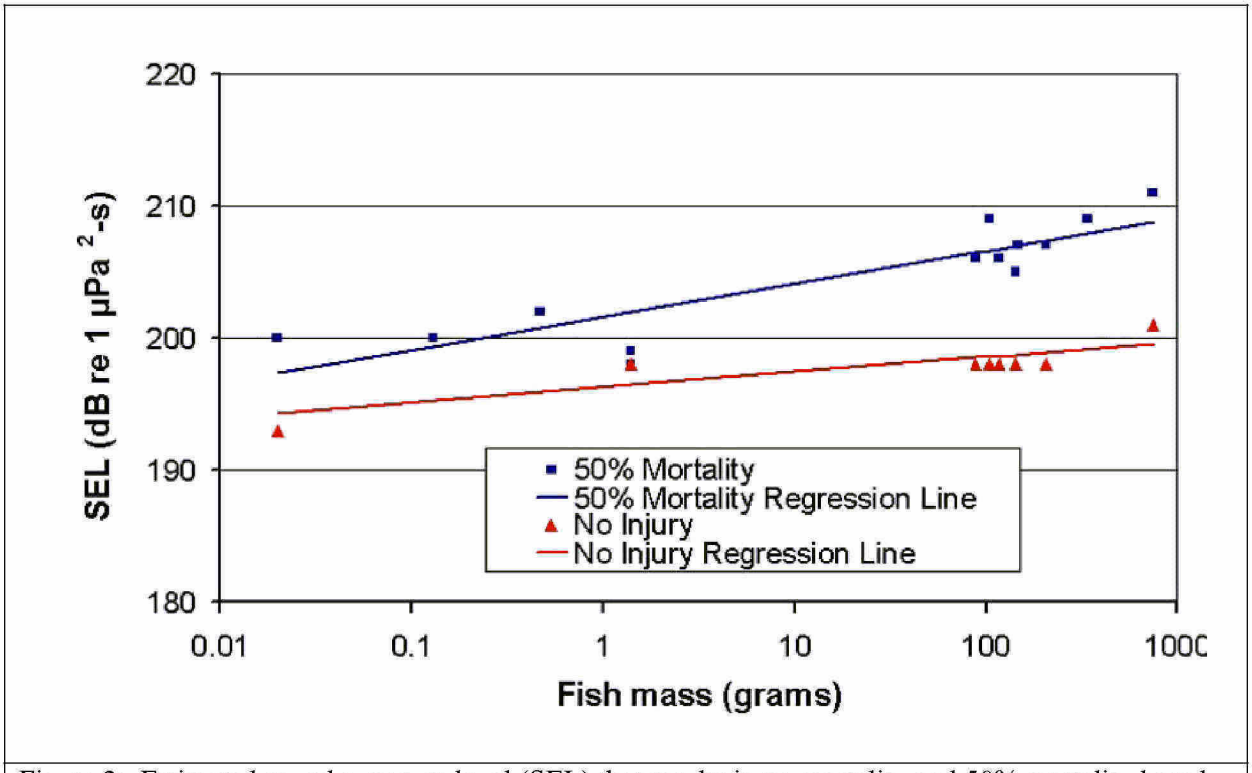

Figure 2: Estimated sound exposure level (SEL) that results in no mortality and 50% mortality based on data for exposures to a single explosive sound as reported by Yelverton et al. (1975) and modeled as an ideal impulse wave as described in Hastings and Popper (2005). (Friedlander waveform as described by Hamernik and Hsueh 1991). (Figure from Hastings and Popper 2005, Figure 8)

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Request:

Provide a detailed comparison of various backfilling methods that could be used along the length of the pipeline trench. Provide detailed descriptions of the various methods including natural backfilling, active backfilling with rock, and active backfilling with native sediment using various construction methods (e.g., backfill plow, backfill plow with sled, and divers). Also, discuss the potential for using a combination of these methods depending on site-specific considerations along the pipeline corridor. Assess the technical feasibility of success based on other linear marine projects in the region including the Iroquois pipeline, the Eastchester pipeline, the HubLine pipeline, and the Cross Sound cable. For each method, quantify the magnitude, extent, frequency, and duration of impacts associated with turbidity, sediment conversion, and disturbance of the seafloor, benthic communities, and other marine resources.

Response:

The various backfilling methods that could be used along the length of the pipeline trench are directly related to the pipeline lowering or trenching methods that are planned to be used along the length of the pipeline route.

Broadwater Pipeline Lowering Methods

Upon completion of the pipe-laying operation, the pipeline will be lowered below the seabed along its entire length, wherever sediment conditions permit. In general, pipeline lowering can be accomplished by either pre- or post-trenching of the seabed. Pre-trenching is trenching prior to pipeline lay and is used if the pipeline needs to pass through very stiff material. Post-trenching means that the trenching equipment would remove sediment from the underneath and sides of the pipeline while the pipe lies on the seabed.

Based on the observed sediment characteristics together with environmental impact analyses, Broadwater has proposed the post-lay plow method to lower the entire 21.7 mile pipeline. The post-lay plow is placed over the pipeline previously laid on the bottom by the lay barge, and the pipeline is then lifted and the plow shares are closed around and below the concrete coated pipe. The plow is pulled forward by the attendant bury barge with the plow rollers centralizing, supporting and guiding the plow. The plow then excavates a trench below the pipeline and the pipeline is lowered into the furrow in the seabed in a continuous fashion as the plow is pulled ahead. Broadwater has conservatively allowed for two complete passes of the post-lay plow to obtain the target depths of cover. The multi-pass plow will clear the spoil pile to a sufficient distance away from the edges of the trench to prepare the seabed for the second lowering pass.

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Post-lay plowing will decrease the amount of sediment introduced into the water column when compared to other installation technologies that could be utilized. As previously discussed by FERC in recent projects proposed or constructed in the Long Island Sound (*see FEISs for the Eastchester Project [Docket No. CP00-232-000] and the Islander East Pipeline Project [Docket No. CP01- 384-000]*), both jetting and dredging installation technologies are recognized to cause greater disturbance to sediments and disperse sediments over a much larger volume of the water column than the subsea plow, which has been the recommended construction methodology, where feasible.

For safety reasons post-lay plowing will not be used at certain locations as noted in Table EIR 24-1:

Table EIR 24-1 Exceptions to Post-Lay Plowing Method

Locations		Excavation Method
MP 0.0 MP 0.4 MP21.7	FSRU tie-in Check and isolation valve spool Iroquois tie-in	Excavations will be performed using a submersible pump or by divers using hand-jetting or air-lifting equipment
MP 3.0 MP 6.4	Cross Sound Cable crossing AT&T Cable crossing	Airlifting of the material below the pipeline will be completed by divers and will result in the lowering of the pipeline onto bridge supports

The Stratford Shoal is a location where the presence of hard material (boulders or large cobbles) could prevent post-lay plowing. Based on the results of the geotechnical investigations completed by Broadwater in 2005, it is proposed that a trial plow operation using a scaled-down plow be performed prior to construction to evaluate the sediments/materials of the site. Assuming that the trial plow operation is unsuccessful, approximately 4,000-feet (0.75 mile) across Stratford Shoal will require dredging instead of post-lay plowing.

Broadwater notes that this request cites the "backfill plow with sled" as a backfilling method. Broadwater surmises that this is referring to the jet sled method – possibly referencing the SmartJet jet-plow used to lower and backfill the Cross Sound Cable (*see* Table EIR 24-4 for a description of the SmartJet jet-plow). The equipment and methods required for the safe handling, installation and lowering of large diameter subsea pipelines are not at all comparable to the equipment used for the installation and lowering of subsea cables, partly owing to significant differences in the size and weight of the facilities. Post-lay jetting using a pipeline jet sled was rejected by Broadwater. A pipeline jet sled uses high pressure air and water to fluidize the material under the pipeline and removes it away completely creating a void beneath the pipeline. The pipeline then settles into the trench. To reach the required depth of burial one or more passes would be needed depending on the characteristic of the sediments. Jetting will create a larger trench cross section and thus will disturb more sediment than a plow. Unlike plowing which creates a spoil pile alongside the trench, jetting will create high turbidity as the spoil is discharged

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and spread over an extended area on both sides of the pipeline. Recovering this spoil for backfilling with natural sediments is not possible.

Pipeline Backfilling Methods

To minimize the number of passes of the construction barges along the pipeline route, Broadwater has proposed natural backfilling of the pipeline trench except in identified locations, including the first two-mile section of pipeline where active backfilling will be achieved with clean rock imported from an approved location and dumped from a suitable vessel with a "Tremie System" (i.e. drop tube) to ensure accurate placement in the trench.

Alternatively, the post-lay plow method of pipeline lowering would enable the use of a plow to backfill the entire pipeline trench (with certain exceptions) with native substrate. This will, however, increase the number of passes of the construction barge along the pipeline route. The backfill plow would be either a multi-purpose plow that can be modified after completion of pipeline lowering to undertake backfilling, or a separate single-purpose backfill plow. In either case, after lowering the pipeline, the backfill plow would be pulled along the trench by the bury barge to collect the spoil stockpiled on each side of the trench and relocate it back into the trench.

Ecological Restoration

Broadwater is not aware of any publicly available literature that provide monitoring data which assessed the real time impacts from construction projects either in the Sound (i.e. Eastchester Pipeline, Cross Sound Cable) or elsewhere (i.e. Hub Line). Broadwater has acquired two documents that present findings regarding the long term restoration of these projects. Specifically, Broadwater has reviewed the Cross Sound Cable Project Post-Installation Benthic Monitoring Survey conducted in 2003, which assessed the restoration six months post construction, and has reviewed the FEIS for the Neptune LNG Deepwater Port License Application. This FEIS includes, by reference, discussions of the recovery of the Hub Line project.

As indicated in Resource Report 3, Broadwater anticipates that restoration along the proposed pipeline would begin immediately upon completion of construction. Given the depositional environments within which the pipeline is located, Broadwater also anticipates that significant restoration would occur within a relatively short timeframe. Data presented in these two sources would appear to support this conclusion. Summaries of each review are provided below. A review of these studies confirm Broadwater's conclusions that pipeline installation will most likely result in short term impacts associated with turbidity and disturbance of the seafloor, and that benthic biota will likely

recolonize the area quickly and naturally in the silt/clay depositional areas of Long Island Sound.

Cross Sound Cable Study

The Cross Sound Cable was installed in spring 2002 using jet plow installation techniques. Long term monitoring locations were established along the length of the cable, but were concentrated in the more critical near shore areas off of New Haven and the Long Island coast line. A single monitoring point was established in the central portion of the Sound. This central monitoring location in the Sound, identified as Area 3, most closely resembles the conditions that would be expected in proximity to the Broadwater Project, and as such, the only monitoring point evaluated for comparison purposes. The majority of the Broadwater pipeline is sited through muddy silt and clay benthic substrates, similar to Area 3 of the Cross Sound Cable Survey. The similar surface sediments at the two sites can be attributed to both areas being located within low energy, depositional portions of the Sound.

The benthic community and benthic conditions in Area 3 were observed prior to installation of the Cross Sound Cable and six months after construction via remote sensing methods. The Cross Sound Cable was buried six feet below the sea floor.

Geomorphology:
Post-installation studies after six months revealed that the depression in the sea floor at the location of pipeline installation varied from 0.5 to 2 feet, while the width of the depression varied from 7 to 19 feet. Being installed via jet sled, the construction did not result in the establishment of mounds on either side of the trench. The process of liquefying the seafloor for installation results in much greater resuspension of sediment, and a more widely spread deposition of sediment. As contours were only measured in 0.5 foot increments, the actual extent and depth of sediment deposition could not be determined through review of this summary report.

In contrast to Cross Sound Cable, which was readily installed via jet plow due to its minimaldiameter, the 30-inch pipeline proposed by Broadwater requires a much larger trench to install the pipeline to adequate depth and movement of a significantly larger volume of sediment. Whereas the Cross Sound Cable was effectively installed in a trench that varied in width from 7 to 19 feet, the Broadwater pipeline will require a ditch that is nominally estimated to be 25 feet wide. Use of a jet plow, with its liquefaction and suspension of the seafloor sediment, would likely result in a measurable deposition of sediment away from the trench. As modeled in Appendix G of Resource Report 3, outside the spoil piles, Broadwater anticipates minimal sediment deposition in conjunction with the plow installation, due to the low energy involved with the actual plow operation. Maximum deposition of 5 mm is modeled directly adjacent to the trench,

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with depositional depths of greater 1 mm not extending more than 100m-200m from the trench line.

Biogenic Activity:
Construction, regardless of installation methodologies will result in some unavoidable direct adverse impact to existing communities within the trench line. However, monitoring documented in the Cross Sound Cable Study revealed significant biological recruitment in the area only six months after construction, in Area 3. After six months, observations revealed biological processes dominating physical processes in the surface sediments, including the presence of feeding mounds, pits, and burrows in the vicinity of the pipeline. Sediment plumes were witnessed in the vicinity as a result of bioturbation, and a large quantity of mobile and epiphytic organisms were identified. Advanced successional communities of organisms were witnessed throughout the area both prior to and post pipeline installation. Observations concluded that the primary factor shaping the benthic community and habitat are the biological processes taking place there, indicating what appears to be a full rebound in benthic biota after six months.

Habitat Quality:
Habitat type and quality did not appear significantly different at the point of pipeline installation and the areas in the vicinity based on the remote sensing techniques being used. Analysis of underwater video imagery did not reveal any habitat differences between areas within and outside the cableway. The Organic Sediment Index (OSI) (Rhoads and Germano, 1986), which assesses benthic habitat on a range from -10 (poor quality habitats) to +11 (high quality habitats), ranged from 6 to 9 for the area following installation of the cable, in comparison to a range of 7 to 10 measured pre-construction, indicating that OSI did not change significantly between pre- and post-installation studies. An OSI of six or higher "indicate good habitat conditions that are generally associated with bottoms that are not heavily influenced by stress, either physical or anthropogenic." (OSI 2003). This was considered a conservative estimate of benthic habitat quality, as two of the four components of the index were not witnessed at the site (only depth of redox potential discontinuity and successional stage of macrofauna were accounted for, not the presence of gas bubbles or low dissolved oxygen).

Broadwater recognizes that the installation of a 30-inch pipeline is likely to have a greater impact than installation of a cable. However, the data from the Cross Sound Cable post-construction monitoring supports Broadwater's conclusion that impacts from installation would be a short term impact and that ecological communities would be expected to rebound quickly. The biotic rebound of the Cross Sound Cable ecosystem in Area 3 after installation is indicative of a system that can assimilate the construction disturbance associated with the pipeline installation.

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HubLine Study

The HubLine natural gas pipeline was constructed by Algonquin Gas Transmission Company in Massachusetts Bay during 2002-2003. This 29.4 mile long, 24" to 30" diameter pipe runs from Salem/Beverly to Weymouth and is buried at a minimum depth of 3 ft. with several exceptions, which provides the opportunity for comparison to the Broadwater Project. Unlike Broadwater, however, HubLine required several different construction technologies to install the pipeline due to variations in the bottom substrate encountered. Horizontal directional drilling, conventional dredging, jetting, plowing, and blasting were all part of the construction process. Depending upon the type of equipment used, the area of disturbed sediments along the pipeline pathway caused by trenching and back-filling varied to as wide as ~70ft. Although Broadwater has not been able to obtain specific restoration monitoring reports completed for the HubLine project, restoration of this pipeline in addressed in the FEIS/EIR that was prepared by the United States Coast Guard for the Neptune LNG Deepwater Port License Application. Specifically, the FEIS/EIR references the year one monitoring conducted for the project.

While the benthic substrate of the HubLine post-construction monitoring is not as comparable to the Broadwater pipeline as is the Cross Sound Cable study (simply described as "soft habitat") due to the diversity of habitat types encountered, a post-construction monitoring effort of the benthos associated with HubLine revealed that benthic community recovery was underway within a year after pipeline installation and that displaced benthic organisms did not delay in re-colonizing the area following construction. The FEIS noted that post-construction monitoring of the HubLine project indicated that all areas showed some form of re-establishment of benthic organisms 1 year after construction. In summarizing the HubLine study, the Final EIS for the Neptune LNG Deepwater Port License Application concludes that pipeline installation will result in "short-term, minor, adverse impacts".

In addition to the discussing the HubLine project, the FEIS/EIR for Neptune further provides a table detailing rates of recovery of benthic communities following dredging activities. While not a direct comparison to the impacts resulting from subsea plow installation of pipeline, dredging would result in a similar disruption of bottom sediment, with restoration largely relying on natural recruitment from adjacent areas to re-establish biological communities. Table 4.2-11 from the FEIS/EIR presents data that indicate recovery times following dredging as between 4 weeks and 18 months for mud substrates, with recovery times anticipated for sandy and gravelly substrates. With the exception of the Stratford Shoal crossing, the bottom sediments that will be disturbed by Broadwater are primarily silts and clays, with this table further supporting a conclusion that short term recovery can be anticipated for the Broadwater Project. Based on this information, the impacts associated with the Stratford Shoal crossing may be of slightly

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longer duration but still would not be considered significant due to the short distance of the crossing and the limited expanse of the Stratford Shoal that would be impacted.

Comparison Tables

To complete this response a number of tables are presented, as follows:

Table EIR 24-2 Provides a detailed description of the various backfilling methods including natural backfilling, active backfilling with rock, and active backfilling with native sediment using various construction methods. For each method, the magnitude, extent, frequency, and duration of impacts associated with turbidity, sediment conversion, and disturbance of the seafloor, benthic communities, and other marine resources are quantified;

Table EIR 24-3 Provides a discussion of the potential for using a combination of the various backfilling methods depending on site-specific considerations along the pipeline corridor; and

Table EIR 24-4 Provides a discussion of the technical feasibility of success of various backfilling methods based on other linear marine projects in the region including the Iroquois pipeline, the Eastchester pipeline, the HubLine pipeline, and the Cross Sound cable.

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Table EIR 24-2 Detailed Comparison of Various Backfilling Methods That Could Be Used Along the Length of the Pipeline Trench

Backfill Method	Description	Impacts
Natural backfilling	Backfilling of the trench is accomplished by the settling of the trench walls and natural sedimentation. The time between trenching and completion of natural backfilling of the trench is estimated to be 36 months, as discussed in Resource Report 2 (Water Use and Quality). While a residual depression may still be evident after 36 months, the bottom contours are anticipated to be within approximately 1 foot of preconstruction contours.	As presented in Resource Report 3, natural recruitment of unimpacted surrounding areas, through vertical migration, and by seasonal reproduction and larval recruitment would initiate upon cessation of construction. Due to the widespread predominance of silt and clay benthic assemblages, and the depositional nature of habitats in Long Island Sound, natural recovery would be evident almost immediately with measurable recolonization present within the first year. With natural backfilling estimated to take upwards of three years, communities would likely be dominated by species that are highly adapted to disturbance. More mature/stable benthic communities would be expected to colonize as the bottom topography equilibrates to final contours.
Active backfilling with native sediments	i) Plowed Trench: The post-lay plow method of pipeline lowering would enable the use of a plow to backfill the entire pipeline trench (with certain exceptions) with native substrate. The backfill plow would be either a multi-purpose plow that can be modified after completion of pipeline lowering to undertake backfilling, or a separate single-purpose backfill plow. In either case, after lowering the pipeline, the backfill plow would be pulled along the trench by the bury barge to collect the spoil stock-piled on each side of the trench and relocate it back into the trench to within approximately 2 feet of preconstruction contours.	Similar recovery of the pipeline trench would be anticipated following active backfilling with native sediments. Instead of the pipeline trench equilibrating within three years, the trench would likely equilibrate within a much shorter time frame, expediting the recovery of the trench. This would be offset though by additional impacts resulting from additional passes of the backfill plow to replace the spoil piles back into the pipeline trench. Based on the rapid recolonization that has been evidenced on other projects, the active backfilling could also potential result in additional impacts on the spoil mounds that would likely start to recolonize immediately. Based on the predominance of the silt and clay sediments in the project area, and the minimal area of sea floor disturbed by the plow operations, the bottom community as a whole would not be expected to benefit significantly from a more rapid colonization timeframe within the ditchline.

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Table EIR 24-2 Detailed Comparison of Various Backfilling Methods That Could Be Used Along the Length of the Pipeline Trench

Backfill Method	Description	Impacts
Active backfilling with native sediments	ii) Dredged Trench: Only the Stratford Shoal is a candidate for a dredged trench. Stock piling the excavated material adjacent to the trench then attempting to reuse it for backfilling would be largely ineffective. Trying to locate and recover spoil to replace in the trench in these water depths is not an easy operation and with monitoring and inefficiencies will be a very costly and time consuming operation. Backfilling with native sediments would be partly successful using stored spoil dumped from hopper barges. Loss of spoil from the excavator bucket during excavation and due to dispersion through the water column during dumping will likely necessitate augmentation via natural backfilling or placement of additional imported fill using a Tremie system.	Dredging will result in greater impacts than plowing due to the greater area of impact associated with the trench excavation. Attempts to recover side cast spoil would likely result in an expansion of impact as the process of capturing sidecast spoil would likely increase the bottom surface impacted. Assuming Broadwater temporarily stored native material in hopper barges, and replaced via tremie tube, recovery would occur through natural processes as discussed above. As indicated, though the loss of spoil during the dredging activity would make this only partially successful and full restoration would not initiate until after the topography of the pipeline trench reached equilibrium.
Active backfilling with imported fill	Imported fill would be sourced and processed at a suitable onshore location and transported to a staging area for loading onto tug assisted barges. The barges would then be moved to the work site and their cargoes would be either installed directly from the barge or transferred to another surface vessel for installation. Imported fill would comprise either clean rock material, or an engineered backfill system that would generally consist of a graded mixture of clean sand, small rock (3 to 4 inches) and possibly pea gravel to produce the desired backfill density. Placement of either of these imported fill systems would be from the surface via the so-called Tremie System (i.e. drop tube). Accurate positioning of the tremie tube at the trench location, coupled with minimizing the “drop” distance would help minimize loss of material due to dispersion through the water column.	Active backfilling with imported fill would provide for equilibrium to be reached quicker within the pipeline trench. The importation of non-native material though, may not be conducive to the predominant benthic communities within the central portion of Long Island Sound which may result in a long term modification to community structure. This could result in both positive and negative benefits. With the large expanse of silt and clay sediments in the Sound, the establishment of communities more suited to sand/gravel rock substrates could establish, providing diversity of community structure. Given the depositional nature of the central Long Island Sound, however, over time, normal sedimentation would likely infill this non-native material making it less conducive to species that established following initial construction.

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Table EIR 24-2 Detailed Comparison of Various Backfilling Methods That Could Be Used Along the Length of the Pipeline Trench

Backfill Method	Description	Impacts
Active backfilling using divers	Backfilling using divers would only be used at certain specific locations, such as tie-ins and cable crossings, and only then to supplement mechanical (active) or natural backfilling processes. Diver activities would include placement of protective measures (e.g. direct placement of sand/cement bags), and will assist with placement of concrete mats and/or protective structures.	Active diver supported of backfilling is only being proposed where protective measures (concrete mats/sandbags) are proposed. The need for additional support/protection of project facilities requires the use of hard structure. The placement of this hard substrate will provide minimal opportunity for diversification of existing communities as they will encourage colonization by species not typically found in the soft bottom substrates of central Long Island Sound. By design, these areas are limited to utility line crossings, tie-ins, spool locations, and at the base of the mooring tower.

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Table EIR 24-3 Discussion of the Potential for Using a Combination of Backfilling Methods Depending on Site-Specific Considerations

Route Segment Description	Backfill Method	Feasibility
Normal construction (MP 2 to MP 21.7) Encompasses the majority of the route where the preferred lowering method is one or more passes of a post-lay plow to a target depth of cover of 3 feet. If the target depth of cover cannot be achieved based on sediment conditions, then rock, concrete mats, or sand bags may be installed for supplemental protection and stability.	Natural backfilling	Feasible if permitted, or as augmentation of active backfilling.
	Active backfilling with native sediments	Feasible with backfill plow if the pipeline is first lowered by post-lay plow.
	Active backfilling with imported fill	Not feasible as a total backfill solution due to cost. However, limited imported fill may be used in specific areas as supplemental pipeline protection.
	Active backfilling using divers	Not feasible as a total backfill solution due to inefficiency. Divers may be used to support placement of supplemental pipeline protection where needed.
First 2 miles from the FSRU location (MP 0 t o 2) Where, taking into account warm gas conditions, the preliminary pipeline design calls for the pipeline to be lowered below the seabed to a target depth of cover of five feet and actively backfilled.	Natural backfilling	Not feasible for reasons of unacceptable design.
	Active backfilling with native sediments	Feasible using backfill plow if deemed an acceptable design and if the pipeline is first lowered by post-lay plow (See also EIR 3-20).
	Active backfilling with imported fill	Feasible using imported rock or engineered backfill if deemed to be the preferred design (See also EIR 3-20).
	Active backfilling using divers	Not feasible as a total backfill solution due to inefficiency.
Stratford Shoal contingency (MP 14 to 15) If pipeline lowering via post-lay plow is not feasible, then pre-lay trenching for up to 4,000 feet using a spud-moored backhoe dredge will be undertaken to obtain a target depth of cover of 3 feet. Spoil would be removed to hopper barges complete with dump chutes. If the target depth of cover cannot be achieved based on the sediment conditions, then rock, concrete mats, or sand bags may be installed for supplemental protection and stability.	Natural backfilling	Feasible if permitted, or as augmentation of active backfilling methods.
	Active backfilling with native sediments	Partly feasible using spoil dumped from hopper barges. Loss of spoil during excavation and backfilling will likely necessitate augmentation via natural backfilling or placement of additional imported fill (See also EIR 3-10).
	Active backfilling with imported fill	Feasible as a total backfill solution, or as a supplement to active backfilling with native sediments (See also EIR 3-10).
	Active backfilling using divers	Not feasible as a total backfill solution due to inefficiency. However, divers may be used to support the placement of supplemental pipeline protection where needed.

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Table EIR 24-3 Discussion of the Potential for Using a Combination of Backfilling Methods Depending on Site-Specific Considerations

Route Segment Description	Backfill Method	Feasibility
Tie-ins, spools and cable crossings Where protection independent of main backfilling operations utilizing concrete mats, sand/cement bags, protective structures, and additional imported rock or engineered backfill material will be installed.	Natural backfilling	Not feasible as a total backfill solution for reasons of unacceptable design. Supplemental protection will be necessary as noted.
	Active backfilling with native sediments	Not feasible as a total backfill solution for reasons of unacceptable design. Supplemental protection will be necessary as noted.
	Active backfilling with imported fill	Feasible using imported rock or engineered backfill if deemed to comprise either the total or partial design solution.
	Active backfilling using divers	Not feasible as a total backfill solution. Divers will support placement of protective measures (e.g. direct placement of sand/cement bags), and will assist with placement of concrete mats and/or protective structures.

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Table EIR 24-4 Discussion of Other Linear Marine Projects in the Region

Project	Description	Discussion
Iroquois Gas Transmission System pipeline	The original IGTS crossing of Long Island Sound is part of a larger 375 mile long interstate natural gas pipeline extending from the U.S.-Canadian border at Waddington, NY through western Connecticut to its terminus in Commack, NY on Long Island. The Long Island Sound crossing (including shore crossings) involved the construction of 26.3 miles of 24-inch mainline between Milford CT and Northport NY. In-Service 1992	Broadwater understands that lowering was performed using a combination of pre-lay plow, a post-lay jetting spread and inner shore dredging, and that all had mixed successes. Active ("mechanical") backfill was completed for each of the open cut shore crossings and out to a specified water depth from shore. For approximately 22.5 miles, i.e. the majority of the pipeline route between the shore crossings, the trench was allowed to backfill naturally. In 2005 Broadwater completed marine surveys over the Iroquois pipeline during the investigation of potential subsea tie-in points for the Broadwater pipeline. As expected, a residual depression over the pipeline trench at the tie-in location in the Central Basin of Long Island Sound was observed where natural backfilling has taken place.
Eastchester Extension pipeline	The IGTS Eastchester Extension is a 36.5 mile 24-inch mainline extension of the Iroquois system between Northport, NY, and Hunts Point, The Bronx, New York City, of which about 35 miles (including shore crossings) was installed beneath Long Island Sound and the East River. In-Service 2004	Save for two horizontal directional drill (HDD) shore crossings, the Eastchester pipeline was lowered using a post-lay plow. A combination of backfill methods was used. Up to MP 25 in Long Island Sound the backfilling method was natural backfilling. For the remainder of the route, including the portion in the East River, backfilled either using the same plow rigged for backfilling with native sediments was undertaken, and/or backfilling with imported rock fill was completed. For the most part, these operations were successful.
HubLine pipeline	The HubLine project involved the construction of approximately 30 miles of 24-inch mainline pipeline primarily offshore around outer Boston Harbor between Beverly and Weymouth MA. Owner: Algonquin Gas Transmission Co. In-Service 2003	Save for two HDD shore crossings, and a water to water HDD under an island, the HubLine pipeline was lowered using two different plows. Broadwater understands that active backfilling with imported fill, where completed, had mixed success due to inaccurate placement, and that remedial backfilling has since been completed or called for. Broadwater would avoid this situation through the use of properly designed and operated Tremie System for active backfilling with imported fill.

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Table EIR 24-4 Discussion of Other Linear Marine Projects in the Region

Project	Description	Discussion
Cross Sound Cable Interconnector	The CSC cable is a high voltage direct current (HVDC) electrical power transmission cable consisting of a bundle of two solid dielectric cables and a fiber optic telecommunications cable, which traverses between New Haven and Brookhaven, Long Island, with a landfall at Shoreham. Each electric cable is 4.1 inches in diameter with a unit weight of approximately 22 pounds per foot, and the fiber optic cable is approximately 1 inch diameter. The CSC cable is buried 6 to 7 ft below the natural seabed. The cable bundle was laid on the seabed by the Sea Spider, a ship specially designed for subsea cable installation. In water depths greater than 30 feet (i.e. the majority of the route) lowering and burial was completed concurrent with cable laying using SmartJet jet-plow equipment towed by the Sea Spider. Construction was started in 2002. Commercial operation was delayed until after the August 14, 2003 blackout of much of the eastern North American power system. Immediately after the blackout, emergency permission was secured to operate the cable. The cable has since been operating and, generally, sells electricity from the New England power grid to the New York power grid. Owner: Babcock & Brown Infrastructure	The SmartJet jet-plow is fitted with two blades with high-pressure nozzles and pumps to fluidize sediments creating a narrow trench into which the cable bundle settles. Evidence filed by CSC in its Connecticut Siting Counsel application [*Docket No. 208*] estimated the trench to be approximately nine feet deep, and six feet wide in fine-grained sediments, and twelve and one-half feet wide in sand-grained sediments; and that approximately one-third of the hydrated sediment would be introduced into the water column, while the rest would remain in the trench and would settle an additional eight to 18 inches (1.5 feet) over a period of approximately seven to 38 months depending on the physical characteristics of the sediment. Post-installation studies after six months revealed that the depression in the sea floor at the location of pipeline installation varied from 0.5 to 2 feet, while the width of the depression varied from 7 to 19 feet. The equipment and methods required for the safe handling, installation and lowering of large diameter subsea pipelines are not at all comparable to the equipment used for the installation and lowering of subsea cables, partly owing to significant differences in the size and weight of the facilities. A comparison between CSC and Broadwater is as follows: **Facility** / **Description** / **Cross Section** / **Unit Weight** Cross Sound Cable: Bundle of 2 HVDC power cables and 1 fiber optic cable; Approx. 8.2 inches by 4.1 inches, bundled; 44 pounds per foot, not including fiber optic cable Proposed Broadwater Pipeline: 30 inch O.D. high strength steel line pipe, with approx. 3 inches of high density concrete weight coating; 36 inch nominal O.D. complete with concrete weight coating applied; 600 to 800 pounds per foot, depending on concrete and steel thicknesses from detailed design

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Request:

Tidal modeling information for Long Island Sound indicates that tidal currents approaching 0.8 meters per second (m/s) are reportedly common in the vicinity of the YMS, and this current speed was considered to be the extreme current (1 in 100 year) in Broadwater's YMS design criteria. Review available data and modeling information on Long Island Sound currents and update the YMS design criteria as appropriate based on:

a. Constant cycling of tidal currents approaching 0.8 m/s;
b. Updated estimates of extreme currents (1 in 100 year); and
c. Anticipated loadings with and without an LNG carrier moored alongside the FSRU.

Response:

The current criteria for operation (spring tide) design of the YMS is defined at 0.6 m/s with (going to) direction of 60-65 and 260-265 degrees, and the extreme current of 1/100 year at 0.8 m/s. For marine operations, the 99.5% non-exceedance tidal current is at 0.45 m/s. The metocean criteria including currents are preliminary and will be updated during the Detailed Design phase to incorporate measurements obtained in 2006.

Current criteria are depth-averaged, rather than the maximum surface current velocity. Commercial navigation software suggests maximum tidal currents in Long Island Sound of about 0.6 m/s. These are spot measurements at one point in the water column and would be expected to be higher than a depth-averaged value. Similarly, a maximum surface current of 0.8 m/s would be expected to be significantly greater than a depth-averaged current.

To address the identified questions regarding the tidal current criteria and associated design impact, the project technical execution scope includes the following:

a. In Detailed Design, a tidal modeling will be conducted and newly acquired measurement data will be processed to update the tidal current criteria and confirm whether a constant cycling tidal current would approach 0.8 m/s;

b. In Detailed Design, the extreme metocean design criteria will be updated including the 100-year return period extreme current criteria; and

c. The design driver of the YMS structure is expected to be the 100-year extreme wave with associated wind and current, and the 10,000-year survival conditions. Current alone is not likely to be a design driver. During the Detailed Design of the YMS structure, integrated multi-body hydrodynamic calculation analyses will

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be conducted to predict the hydrodynamic loads on the YMS structure for structural design. These analyses will consider both loading scenarios with and without an LNG carrier moored alongside the FSRU. A model test program will also be executed to validate the key analysis calculations.

CERTIFICATE OF SERVICE

I hereby certify that I have this day served the foregoing document upon each person designated on the official service list compiled by the Secretary in this proceeding in accordance with the requirements of Rule 2010 of the Commission's Rules of Practice and Procedure.

Dated at Washington, D.C. this 19th day of March 2007.

/s/ Brett A. Snyder
Brett A. Snyder

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