APPENDIX A: BROADWATER CORRESPONDENCE

BROADWATER

30 West Main St. | Riverhead, NY 11901
Phone: 631-208-8343 | Fax: 631-208-8346

November 9, 2004

Captain Peter Boynton
Captain of the Port, Long Island Sound
120 Woodward Avenue
New Haven, CT 06412

Re: Letter of Intent
Broadwater Energy Liquefied Natural Gas Terminal and Related Facilities
Long Island Sound, New York

Dear Captain Boynton:

Broadwater, a joint development project between TransCanada PipeLines USA Ltd. ("TransCanada") and Shell US Gas & Power LLC ("Shell"), intends to construct and own a liquefied natural gas ("LNG") terminal and sendout pipeline near the center of Long Island Sound (the "Project"). In accordance with the requirements contained in 33 C.F.R. 127, Broadwater submits the following information about the Project:

1. Name, address, and telephone number of the owner and operator

The Broadwater LNG terminal will be jointly owned by TransCanada and Shell, and operated by Broadwater.

TransCanada is a wholly-owned subsidiary of TransCanada PipeLines Limited, a leading North American energy company, which owns and operates 24,200 miles of natural gas pipelines used to transport the majority of western Canada's natural gas production to markets in Canada and the United States. TransCanada's address and telephone number are:

450 – 1 Street S.W.
Calgary, Alberta T2P 5H1
403-920-2000

Shell is a worldwide leader in exploration for and production of natural gas, production of LNG and transportation to markets throughout the world for over 40 years. It is the world's largest private producer of LNG and is a leader in developing LNG technology and establishing the safety of LNG operations and shipping standards used throughout the industry. Shell's address and telephone number are:

Two Shell Plaza
777 Walker Street
Houston, Texas 77002
713-241-6161

2. *Name, address, and telephone number of the facility*

The mailing address and telephone number for Broadwater's project management office are:

Broadwater
777 Walker Street, 22nd Floor
Houston, Texas 77002
713-241-8938

3. *The physical location of the facility*

The terminal will be located approximately 9 miles off the coast of the Town of Riverhead, New York in the Central Basin of Long Island Sound, and will connect with the existing subsea Iroquois Gas Transmission System ("Iroquois") in Long Island Sound at a subsea interconnection through an approximately 25 mile marine pipeline. A map of the proposed location is attached as Attachment 1. The current base case location is Latitude 41 deg 06 min 02.870 secs N. Longitude 72 deg 49 min 14.556 secs W, although this may be modified slightly as a result of the consultation process.

4. *A description of the facility*

The proposed Broadwater terminal will be a ship-like vessel, known as a Floating Storage and Regasification Unit ("FSRU"). The FSRU will be approximately 1,200 feet long, 180 feet wide and stand approximately 75 to 100 feet above the water line. The FSRU will be constructed in a shipyard, towed to the proposed location in Long Island Sound and attached to a mooring system. It will be equipped with multiple docking lines/stabilizing connections and four unloading arms to provide a berth to receive and discharge LNG carriers which will off-load their cargoes into the storage tanks of the FSRU.

The LNG will be stored onboard the FSRU in specially designed storage tanks supported by the ship's inner hull and built with special alloy materials and laminates. The FSRU is designed to have an onboard LNG storage capacity of approximately 8 billion cubic feet ("Bcf") of natural gas, and will have a peak sendout capacity of approximately 1.25 Bcf per day. Average send-out will be 1 Bcf per day.

The upper deck of the FSRU will house all of the pumps, pipeline and process equipment including regasification facilities to convert the LNG to gas by a submerged combustion vaporization process. The regasified LNG will be transported to the market by a connecting pipeline to a subsea interconnection point on Iroquois, where the gas will enter the interstate natural gas transmission grid. The Broadwater pipeline will be 30 inches in diameter and approximately 25 miles in length. No compression of send-out natural gas will be required on the FSRU.

5. The LNG vessels' characteristics and the frequency of LNG shipments to the facility

The proposed Broadwater terminal will be designed to accept LNG carriers with capacities between 125,000 m^3 and 250,000 m^3 of LNG. The frequency of LNG shipments to the terminal is expected to be between 2 and 3 times per week on average.

6. Charts showing waterway channels and identifying commercial, industrial, environmentally sensitive, and residential areas in and adjacent to the waterway used by the LNG vessels en route to the facility, within 25 kilometers (15.5 miles) of the facility

A chart showing the waterway channels to be used by the LNG vessels en route to the facility is shown as Attachment 2. Attachment 2 also describes the proposed FSRU location, LNG carrier maneuvering area, and USCG area of investigation. The LNG carriers delivering LNG to the FSRU will pick up the USCG pilots at Block Island, and then follow normal commercial routing for transiting Long Island Sound.

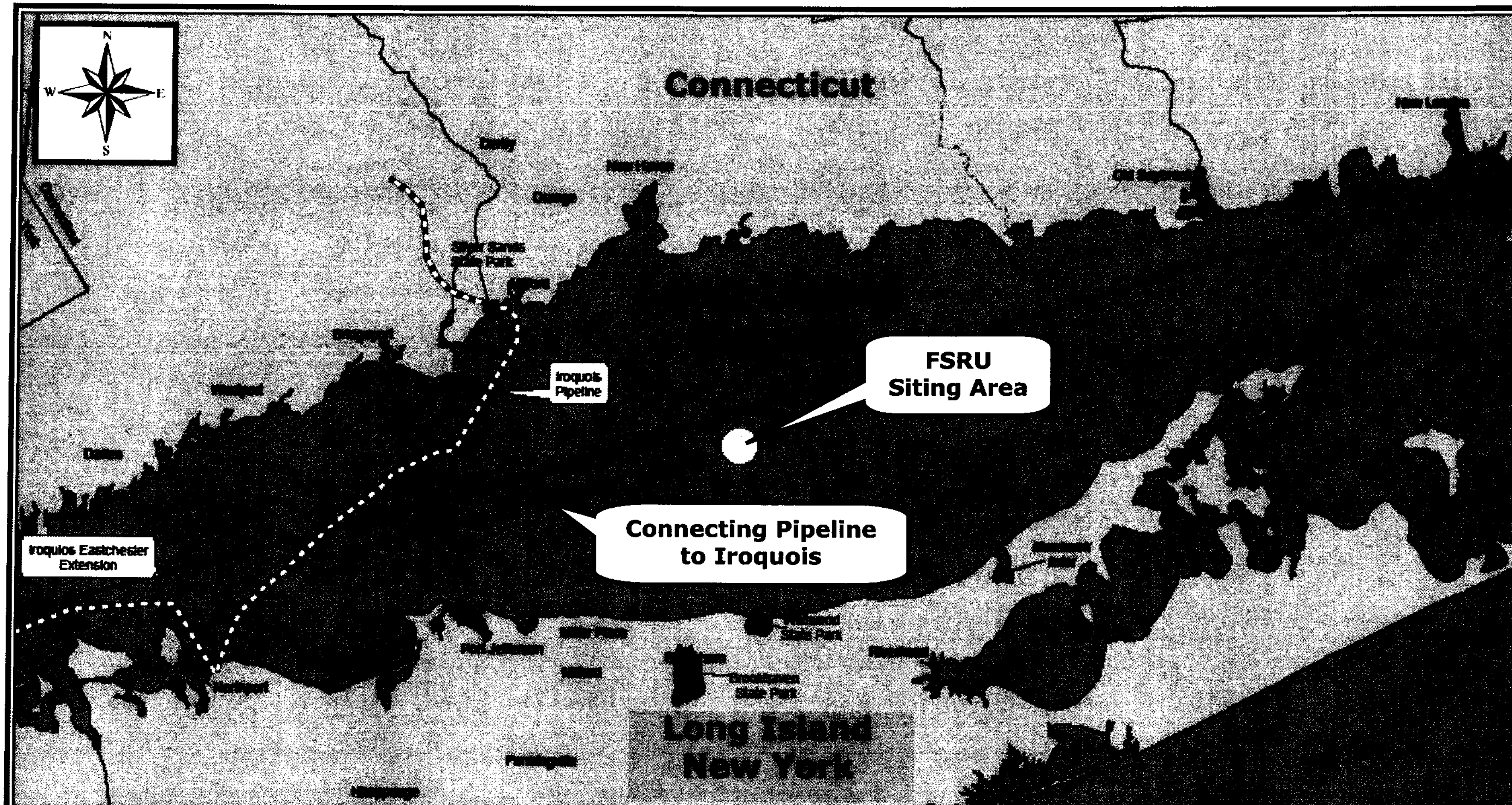
Please feel free to contact Stephen Marr, Broadwater Permit Application Manager at (713) 241-8939 should the Coast Guard have any questions or require any further information.

Yours truly,

James A. Thompson, Jr.
LeBoeuf, Lamb, Greene & MacRae, LLP
Goodwin Square
225 Asylum Street, 13th Floor
Hartford, CT, 06103
tel 860-293-3507
fax 860-293-3555
email: jthompso@llgm.com

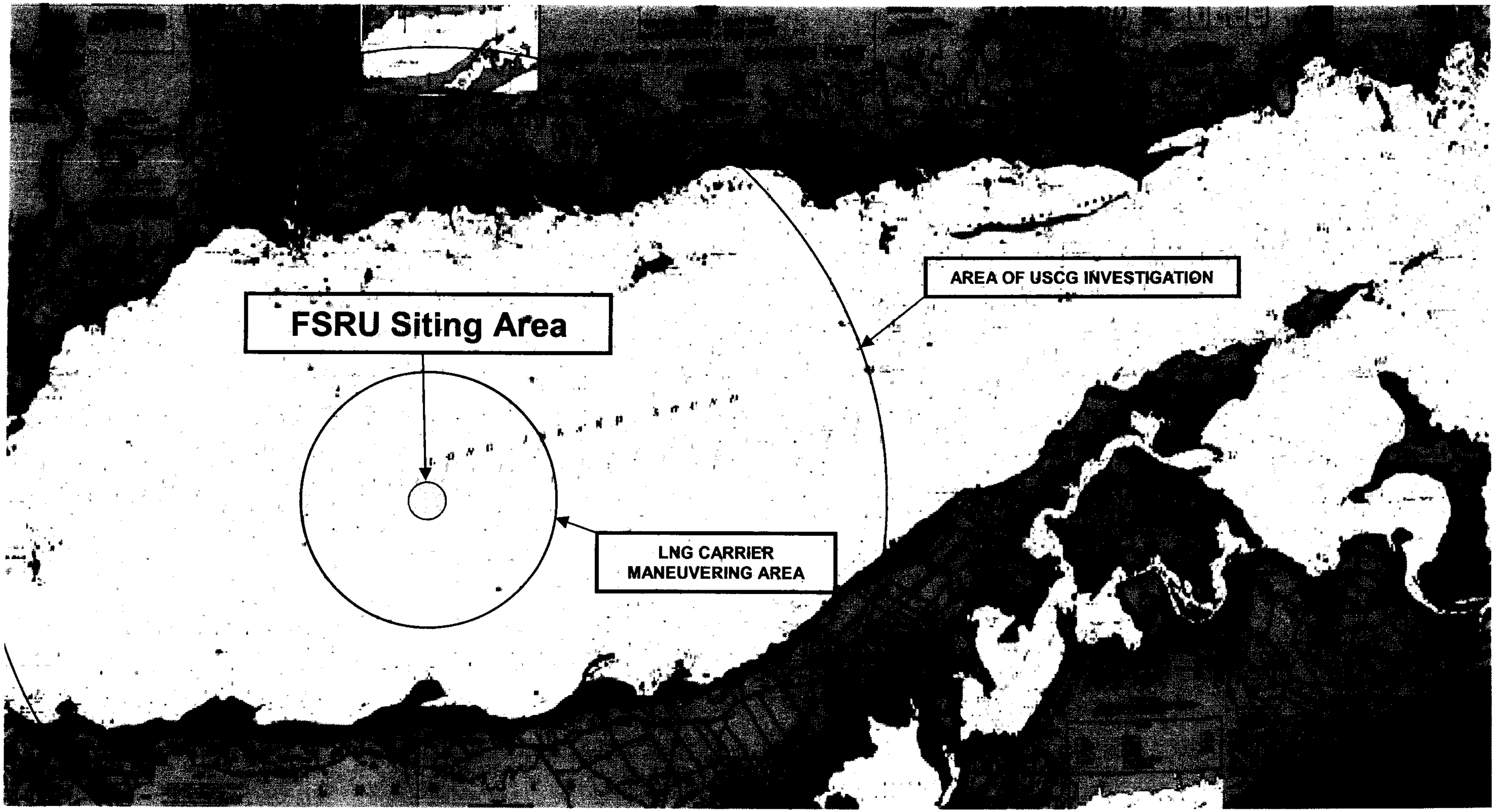
COUNSEL FOR BROADWATER

Attachment 1



BROADWATER

Attachment 2



BROADWATER

BROADWATER

30 West Main St. | Riverhead, NY 11901
Phone: 631-208-8343 | Fax: 631-208-8346

April 26, 2005

Captain Peter Boynton
Captain of the Port, Long Island Sound
120 Woodward Avenue
New Haven, CT 06412

Re: Amendment to the Letter of Intent dated November 9, 2004 (the "Letter of Intent") Broadwater Energy Liquefied Natural Gas Terminal and Related Facilities Long Island Sound, New York

Dear Captain Boynton:

Further to our Letter of Intent dated November 9, 2004 and in accordance with the requirements contained in 33 C.F.R. 127.007(e), Broadwater submits the following change to the information regarding the physical location of the facility.

Section 3 of the Letter of Intent stated in part:

> *The current base case location is Latitude 41 deg 06 min 02.870 secs N. Longitude 72 deg 49 min 14.566 secs W, although this may be modified slightly as a result of the consultation process.*

As a result of the consultation process, the above referenced part of Section 3 of the Letter of Intent is hereby amended to state:

> *The current base location is Latitude 41 deg 06 min 01.31 secs N. Longitude 72 deg 50 min 44.56 secs W, although this may be modified slightly as a result of the consultation process.*

Please feel free to contact Stephen Marr, Broadwater Permit Application Manager at (713) 241-8939 should the Coast Guard have any questions or require any further information.

Yours truly,

James A. Thompson, Jr.
LeBoeuf, Lamb, Greene & MacRae, L.L.P.
Goodwin Square
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COUNSEL FOR BROADWATER

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August 19, 2005

<u>BY FACSIMILE & FIRST-CLASS MAIL</u>

Lieutenant Commander Alan Blume
Chief, Prevention Department
Group/Marine Safety Office – Long Island Sound
U.S. Coast Guard
120 Woodward Avenue
New Haven, CT 06412

Re: <u>Broadwater Energy</u>

Dear Lieutenant Commander Blume:

Enclosed is a recent letter from the American Bureau of Shipping ("ABS") regarding the preliminary design of Broadwater Energy's proposed floating LNG storage and regasification unit ("FSRU"). The letter provides that, based on ABS' review of the FSRU's preliminary design, the FSRU meets ABS Ship Classification Rules and can be built and receive a formal Class designation from ABS.

I trust that a copy of this letter will be included in the Coast Guard's file for this project and as indicated in your voicemail message, you will distribute copies to the appropriate Coast Guard personnel.

Respectfully submitted,

James A. Thompson, Jr.
Attorney for Broadwater Energy

JAT:jzg

Enclosure

cc: Mr. James Martin, Project Manager, FERC

ABS
AMERICAS DIVISION

27 July 2005

Mr. David Carpenter
Technical Manager
Shell Trading (US) Company
Two Shell Plaza
777 Walker, Room 2258
Houston, TX 77002

Ref: Program Class- Approval in Principle for Broadwater –FSRU

Dear David:

ABS has received documentation for the Floating Storage Regas Unit on 18 March and 7 July 2005; this information is:

1- Broadwater LNG PROJECT – Floating Storage & Regasification Unit Basis of Design Part A and Part B dated February 2005
2- Broadwater Resource Report No 13 dated August 2005 (draft)

This has been provided for review in accordance with ABS proposed work scope by ABS in "ABS Proposal for Approval in Principle (AIP) dated March 2005". All elements requested for review are in the proposed work scope. Key elements to be evaluated for the FSRU concept are:

1) Hull and containment system –366.36X 60 X 27 M with membrane tanks
2) Yoke mooring system
3) Loading from the LNG Carrier
4) Topsides Vaporization Plant
5) Conventional Marine Systems
6) Accommodations
7) Send out 1.25 bcf/d
8) HAZID, HAZOP and other special studies.

Whilst the concept of combining a floating re-gasification unit and distribution network with a yoke moored LNG hull can be viewed as a first time combination of systems, the technologies employed are not in themselves novel and are covered by established Rule criteria.

The documents provided illustrate that the concept will:

1- Utilize the hull and cargo tanks that comply with the IGC Code and ABS Rules
2- Yoke mooring system will comply with conventional practice
3- Loading from the LNG Carrier will use conventional systems but be at Broadwater site
4- Topsides will use components in use on shore
5- ABS- Guidance Notes on Review and Approval of Novel Concepts dated June 2003 is being followed
6- Initial Risk Studies have been done and a HAZID Register is being maintained

ABS PLAZA, 16855 NORTHCHASE DRIVE, HOUSTON, TX 77060-6008 USA
TEL: 1-281-877-6000 FAX: 1-281-877-6001 EMAIL: abs-amer@eagle.org

ABS
AMERICAS DIVISION

7- Additional Studies will be done as the design develops.

ABS review of the above documentation for Class- AIP for the FSRU is subject to the following:

1. The FSRU is to comply with the IGC Code and ABS Rules as well as those where the Unit is located. Kindly refer to the Annex 2 of Part 5 Chapter 8 of the Steel Vessel Rules for additional requirements for operation in US waters.

2. During final design for the FSRU details are to comply with ABS Rules and Guides for:

   - **ABS Rules for Building and Classing Steel Vessels– 2003**
   - **ABS Rules for Building and Classing Single Point Moorings – 1996**
   - **ABS Guide for Building and Classing Floating Production Installations – June 2000**
   - **ABS Guide for Building and Classing Facilities on Offshore Installations – June 2000**
   - **ABS Guide for Building and Classing Offshore LNG Terminals – December 2002**
   - **ABS Guidance Notes on Risk Assessment Application for the Marine and Offshore Oil and Gas Industries – June 2000**
   - **ABS Guide for Risk Evaluations for the Classification of Marine-Related Facilities**
   - **ABS Guidance Notes on Review and Approval of Novel Concepts – June 2003.**

3. HAZARD Register is to be maintained to confirm that any necessary mitigation provided will satisfy the intent of the International Maritime Organization (IMO) Formal Safety Assessment Guidelines, the tenets of the International Gas Code, and ABS Rules and Guides. This is to include hazards identified by current studies and those requested.

   You may also refer to *ABS Guidance Notes on Alternative Design and Arrangements for Fire Safety*. This would be useful in establishing the suitability of alternatives that may be found necessary for the FSRU.

The FSRU could be classed in accordance with ABS Rules and other requirements identified in the class –AIP and receive a class certificate when built. ABS notes that the concept has been discussed with FERC and USCG to assure that any special concerns that they may have are properly evaluated and incorporated in the final design.

Regards,

for

Philip G. Rynn
Senior Staff Consultant

cc: K. Richardson, B. Lind, P. Rynn, H. Patel

LeBoeuf, Lamb, Greene & MacRae LLP

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November 1, 2005

Peter J. Boynton
Captain of the Port, Long Island Sound
United States Coast Guard
120 Woodward Avenue
New Haven, Connecticut 06512

Re: Broadwater Energy Project
USCG Docket USCG-2005-21863
FERC Docket PF05-4-000

Dear Captain Boynton:

Broadwater Energy (Broadwater) is in receipt of your request, dated October 5, 2005, for additional information related to the marine aspects of the proposed LNG terminal to be located within Long Island Sound. It is our understanding that this information is needed to allow the U.S. Coast Guard to complete its assessment of the potential risks to waterway safety and port security associated with the project.

Responses to the majority of the questions in your October 5th request are enclosed. Responses to Questions 2, 3, 4 and 16 are still in preparation and are not yet completed. They will be provided by November 8, 2005.

Also, the responses to Questions 2, 3 4 and 16 include Sensitive Security Information (SSI) as defined within 49 CFR 1520 and NVIC 9-02. Consequently, the responses to these questions will be prepared accordingly and will be clearly indicated as SSI.

If there are any questions or a need for clarification of any of the enclosed information, please have your staff contact Mr. David Thomson of Broadwater at (713) 241-8931.

Respectfully submitted,

Brian D. O'Neill

Attorney for Broadwater Energy

Enclosure

Response to US Coast Guard Request of October 5, 2005

1. ***The letter of intent submitted for this project indicated that the LNG carriers that may call at the proposed floating storage and regasification unit (FSRU) would have a design capacity between 125,000 m^3 and 250,000 m^3. Please provide the length, beam and draft (loaded and in ballast) of these vessels based on capacity.***

The dimensions of 125,000 m^3 and 250,000 m^3 LNG carriers are set forth below.

Table 1 – LNG Carrier Dimensions

	Carrier Capacity 125,000 m^3		**Carrier Capacity 250,000 m^3**	
	(feet)	(meters)	(feet)	(meters)
Length overall	886	270	1,132	345
Beam	131	40	180	55
Draft (laden)	36	11	39	12
Draft (ballast)	30	9	33	30

5. ***What is your assessment of the impact of environmental factors (e.g. fog, current, high winds, storms, ice formation around or ice floe, etc.) on LNG carrier traffic and FSRU operations?***

The operations at the FSRU and LNG carrier arrivals have been modeled using a discrete event simulation. The durations of all operations, starting with the LNG carrier arriving at the Block Island pilot boarding station and ending with departure and pilot disembark at Block Island, were included. The total duration of these operations was 40 hours per LNG carrier.

These operations are subject to a variety of limiting environmental conditions:

- Approach and departure limits as determined from the ship handling simulation exercises conducted at MarineSafety International in Rhode Island with a Long Island Sound pilot.
- Side-by-side mooring limits determined from the motions analyses, which considered mooring line tensions, fender forces, and roll and manifold motions.

The limiting wave, wind, and current limits were applied in combination. Because the objective was to determine downtime with respect to local environmental conditions only, the simulations were run with an LNG carrier always waiting to proceed from the Block Island pilot boarding area, once the preceding carrier arrives back at Block Island. At this point the weather forecast is carried out to locate a 40-hour weather window during which none of the operational limits are exceeded, thus allowing all operations to be completed without interruption.

A Base Case and four sensitivity simulations were completed:

- Base Case: Approach and departure limits of 2 m significant wave height, 33 knot wind and 0.9 knot current; side-by-side mooring limits of 3 m significant wave height, 39 knot wind and 0.9 knot current, with the exception of cross-wind conditions where the significant wave height was 2.5 m.
- Case S1: Reduced approach and departure limits of 1.5 m significant wave height.
- Case S2: Same as Base Case, but including night restrictions
- Case S3: Same as Base Case, but including visibility restrictions
- Case S4: Start-up operations, for which the approach/departure limits are reduced to 1.2 m significant wave height, 25 knot wind and 0.7 knot current.

Each simulation was run for a period of 100 years in order to provide a sufficient number of outcomes to perform statistical analysis. Annual and monthly exceedence data were developed for waiting time (or downtime). Annual exceedence data were developed for three other output parameters: inter-arrival time, time between closures, and available slot.

Results are summarized as follows:

- The Base Case results in minor downtime, with 0.9% of vessels experiencing downtime. Downtime is typically associated with the tug limit being exceeded during approach or departure. The largest exceedence values for downtime are observed in March, with no downtime experienced in the months of May through August.
- When reduced tug limits are imposed, an additional 3% of vessels experience downtime (i.e. 3.9% of vessels experience some level of downtime). As for the Base Case, no downtime is experienced in the months of May through August.
- When night restrictions are imposed, the vast majority of vessels experience 7-8 hour delays waiting for daylight. Delays associated with tug limits being exceeded are longer than for the Base Case, because they result from a combination of night and tug limit delays before the vessel may proceed. Similar results would be expected for the case where night transit is preferred over day transit, which may be the case in the busy summer months when a multitude of recreational boaters are in the Sound.

- When a visibility restriction of 0.5 nautical miles is imposed, approximately 6% of vessels are subject to some waiting time and some level of downtime is experienced during every month of the year, with the highest downtime occurring during the winter months.

The study demonstrates that for the Base Case, which represents the most likely operating scenario, weather downtime should not be a concern. This result should be considered in the following context:

- The downtime estimate includes downtime due to local environmental conditions only. Delays that might occur en-route to the U.S. East Coast, or downtime due to equipment breakdown, were not part of the scope of this study.
- The downtime estimate can be considered to be on the conservative side, because the logic implemented in the simulations required that a 40-hour favorable weather window be available before the LNG carrier may approach the FSRU. Thus, no advantage was taken for bringing the vessel in and starting offloading, with possible suspension of off-loading if required.
- The underlying assumption in the methodology applied in these downtime simulations is that weather forecasting is satisfactory for a period of at least 40 hours and metocean and climate parameters are known precisely for each hour, many hours in advance.

With regard to the effect of severe weather conditions on the FSRU, the 1938 hurricane was a Category 3 or 4 storm and is the strongest tropical cyclone to strike the Atlantic coast between Virginia and Massachusetts since at least the year 1869. Although the maximum wind speeds recorded of 120 miles per hour (mph) falls within the lower category, some estimates suggest wind speeds up to 150 mph may have been experienced along the coastline.

We have analysed the extreme weather conditions that may be experienced at the FSRU site, which relate to a maximum significant wave height of 3.77 m (12.4 feet) and a maximum 1-hour average wind speed of 31.4 m/s (70.2 mph) during the 1938 storm.

The FSRU itself will be designed and constructed in accordance with international shipbuilding codes and standards, which take into account the severe weather conditions a vessel may be exposed to during worldwide trading. These conditions are more severe than those predicted for Long Island Sound in a Class 3 or 4 hurricane. However, some damage can be expected, particularly as a result of the strong winds, but it would be unlikely to require the removal of the FSRU for dry-dock repairs.

Response to US Coast Guard Request of October 5, 2005

Broadwater will develop procedures to be followed in the event of a hurricane warning, which may include a reduction in manning levels to essential personnel and a reduction or cessation of natural gas deliveries. LNG carriers will not be allowed to enter the Sound when forecast weather conditions reach pre-determined limits and would remain at sea in open waters to await the passage of a hurricane.

To put the survivability of the Broadwater mooring system into perspective, the following extract is taken from an article in *Time Magazine* dated September 7, 1998:

> *"Even more surprising, however, were the results of computer models done with a computer program called SLOSH, which stands for Sea, Lake and Overland Surge from Hurricanes. The program, the backbone of all evacuation studies, takes into account storm tracks, local landmarks, and coastal geography to calculate the effects of a hurricane storm surge, the dome of water pushed ashore by strong winds. Such surges can be the deadliest aspect of a hurricane ..."*
>
> *The researchers concluded that the surge from a Category 4 storm would put John F. Kennedy International Airport under 20 feet of water. Seawater would pour through the Holland and Brooklyn-Battery tunnels and into the city's subways throughout lower Manhattan ... The report didn't estimate casualties, but observed that storms 'that would present low to moderate hazards in other regions of the country could result in heavy loss of life'."*

Analyses of the extreme weather conditions that may be experienced within Long Island Sound have been completed and form the basis for design (and survivability) criteria of the Yoke Mooring System. These conditions are summarized in Table 2.

For further details see draft Resource Report No. 13, Section 13.16.

Response to US Coast Guard Request of October 5, 2005

Table 2 – Yoke Mooring System Design Criteria

Waves	Operational	95% of the time with Hs < 1.2 m Direction: to east-northeast & west-southwest
	Extreme 1:100 year	Hs=4.3 m & Tp=7.4 s
	Extreme 1:1,000 -10,000 year	Hs=5.7 - 7.0m & Tp=8.7 – 9.9 s
Wind	Operational	Speed: 99.5% of the time below 17.5 m/s Directions: toward northeast & southeast
	Extreme 1:100 year	41.9 m/s
	Extreme 1:1,000 -10,000 year	50.2 – 56.8 m/s
Tidal Current	Operational	99.5% of the time < 0.45 m/s (0.9 knots) Direction: to east-northeast & west-southwest
Tide	CD + m	1.7 – 2.0 with average 0.94 m
Extreme Water Level	Extreme 1:500 year	5.5 m Storm surge + long-term sea level rise
Air Temperature	Operational (onshore)	Minimum –18 deg °C Maximum + 38 deg °C
Seawater Temperature	Operational	0 – 27 deg °C
Precipitation	Average	30-58 mm/month
Barometric Pressure		96.31 – 104.62 [kPa]
Humidity	Average	62 - 71 %
Visibility/Fog	Average (Onshore)	0.4% - 4.2% of the time < 1 km visibility
Snowfall	Maximum (Onshore)	104.1 cm in February
Ice		Rarely freezes

6. ***Please describe your assessment of what operational restrictions will be imposed when an LNG carrier may approach, remain alongside, discharge cargo to the FSRU, or be required to get underway based on environmental conditions, actual or forecast.***

MarineSafety International performed a 3.5 day simulation evaluation of the marine aspects of the Broadwater LNG Terminal. The purpose of this study was to determine limiting weather conditions for mooring LNG carriers, when assisted by four Azimuthing Stern Drive (ASD) tugs rated at 60 tonnes bollard pull, on the FSRU's starboard side.

The study was conducted on a full mission simulator without visual graphics. A participating Block Island Sound Pilot was making conning decisions based on observing the LNG carrier, the FSRU and tug outlines on a monitor. Ships used for the study were two membrane LNG carriers, one with a capacity of 138,000 m^3 and the other of 250,000 m^3 capacity. As trial data for the 250,000 m^3 LNG carrier does not exist, a proven model of an actual 138,000 m^3 was used to assess the appropriateness of handling characteristics of the 250,000 m^3 model. The weather conditions simulated were up to winds of 33 knots, currents of 1.2 knots and significant wave heights of 2 meters.

The study found that only four of the twenty five simulations resulted in less than acceptable safety margins. All four simulations were conducted at upper end weather conditions (i.e. winds of 33 knots, currents of 0.8 knots and significant wave heights of 1.6 meters or higher). While four tugs were available, two thirds of the simulations were satisfactorily completed with two tugs, under the following weather limits, which are the basis for actual operational limitations:

- Winds: 33 knots (17.0 m/s)
- Tidal Currents: 0.9 knots (0.45 m/s)
- Waves: 2 meters

In a similar manner to the berthing simulations, the on berth conditions were also assessed to determine the limiting criteria for an LNG carrier to remain alongside the FSRU. A series of environmental combinations of wind, waves and current, based on a 10-year operating metocean data, have been considered in an AQWA time-domain analysis. These operating environmental conditions were divided into the same three major categories based on the relative wind-wave headings: parallel cases, oblique-wind cases and cross-wind cases. The selected current speed was 0.45 m/s; the selected wind speeds were 17.5 m/s and 19.5 m/s; and the selected significant wave heights were 2.0 m, 2.5 m and 3.0 m.

The AWQA time-history analysis results can be summarized as follows:

- For the parallel and oblique wind cases - the safe environmental limits for the LNG carrier moored alongside the FSRU are a combination of 3.0 m waves, 19.5 m/s wind and 0.45 m/s current, under which all peak mooring line loads, fender loads, and manifold motions are within the maximum allowable limits.
- For the cross wind cases - the environmental limits for the LNG carrier moored alongside the FSRU are reduced to a combination of 2.5 m waves, 19.5 m/s wind and 0.45 m/s current.
- Relative manifold motions are well within typical limits and will not govern the operational analysis. The table below presents maximum relative manifold motions by case compared to typical allowable manifold relative motions. Surge and sway relative manifold motions are typically governed by cross wind conditions, while maximum heave relative manifold motions occur in all different wind conditions.

Table 3 - Maximum Relative Manifold Motions

Case	Maximum Relative Manifold Motions (m)		
	Surge	Sway	Heave
Base - Polyester Tails			
Forward Hs = 2.0m	0.52	0.47	0.19
Forward Hs = 2.5m	0.74	0.67	0.22
Forward Hs = 3.0m	0.68	0.71	0.29
Forward Hs = 3.2m	1.31	1.62	0.62
Aft Hs = 2.0m	0.47	0.40	0.19
Aft Hs = 2.5m	0.62	0.82	0.26
Aft Hs = 3.0m	0.63	0.76	0.31
Aft Hs = 3.2m	0.86	1.44	0.40
Sensitivity - Nylon Tails			
Forward Hs = 2.0m	1.19	0.64	0.23
Aft Hs = 2.0m	1.18	1.04	0.26

Typical Manifold Motion Limits (m)		
Surge	Sway	Heave
± 5	± 5	± 10

- Sensitivity studies indicate that nylon tails may increase the limiting significant wave height, but since the practical limits of the metocean database are within the limits of the polyester tails, nylon tails are not necessary. A corollary to this finding is that the stiffer polyester tails exacerbate the differences in line tension and that nylon tails may need to be examined for other mooring configurations if the geometry of the mooring becomes less desirable. Maximum relative manifold motions increase due to the increased flexibility of the nylon, but are still well within typical allowable limits.
- Roll motions are not significant in this study. This is due to the relatively small size of the incident waves.

In summary, operational limits are assessed as being the following:

Table 4 – Summary of Operational Limits

Operational Limit	Significant Wave Height		Wind Velocity		Current Velocity	
	(m)	(ft)	(knots)	(mph)	(knots)	(ft/sec)
Approach Limits	2	6.6	33	38	0.9	1.5
Side-by-Side Mooring Limits	3	9.8	39	45	0.9	1.5
Departure Limits	2	6.6	33	38	0.9	1.5

Response to US Coast Guard Request of October 5, 2005

7. ***Please describe any loading conditions when an LNG carrier may not be able to safely get underway from the FSRU to prevent, among other things, conditions such as sloshing.***

Also, please describe any loading conditions for the FSRU and associated environmental conditions when sloshing may be of concern for the FSRU.

Before any LNG carrier transfer operations commence, a meeting will take place between the Broadwater Cargo Transfer Supervisor and the LNG carrier Master (or his authorized deputy). During this meeting, they will:

(a) Complete/carry out the ship/shore safety checklists (per current Oil Company International Marine Forum [OCIMF] standards).

(b) Discuss any deficiencies shown up by (a) above and agree upon any additional precautions required. Broadwater terminal will reserve the right to refuse to discharge an LNG carrier if the required standards are not met.

(c) Complete a discharge plan that includes:

- Connection/disconnection procedures;
- Quantities of cargo to be loaded/discharged;
- Discharge rates and pressures;
- Ballasting procedure;
- Vapor return procedure;
- Cargo line cool-down procedure;
- Emergency Shutdown (ESD) procedures; and
- Emergency procedures.

The Master shall certify that, in accordance with the cargo plan of operation that has been tabled and discussed, the stress on the ship's hull does not exceed the maximum permissible level by the Classification Society and that the LNG carrier has adequate stability throughout to leave the berth at any time.

Although the LNG carrier may have to transfer cargo after leaving the berth in order to comply with Class limitations on cargo tank filling limits, this should not affect the actual unberthing operation. The Class sailing restrictions have historically limited LNG carriers proceeding to sea when the liquid level within a cargo tank is between 10% and 80% full. These limits are currently being reviewed by the Classification Societies and certain vessels have been approved to operate with reduced upper filling limits. The Broadwater location, within Long Island Sound, will allow an LNG carrier to internally transfer its cargo after unberthing at anchor or underway in relatively sheltered waters before proceeding to sea. In this way, the limitations on cargo tank liquid levels can be met.

Response to US Coast Guard Request of October 5, 2005

The FSRU will be designed and built to worldwide trading standards. This will ensure that the less severe Long Island Sound environment is safely accommodated. For cargo tank membrane systems, natural wave periods have been determined using ABS Safehull LNG formulae for various loading conditions. This is an important parameter in the selection of the tank excitation period, since if the excitation period and tank natural period are similar, fluid resonance in the tank will occur and cause sloshing risk. In addition, critical sea state conditions have been identified such that for the detailed design phase, sloshing analysis can be completed to determine potential sloshing impact loads by which the tanks structure can be designed to ensure the safety of the cargo containment system at all filling levels. The analysis and modeling will be verified by the Classification Society. Hence, there will be no conditions under which sloshing will be of concern for the FSRU.

Further details on the analysis performed to date can be found in draft Resource Report No. 13, Section 13.9.

8. Broadwater Energy has indicated that there will be specialized assist tugs available for the LNG vessels. Please provide the following infornation related to the assist tugs:

a. What is your assessment of the appropriate number of assist tugs needed to assist LNG vessels during mooring and unmooring operations at the FSRU as well as the impact environmental conditions might have on that number? In addition, please describe the arrangements Broadwater will take to ensure that the number of required tugs will be available at all times while the FSRU, if approved and constructed, is in operation.

b. Please identify the following characteristics of the assist tugs:
   - *i. Horse power;*
   - *ii. Bollard pull; and,*
   - *iii. Design cruising speed and speed range where they can safely provide assistance to an LNG carrier.*

c. During the Ports and Waterways Safety Assessment (PAWSA) for Long Island Sound that was conducted in May 2005, representatives from Broadwater stated that these tugs would be equipped to respond to fires on the FSRU or LNG carriers. Please describe the fire fighting capabilities of the assist tugs as well as how they would be employed in the event of an LNG release that may or may not involve a fire.

d. What is your assessment of where along the LNG carriers' proposed route will tugs be available to meet inbound vessels?

e. ***Would the assist tugs be used for other purposes other than supporting the FSRU and LNG vessels?***

f. ***What is your assessment of the necessity of assist tugs remaining in the vicinity of the FSRU while an LNG carrier is moored at the facility?***

8(a) The berthing simulations conducted at the MarineSafety International simulator at Rhode Island, concluded that for the majority of cases two Azimuthing Stern Drive (ASD) tugs rated at 60 tonnes bollard pull are sufficient for the majority of berthing/unberthing operations. When the upper environmental conditions are approached, particularly for the largest vessels, a third tug is required. Based on observations during the simulations it is recommended that tugs be employed as summarized below.

Table 5 – Assessed Tug Support Requirements

	Winter	Summer
Small LNG Carrier Berthing	3 tugs	3 tugs
Small LNG Carrier Unberthing	2 tugs	2 tugs
Large LNG Carrier Berthing	4 tugs	3 tugs
Large LNG Carrier Unberthing	3 tugs	2 tugs

"Small" and "large" refer to LNG carriers of 138,000 m^3 and 250,000 m^3 capacity, respectively.

The number of tugs employed for berthing was established using an "n + 1" philosophy to ensure sufficient reserve towing capacity is available in the event of a single tug failure. This is particularly important at an offshore location. Tug utilization will be further investigated when pilot simulator training is completed before Broadwater commences operations.

Although tug deployment is a contractual agreement between the LNG carrier operator and the towage provider, Broadwater will arrange contracts to ensure suitable tugs are available for all marine operations at the facility. This arrangement has already been proven at the Cove Point terminal in Maryland.

8 (b) The functional requirements of the tugs required for Broadwater have not been formalized but it is expected a 5000 hp ASD tug with a bollard pull of 60 tonnes will be required. This type of tug has been built for the Cove Point LNG terminal operations as detailed in the specification below:

EMILY ANNE McALLISTER

#1137521

GENERAL		**MACHINERY**	
Built:	2003 Eastern Shipbuilding Panama City, FL	Main Engines:	(2)EMD 12 - 645-E7B with Remote Control Start/Stop capability
Flag:	U.S.A.	Propulsion System:	(2) Shottel SRP 1212F Steerable Kort Nozzle Rudder Propellers
Type of Equipment:	Tug	Towing Gear:	(1) Fwd. / (1) Aft Jon Rie Hawser Winches 450' of 7" Amstel Blue synthetic
Radio Call Sign:	WD5443	Automation:	Full Engine Room Monitoring System w/ Remote Monitoring Capability at Main Helm
DIMENSIONS		**NAVIGATION & COMMUNICATION**	
Length:	96'	Radar:	(2) Furuno FR7062/4
Breadth:	34'	Gyro Compass:	Simrad Robertson RGC50
Depth:	14.9'	VHF Radio:	(3) ICOM M-502
Registered Gross Tonnage:	189	DGPS:	(2) Furuno GP-37
Registered Net Tonnage:	124	Fathometer:	Furuno RD-30 Digi-Depth
CAPACITIES		**SAFETY**	
Fuel Oil:	28,280 gal.	Fire Fighting:	(2) 12V-92TA w/ Nijhuis HGT1 Pumps @ 11,600 GPM (2) Skum MK-250EL/VR Remote Controlled Monitors with Foam Injection Capability with 1,100 GPM Deluge system
Lube Oil:	500 gal.		
Potable Water:	6,700 gal.		
Free Running Speed	12 Knots		
H.P:	5,000		
AFF Foam	3,000 gal		
ABS CLASS:	+A-1 Towing; +AMS, +A-1 Fire Fighting (FiFi 1) ABS Escort	EPIRB:	ACR 5850 Cat. 1

These tugs are not used for escort purposes and therefore the cruising speed would need to be increased to 15 knots if this becomes a requirement for Long Island Sound transits.

There are escort tugs operating with towlines attached at speeds up to approximately 10 knots. In the indirect mode at this speed, these tractor tugs can produce up to 2 to 2.5 times the rated static bollard pull. The forces involved can be very large and typically tethered escorts are normally conducted when the vessels speed is in the 3 to 7 knot range. In open sea conditions the speeds are generally lower to avoid snap loading associated with wave generated vessel and tug motions.

As standard practice, all LNG carriers will test critical systems on board before arrival in port but there remains a potential for power, propulsion or steering failure. In the case of LNG carriers entering Long Island Sound, The Race is the most navigationally constrained area. Transit through The Race would take approximately fifteen minutes at full maneuvering speed and the predominant concern is associated with steering failure at this critical point (in particular, should the rudder fail in a hard-over aspect). Mitigation at this time is predominantly by manning the emergency steering arrangements to ensure a timely corrective response. Escort tugs could assist an LNG carrier's recovery from a system failure, but vessel speed and associated maneuverability will be reduced.

8 (c) The Broadwater tugs will be equipped with Firefighting equipment that meets the "Fi-Fi 1" standard. This classification was originally introduced for offshore oil production support vessels and is often incorporated in the tug requirements for LNG marine terminals.

The main components of Fi-Fi Class 1 are as follows:

- Two marine water/foam monitors capable of delivering a minimum combined total of 2,400 cubic meters of water per hour at a minimum range of 120 meters and minimum trajectory height of 45 meters; also capable of producing a total of 15,000 litres per minute of foam solution at a minimum range of 65 meters and geared for both vertical and horizontal movement from a remote station. Each monitor shall be served by a dedicated pump and prime mover of commensurate capacity. The pump and prime mover serving one monitor shall be independent of the pump and prime mover serving the other. The vertical pivot point of the monitors shall be not less than 17 meters above the water.
- A fog nozzle of adequate capacity to fit one of the monitors.
- A water spray system for self protection. The system shall be capable of delivering a spray of water over all the exposed external vertical surfaces of the hull, superstructure, deckhouses and monitor positions. Minimum rate of application shall be 10 litres per square metre per minute.
- Fire Hydrants, Branches, Nozzles and Hoses in accordance with Flag State or Classification Society requirements.
- Capability and equipment to supply water to the FSRU in the event of malfunction of fire pumps.

In the event of an LNG spill the water fire fighting capability of the tugs would primarily be used to protect personnel and structures. Two scenarios can be considered for LNG spills on the water but actual response will depend on individual situations:

Unignited Spill:

- Tugs would position themselves upwind of the spill.
- Water monitors may be used to increase the vaporization rate of the spill.
- Tugs may be used to evacuate personnel.

- If a risk of vapor ignition exists, water cooling of structures should be considered.

Ignited Spill:

- Tugs would position themselves upwind of the spill.
- Tugs may be used to evacuate personnel.
- Primary response would be to cool adjacent structures and not to extinguish the fire.
- Under certain circumstances, the pool fire could be controlled by the use of the water monitors.

8 (d) When LNG carriers arrive within two miles of the FSRU location, tugs are required to be in attendance and commence the hooking up process once the final approach run for berthing is started.

Tugs may also be available to rendezvous with an inbound carrier at The Race area if required. These tugs would be capable of passive escort of the LNG carrier through Long Island Sound.

Before an LNG carrier is permitted to enter the Sound, the current and forecast weather conditions will need to satisfy certain limiting criteria (see response to Question 6) that will include wave conditions, which are a controlling factor in the tugs' ability to assist with berthing operations. While some localised differences in wave heights can be expected at different locations in the Sound, in general terms if the wave heights at the FSRU are suitable for berthing, the tugs should be able to perform escort duties during LNG carrier transits.

8 (e) It is not intended for the assist tugs to perform other duties apart from support to the FSRU and LNG carrier operations. The tugs may be released on request for emergency or salvage purposes, but only at the discretion of Broadwater, where the safety of operations is not compromised.

8 (f) Two tugs will remain in close stand-by to the FSRU whenever an LNG carrier is berthed alongside. These tugs will be available to assist in emergency situations or where an unplanned unberthing is required.

9. *Please provide an assessment of where along the proposed transit route for LNG carriers assist tugs would be most useful. Please include in this assessment how environmental factors will impact the ability of assist tugs to provide assistance to the LNG carriers in these areas.*

See responses to Question 6 and Question 8 (d).

10. *Please provide the following information regarding the environmental factors considered when establishing design criteria for the mooring system:*

   a. *What is the weather design criteria being applied to the mooring system?*

   b. *In looking at the weather design criteria, how did you elect to use these particular criteria?*

   c. *Has seismic activity been considered? If so, please identify the intensity of the seismic activity that was considered and the basis for selecting it.*

   d. *In the design of the mooring system, has the potential for ice formation and ice floes, including the scenario where Long Island Sound is frozen over and is then subject to high winds, been considered? If yes, please identify the factors that were considered. If no, why were these not considered?*

<u>10 (a)</u> The main weather design criteria applied to the Broadwater mooring system consisted of the components associated with predicted extreme storm conditions. These components were an H_s (significant wave height) of 7.0 meters with a T_p (wave period) of 9.9 sec, a LAT (Lowest Astronomical Tide) of 27.0 meters, a HAT (Highest Astronomical Tide) of 32.5 meters, a V_c (maximum surface current) of 0.8 m/s and a V_w (maximum 1 minute sustained wind velocity) of 56.8 m/sec.

The weather conditions within Long Island Sound are relatively benign but strong winds associated with hurricanes or other storms are a feature at this location. These winds may generate significant waves, depending on the direction and duration of the wind. As the FSRU is a floating structure, it is imperative that the mooring arrangement be such that the terminal is able to remain on station. For this reason, Broadwater has increased the survivability criteria for the yoke mooring system from the more typical design criteria of a 100-year storm event to credible storm scenarios well in excess of those experienced in the recent history of the region. By way of comparison, the hurricane experienced in the region on September 21, 1938 was equivalent to a 50-year storm event, based on Broadwater's analysis of historical weather data. Consequently, the yoke mooring system would be capable of surviving events of greater magnitude than this particular event, which had wave heights of approximately 12 feet (3.8 meters). The 100-year storm condition is typically used as design basis for offshore structures.

10 (b) The weather design criteria of the 10,000 year event was included to ensure that the Yoke Mooring System could safely accommodate all expected weather conditions based on past recorded conditions and future expectations.

10 (c) The seismic data for the area indicated a very low incidence of seismic activity that when analyzed did not require any additional structural reinforcing. The design of the structure was such that the controlling design criteria (which was the worst environmental condition) subjected greater forces to the structure than a potential credible seismic event.

10 (d) Ice formation and floes were not analyzed in detail as part of the mooring system design. Available metocean data indicates that at an extreme, seawater temperatures range from 32°F (0°C) to 74°F (23°C). Sea water freezes at 28.4°F (-2°C) and as such, freezing is not expected. However, should some shallow surface freezing occur, the mooring system is substantially strong enough to withstand the associated low ice loads.

Additional details with respect to items 10 (a) to 10 (d) and 11, can be found in draft Resource Report No. 13, Section 13.16.

11. ***What backup mooring arrangements for the FSRU are provided in the event of a failure of the primary mooring system? Of particular concern is a failure that would occur during a heavy weather event, e.g., a Northeaster or hurricane, when assist tugs would not be available or physically capable of rendering assistance.***

The primary yoke mooring system design will safely accommodate the most severe weather that can credibly occur in the area, including hurricanes and Northeasters. The redundancy within the mooring system and the reduced environmental loadings resulting from the weathervaning FSRU reduce the risk of a mooring failure to as low as reasonably practicable. For this reason a secondary mooring system has not been incorporated within the design. Additional mitigation measures may be possible by using the azimuth thrusters to reduce the load on the mooring system during severe storm conditions and possibly the use of these thrusters to steer the FSRU or arrest progress in the unlikely event of a mooring failure. The only credible secondary mooring system would be the provision of anchors on the FSRU but the effectiveness and risks associated with this solution would need careful analysis and compared to the potential risk of mooring failure. Based on recent events in the Gulf of Mexico, it is understood certain government agencies are investigating the criteria for mooring systems on offshore floating structures.

12. ***Understanding that the technology used in the mooring tower has been used elsewhere by Shell, please provide the following information:***

   a. ***Please identify where and for what type of facility the mooring tower has been used.***

   b. ***What weather design criteria have been applied in the design of these other mooring towers?***

   c. ***What size facilities have been moored to these other towers and how do they compare to the proposed FSRU in terms of displacement tonnage and windage?***

   d. ***What are the maximum actual weather conditions that have been experienced?***

   e. ***How long have these mooring towers been in service?***

   f. ***Have the mooring towers had any modifications since they were installed? If yes, please identify what modifications were made and why.***

   g. ***Have there been any failures of these mooring towers? If yes, what was the nature and circumstances of the failure?***

<u>12 (a)</u> There are 8 similar systems currently installed worldwide. These are installed in South East Asia (mainly China) and West Africa. Broadwater's mooring system has a design that is typical of the majority of yoke mooring systems installed using a ballast tank and articulated linkage. The soft yoke mooring technology has been deployed in several projects, and is accepted as a proven design for shallow water mooring installations.

The only Shell installation is the Shell EA system which is installed offshore Nigeria. The Shell EA installation is located on a field development that is located 15 km offshore. The mooring system is a tower soft yoke which moors a Floating Production, Storage and Offloading Unit (FPSO) as opposed to an FSRU. The Broadwater design is based on the Shell EA design, with the Broadwater design being larger.

<u>12 (b)</u> The design weather criteria for Shell EA was based on a 100-year return storm. These components included an H_s (significant wave height) of 3.2 meters with a T_p (wave period) of 15.9 seconds, an LAT (Lowest

Astronomical Tide) of 26.4 meters, an HAT (Highest Astronomical Tide) of 28.3 meters, a V_c (maximum surface current) of 1.0 m/s and a V_w (maximum 1 minute sustained wind velocity) of 14.0 m/sec.

12 (c) The Shell EA FPSO was a new build tanker with a displacement of 213,762 tonnes, 50 meter breadth, 28 meter depth, and an overall length of 273.6 meters.

12 (d) Shell is endeavoring to obtain this information and, if available, will include the information when it responds to the other questions to be answered by November 8, 2005.

12 (e) The complete Shell EA system was installed, commissioned and ready for start-up (first oil) on December 12, 2002.

12 (f) We are not aware of any modifications to any systems.

12 (g) To date, there has only been one published failure of a tower soft yoke mooring system. The mooring system failure however was reportedly caused by the failure of a large chain that made up a portion of the ballast weight suspension arrangement. This type of design is not part of the Broadwater design as no chain is utilized. The Broadwater arrangement, like the Shell EA facility, utilizes only tubular steel and large mechanical connections.

13. What is your assessment of the training state licensed marine pilots may require prior to serving as a pilot on an LNG carrier that will moor at the FSRU?

Compulsory pilotage is expected for all LNG carrier transits and berthing operations in Long Island Sound. Experienced State-licensed pilots are available to complete this task and have considerable local knowledge of the area. Primary training requirements relate to the berthing operation at the FSRU where the pilots may be unfamiliar with the handling characteristics of LNG carriers and the use of ASD tugs. The current generation of LNG carriers has steam turbine propulsion which is becoming increasingly uncommon on other types of vessel. Similarly the use of ASD tugs is not common in U.S. ports and pilot training in their capabilities is normally welcomed.

From a Broadwater perspective, we would expect to provide full mission bridge simulator training to pilots and tug skippers in the berthing and unberthing operations at the FSRU. This was completed before the Cove Point terminal was reactivated in 2003 and allowed the participants to practice ship handling maneuvers with the tugs being conned by the actual tug skippers. This exercise avoided any need for the pilots to test different methods when actual marine operations resumed.

The simulator training also allows emergency situations to be modeled and allows those involved to practice their response. Refresher training will also be considered as this allows the pilots to test new procedures as experience is gained with berthing at the FSRU.

14. What is your assessment of the need for marine pilots to remain on board LNG carriers while they are moored at the FSRU?

Due to the offshore location and the potential need for an LNG carrier to sail at any time, it is considered prudent for the pilot to remain on board throughout the entire discharge operation. It is understood this is a current practice at an existing offshore terminal in the Sound.

15. What is your assessment of the qualifications required by personnel on the FSRU who will be engaged in marine operations, including operation of the FSRU's thrusters, directing mooring and unmooring operations, as well as monitoring vessel traffic on the waters in the vicinity of the FSRU?

Detailed manning studies have not been completed for the Broadwater facility but the following positions will be considered as appropriate for the marine aspects of the operation.

Port Superintendent. The Broadwater Port Superintendent has overall authority over the terminal. This encompasses all personnel at the terminal, including contract personnel, and all vessel and helicopter operations at the terminal. Minimum requirements of the Port Superintendent are as follows:

(1) Adequate experience managing an LNG transfer to demonstrate the capability of managing the Broadwater terminal;

(2) Full understanding of the operational requirements of 33 CFR §150.200;

(3) Familiarity with the hazards of each product handled at the terminal; and

(4) Knowledge of all procedures in the Broadwater terminal's operations manual.

Vessel Traffic Supervisor. The Broadwater Vessel Traffic Supervisor is responsible for all vessel movements into and out of the terminal, safety zone, and Broadwater navigation area. Minimum requirements of the Vessel Traffic Supervisor are as follows:

(1) Experience working with radar plotting and analysis of vessel movement for one (1) of the previous five (5) years or successful completion of a marine radar operators school acceptable to the Commandant (G–M);

(2) Familiarity with the procedures for using the terminal's radar equipment; and

(3) Knowledge of all procedures in the Broadwater terminal's operations manual for vessel control and voice radio-telecommunications.

Response to US Coast Guard Request of October 5, 2005

Mooring Master. All vessels entering and departing the Broadwater terminal are under the direction of the Mooring Master. Minimum requirements of the Mooring Master are as follows:

(1) A current merchant mariners license issued by the Coast Guard under 46 CFR Part 10 as one of the following:

(a) Master of ocean steam or motor vessels of any gross tons, endorsed as radar observer, and have one (1) year of experience as:

(i) A Master on tankers of 70,000 deadweight tonnage (DWT) or larger and satisfactory completion of a very large crude carrier (VLCC) ship handling course acceptable to the Commandant (Chief, Office of Marine Safety, Security, and Environmental Protection [G-M]); or

(ii) A Mooring Master at any deepwater port servicing tankers of 70,000 DWT or larger.

(b) Master of ocean steam or motor vessels of limited tonnage, endorsed as radar observer, and endorsed as first class pilot of vessels of any gross tons for at least one port, and have one (1) year of experience:

(i) Piloting ocean going vessels, including tankers of 70,000 DWT or larger; or

(ii) As Assistant Mooring Master at the terminal and satisfactory completion of a VLCC ship handling course acceptable to the Commandant (G-M).

(c) Master of ocean steam or motor vessels of limited tonnage or chief mate of ocean, steam, or motor vessels of unlimited tonnage with 1-year experience in charge of an offshore crude oil lightering operation.

(2) Knowledge of all procedures in the Broadwater terminal's operations manual and the Broadwater Spill Response Plan for:

- Vessel control;
- Vessel responsibilities;
- Spill prevention, containment, and cleanup;
- Accidents and emergencies; and
- Voice radio-telecommunications.

Cargo Transfer Supervisor. The Cargo Transfer Supervisor supervises the unloading of LNG to the terminal. Minimum requirements of the Cargo Transfer Supervisor are as follows:

(1) Sufficient experience managing cargo transfers at an oil or LNG transfer facility to demonstrate the capability of managing cargo transfers at the Broadwater terminal;

(2) At least one (1) year of continuous employment as supervisor at an oil or LNG transfer facility in charge of offloading tank vessels of 70,000 DWT or larger;

(3) Supervision of at least 25 cargo transfer evolutions from tankers of 70,000 DWT or larger or service in a training capacity for cargo transfer supervisor at a deepwater port in the United States for at least one (1) year;

(4) Knowledge of the requirements for LNG transfer operations in 33 CFR 150 subpart E;

(5) Knowledge of the LNG transfer procedures and transfer control systems, in general, of LNG carriers serviced at the Broadwater terminal;

(6) Familiarity with the special handling characteristics of each product transferred at the Broadwater terminal; and,

(7) Knowledge of all procedures in the Broadwater terminal's operations manual and the Broadwater Spill Response Plan for:

- LNG transfers;
- Spill prevention, containment, and cleanup;
- Accidents and emergencies; and
- Voice radio-telecommunications.

Cargo Transfer Assistant. The Cargo Transfer Assistant must have:

(1) One (1) year of experience or must have performed 15 cargo transfer evolutions at an oil or LNG transfer facility servicing tankers of 70,000 DWT or larger;

(2) Knowledge of the requirements for LNG transfer operations in 33 CFR 150 subpart E;

(3) Knowledge of the LNG transfer procedures and transfer control systems, in general, of LNG carriers serviced at the Broadwater terminal;

(4) Familiarity with the special handling characteristics of each product to be transferred;

(5) Knowledge of all procedures in the Broadwater terminal's operations manual and the Broadwater Spill Response Plan for:

- LNG transfers;
- Spill prevention, containment, and cleanup;
- Accidents and emergencies; and
- Voice radio-telecommunications.

U.S. Department of Homeland Security

United States Coast Guard

Commander
U.S. Coast Guard
Sector Long Island Sound

120 Woodward Ave.
New Haven, CT 06512
Staff Symbol: Prevention
Phone: (203) 468-4504
Fax: (203) 468-4445
Email: ablume@sectorlis.uscg.mil

16211/05-316
October 5, 2005

Broadwater Energy
Attn: Mr. Stephen Marr, Permit Application Manager
777 Walker Street, 22nd Floor
Houston, TX 77002

Dear Mr. Marr:

Last November, you submitted a letter of intent regarding the Broadwater Energy Liquefied Natural Gas (LNG) project, proposed to be located in Long Island Sound. Your letter and its subsequent amendment, dated April 26, 2005, met the requirements under 33 Code of Federal Regulations, section 127.007. Additionally, we have reviewed information that has been submitted to the Federal Energy Regulatory Commission (FERC) during the pre-filing process. As you are aware, FERC is the lead federal agency for licensing this project since it would be located in state waters. As the Coast Guard Captain of the Port for Long Island Sound, I am responsible for conducting an assessment of the potential risks to waterway safety and port security associated with the project. These assessments include identifying potential risks associated with the project to waterway safety and to port security. These also include determining measures that could be put in place to mitigate the identified risks.

In order to complete the waterways safety assessment, I require additional information from Broadwater Energy in order to accurately evaluate the potential risks to waterway safety associated with this proposal and the suitability of Block Island Sound and Long Island Sound for LNG marine traffic. In conducting the safety assessment, we have compiled a series of questions that are necessary to answer prior to continuing with the assessment:

1. The letter of intent submitted for this project indicated that the LNG carriers that may call at the proposed floating storage and regasification unit (FSRU) would have a design capacity between 125,000 m^3 and 250,000 m^3. Please provide the length, beam and draft (loaded and in ballast) of these vessels based on capacity.

2. Noting the draft restriction of 38 feet for vessels using Montauk Channel established by the New York Board of Pilots and the Connecticut Department of Transportation that pilots licensed by these states are required to comply with, please provide an assessment of relative risk of LNG carriers transiting from Montauk Channel to The Race versus transiting from Point Judith Pilot Boarding Station, north of Block Island to The Race.

3. Identify the proposed route, or routes, the LNG carriers may transit from entry into the United States territorial sea to mooring at the FSRU, and its outbound transit to the territorial sea, if different. This should be presented graphically and in writing, and should indicate the outer limits of the zones of concern for an intentional release of LNG that are contained in the Sandia National Laboratories Report SAND2004-6258 (Sandia Report). Identification of the transit route should include specific safety concerns in the following areas:

    a. Block Island Sound;

b. Montauk Channel (if applicable);

c. Approach to the pilot station;

d. Where LNG vessels will embark/disembark a pilot if seaward of the established pilot stations;

e. Approach to The Race; and

f. Transit from The Race to mooring at the FSRU.

4. What is your assessment of the density and character of marine traffic along the proposed LNG vessel transit route and at the proposed location of the FSRU as well as of specific areas along the proposed route where vessel congestion is a particular concern? In addition, what is your assessment of the potential impacts that LNG vessel traffic and the FSRU may have on other vessel traffic?

   You should base your response to this question on the assumption that the Coast Guard will establish a moving safety and security zone around the LNG carriers while they are underway on the navigable waters of the United States as well as a safety and security zone that will remain in place around the FSRU. The sizes of these zones have not been established. Therefore, you should base your analysis for the impact on the following:

   a. For the moving safety and security zone, you should base your analysis on what is in place for Boston Harbor (33 C.F.R. 165.114), Chesapeake Bay (33 C.F.R. 165.500), the Savannah River (33 C.F.R. 165.756) and the Calcasieu River ship channel (33 C.F.R. 165.805(b)).

   b. For the safety and security zone around the FSRU you should base your analysis on zones that:

      i. Move with the FSRU as it pivots on the mooring tower that extend 500, 1000, 1500 and 2000 yards from the FSRU and mooring tower; and,

      ii. Are centered on the mooring tower and have a radius equal to the distance from the center of the mooring tower to the farthest most point on the FSRU when the yoke is fully extended plus 500, 1000, 1500 and 2000 yards.

5. What is your assessment of the impact of environmental factors (e.g. fog, current, high winds, storms, ice formation around or ice floe, etc.) on LNG carrier traffic and FSRU operations?

6. Please describe your assessment of what operational restrictions will be imposed when an LNG carrier may approach, remain alongside, discharge cargo to the FSRU, or be required to get underway based on environmental conditions, actual or forecast.

7. Please describe any loading conditions when an LNG carrier may not be able to safely get underway from the FSRU to prevent, among other things, conditions such as sloshing. Also, please describe any loading conditions for the FSRU and associated environmental conditions when sloshing may be of concern for the FSRU.

8. Broadwater Energy has indicated that there will be specialized assist tugs available for the LNG vessels. Please provide the following information related to the assist tugs:

   a. What is your assessment of the appropriate number of assist tugs needed to assist LNG vessels during mooring and unmooring operations at the FSRU as well as the impact environmental conditions might have on that number? In addition, please describe the arrangements Broadwater will take to ensure that the number of required tugs will be available at all times while the FSRU, if approved and constructed, is in operation.

   b. Please identify the following characteristics of the assist tugs:

      i. Horse power;

      ii. Bollard pull; and,

      iii. Design cruising speed and speed range where they can safely provide assistance to an LNG carrier.

   c. During the Ports and Waterways Safety Assessment (PAWSA) for Long Island Sound that was conducted in May 2005, representatives from Broadwater stated that these tugs would be equipped to respond to fires on the FSRU or LNG carriers. Please describe the fire fighting capabilities of the assist tugs as well as how they would be employed in the event of an LNG release that may or may not involve a fire.

   d. What is your assessment of where along the LNG carriers' proposed route will tugs be available to meet inbound vessels?

   e. Would the assist tugs be used for other purposes other than supporting the FSRU and LNG vessels?

   f. What is your assessment of the necessity of assist tugs remaining in the vicinity of the FSRU while an LNG carrier is moored at the facility?

9. Please provide an assessment of where along the proposed transit route for LNG carriers assist tugs would be most useful. Please include in this assessment how environmental factors will impact the ability of assist tugs to provide assistance to the LNG carriers in these areas.

10. Please provide the following information regarding the environmental factors considered when establishing design criteria for the mooring system:

    a. What is the weather design criteria being applied to the mooring system?

    b. In looking at the weather design criteria, how did you elect to use these particular criteria?

    c. Has seismic activity been considered? If so, please identify the intensity of the seismic activity that was considered and the basis for selecting it.

d. In the design of the mooring system, has the potential for ice formation and ice floes, including the scenario where Long Island Sound is frozen over and is then subject to high winds, been considered? If yes, please identify the factors that were considered. If no, why were these not considered?

11. What backup mooring arrangements for the FSRU are provided in the event of a failure of the primary mooring system? Of particular concern is a failure that would occur during a heavy weather event, e.g., a Northeaster or hurricane, when assist tugs would not be available or physically capable of rendering assistance.

12. Understanding that the technology used in the mooring tower has been used elsewhere by the Shell, please provide the following information:

    a. Please identify where and for what type of facility the mooring tower has been used.

    b. What weather design criteria have been applied in the design of these other mooring towers?

    c. What size facilities have been moored to these other towers and how do they compare to the proposed FSRU in terms of displacement tonnage and windage?

    d. What are the maximum actual weather conditions that have been experienced?

    e. How long have these mooring towers been in service?

    f. Have the mooring towers had any modifications since they were installed? If yes, please identify what modifications were made and why.

    g. Have there been any failures of these mooring towers? If yes, what was the nature and circumstances of the failure?

13. What is your assessment of the training state licensed marine pilots may require prior to serving as a pilot on an LNG carrier that will moor at the FSRU?

14. What is your assessment of the need for marine pilots to remain on board LNG carriers while they are moored at the FSRU?

15. What is your assessment of the qualifications required by personnel on the FSRU who will be engaged in marine operations, including operation of the FSRU's thrusters, directing mooring and unmooring operations, as well as monitoring vessel traffic on the waters in the vicinity of the FSRU?

16. The Sandia Report was conducted based on the characteristics of the current generation of LNG carriers and did not detail concerns for FSRUs. This study was generic to location. Please conduct modeling specific to the site, the proposed FSRU as well as the future generation LNG carriers and provide the analysis and following results:

    a. Validate the applicability of the Sandia Report to the FSRU;

b. Validate the applicability of the Sandia Report to the future generation of LNG carriers (i.e. carriers in excess of the capacity considered in the Sandia Report); and

c. In terms of site specific, seasonal environmental and weather factors, determine the effects, if any, these will have on the travel of vapor clouds from the FSRU; and in wind speeds in excess of Sandia models, including Northeastern gales, a most probable hurricane, and a worst case hurricane.

Answers to these questions are required for us to complete our assessment of potential impacts to waterway safety associated with the proposed project. Furthermore, such answers are critical for the safety and security assessments since they will influence possible mitigation measures that can be considered for potential risks to port security as well as for consequence management planning if the project is licensed. Please provide answers to these questions no later than Tuesday November 1, 2005.

If there are any questions please have your staff contact Lieutenant Commander Alan Blume, the Chief of the Sector Long Island Sound Prevention Department, at (203) 468-4504.

Sincerely,

PETER J. BOYNTON
Captain, U.S. Coast Guard
Captain of the Port, Long Island Sound

Copy: Commander (dl, m), First Coast Guard District
Mr. James Martin, Office of Energy Projects, Federal Energy Regulatory Commission

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November 18, 2005

Captain Peter J. Boynton
Captain of the Port, Long Island Sound
United States Coast Guard
120 Woodward Avenue
New Haven, Connecticut 06512

RE: Broadwater Energy Project
USCG Docket USCG-2005-21863
FERC Docket PF05-4-000

Dear Captain Boynton:

Broadwater Energy (Broadwater) received your request, dated October 5, 2005, for additional information related to the marine aspects of the proposed LNG terminal to be located within Long Island Sound. It is our understanding that this information is needed to allow the U.S. Coast Guard to complete its assessment of the potential risks to waterway safety and port security associated with the project.

On November 1, 2005, Broadwater provided a response to the majority of the questions raised in your information request. The purpose of this letter is to provide response to the remaining questions, namely Questions 2, 3, 4 and 16.

Attached is a report by Det Norske Veritas (USA) Inc. ("DNV"), which is intended to provide the requested information. This report has been classified as Sensitive Security Information (SSI) as defined within 49 CFR 1520 and NVIC 9-02.

LNG Carrier Safety and Security Zone Considerations

With specific reference to Question 4 and the question of a moving safety and security zone, you have requested that the analysis consider the guidance in place for a number of other locations within the U.S. These are summarized in Table 1 below.

Table 1 – Established Moving Safety and Security Zones

Location	Reference	Safety and Security Zone
Boston Harbor	33 CFR 165.114	• 1000 yards ahead and astern • 100 yards on either side of designated escort vessel
Chesapeake Bay	33 CFR 165.500	• 500 yard radius around LNG vessel
Savannah River	33 CFR 165.756	• No vessel of 1600 gross tons or greater may approach within 2 nautical miles
Calcasieu River	33 CFR 165.805(b)	• 2 miles ahead • 1 mile astern • Either side to the width of the ship channel

We recognize from the wide range of safety and security zones established for activities occurring on these waterbodies that your determination on the appropriate moving and permanent zones for the Broadwater project (the "Project") will take into account such factors as: (1) the density and character of all other water dependent activities in Long Island Sound and Block Island Sound; (2) the nature of the marine environment where these activities will occur; and (3) proximity of those water dependent activities which have potential risks to onshore populations.

As you are aware from the information provided to your office and the Federal Energy Regulatory Commission staff to date, Broadwater's proposed routes for LNG carriers and mooring location for the Floating Storage and Regasification Unit ("FSRU") have been selected based on these and other considerations. For example, significant attention has been focused upon limiting the potential for environmental and economic impacts under multiple coastal management plans. We believe that safety and security zones can be established for the Project which recognize all of these factors.

While in many respects we see numerous similarities between the operating environment for the Project and conditions in Chesapeake Bay, the DNV analysis presented considers a maximum two mile (1.7 nautical miles) moving safety and security zone around LNG carriers for potential transit into Long Island Sound. This is intended to be a very conservative representation, and significantly wider than safety zones experienced at other locations around the world The analysis, however indicates that even under this assumption, there is a very limited intersection with the shore, occurring only in the vicinity of Fishers Island.

The assessment of collision event frequency concludes that the incident frequencies are generally below the normal thresholds considered for risk mitigation and emergency preparedness.

In view of these results, a balance must be achieved between the probability and associated consequence of an LNG carrier collision event or security incident, and the potential impacts on other users of the waters in the vicinity of the proposed carrier routes outlined in the report.

FSRU Safety and Security Zone Considerations

As discussed in the draft Resource Reports filed with the Federal Energy Regulatory Commission, many of the features of the FSRU are common to LNG carriers, including the basic design of the hull and LNG storage tanks.

As discussed in the DNV report, DNV concludes that the results of the Sandia study are applicable to the FSRU, given similarities in structural design and storage tank volumes. Consequences arising from thermal hazards or vapor cloud dispersion would also be anticipated to be highly similar to those quantified by Sandia under equivalent meteorological assumptions.

Given these similarities and based upon our evaluation of the zones established for LNG terminals to date, we believe that the Project compares favorably to the limitations established for Chesapeake Bay operations as described in 33 CFR 165.502.

Because of the importance of this aspect of the regulatory review of the Project, we would like to arrange a meeting with you and your staff in early December to discuss the report and your assessment. We suggest Friday, December 9 in your offices as a possible date. In the interim, if there are any questions or concerns with respect to the attached report, please have your staff contact Captain David Thomson of Broadwater at (713) 241-8931.

Respectfully submitted,

Bruce W. Neely
Attorney for Broadwater Energy

cc: Mr. James Martin

12. ***Understanding that the technology used in the mooring tower has been used elsewhere by Shell, please provide the following information:***

    (d) ***What are the maximum actual weather conditions that have been experienced?***

Response:

The maximum weather related conditions recorded at the Sea Eagle FPSO are as follows:

- Maximum sustained winds: 35 knots; maximum squall winds: 60 knots.
- Maximum roll: 10 degrees port and starboard in 2002. Maximum since that time was an 8 degree roll which occurred this year.
- Maximum pitch: 3 degrees.
- Maximum heave at the helideck: 8 meters.
- Maximum sea state: 4 meters with 3 to 4 foot chop.
- Maximum current: 2 knots.

The wave environment off Nigeria is predominated by swell conditions but other yoke mooring systems are in operation in differing environments.

For details, the following manufacturers' websites provide information.

(1) FMC Technologies

http://www.fmctechnologies.com/FloatingSystems/MooringSystems/TowerYokeMoorings.aspx

(2) Bluewater Energy Services

http://www.bluewater.com/products.asp?refID=204&ID=204&contentID=204

(3) SBM–Imodco Inc.

http://www.sbmimodco.com/gbu/LNGTerminals/SYMOTower.aspx

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

Commander
U.S. Coast Guard
Sector Long Island Sound

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16211
December 16, 2005

Broadwater Energy
Attn: Mr. Stephen Marr, Permit Application Manager
777 Walker Street, 22nd Floor
Houston, TX 77002

Dear Mr. Marr:

As part of the Coast Guard's assessment of the potential risks to waterway safety associated with Broadwater's proposal to construct and operate a liquefied natural gas (LNG) floating, storage and regasification unit (FSRU) in Long Island Sound, we are using recorded Automatic Identification System (AIS) data to examine commercial vessel traffic patterns on Long Island Sound in general and in the vicinity of the proposed location of the FSRU in particular. As you are aware, AIS units are required to be carried by a significant number of commercial vessels that operate on Long Island Sound, including all foreign-flag vessels and many of towing vessels.

We have recently completed a preliminary analysis of the data for every fifth day for the period of January through June 2005. This analysis, which is summarized in enclosure (1), indicates the number of vessel transits on the Sound as well as the number of transits that passed within approximately 2 NM of the proposed location of the FSRU. Based on this analysis, approximately 18% of the total transits passed within 2 NM of the site where Broadwater has proposed to locate the FSRU. Enclosures (2) and (3) present the data for the months of January and February as a graphic. The highlighted box is 4 NM on its side and is centered on the proposed location of the FSRU. We are in the process of analyzing the data for the entire year and will include it in the Coast Guard's report to the Federal Energy Regulatory Commission.

You may contact me at the above phone number or e-mail address if you have any questions.

Sincerely,

A. L. BLUME
Lieutenant Commander, U.S. Coast Guard
Chief, Prevention Department
By direction of the Captain of the Port, Long Island Sound

Enclosures: (1) Long Island Sound AIS Data (partial) for period January - June 2005
(2) AIS data - January 2005
(3) AIS data - February 2005

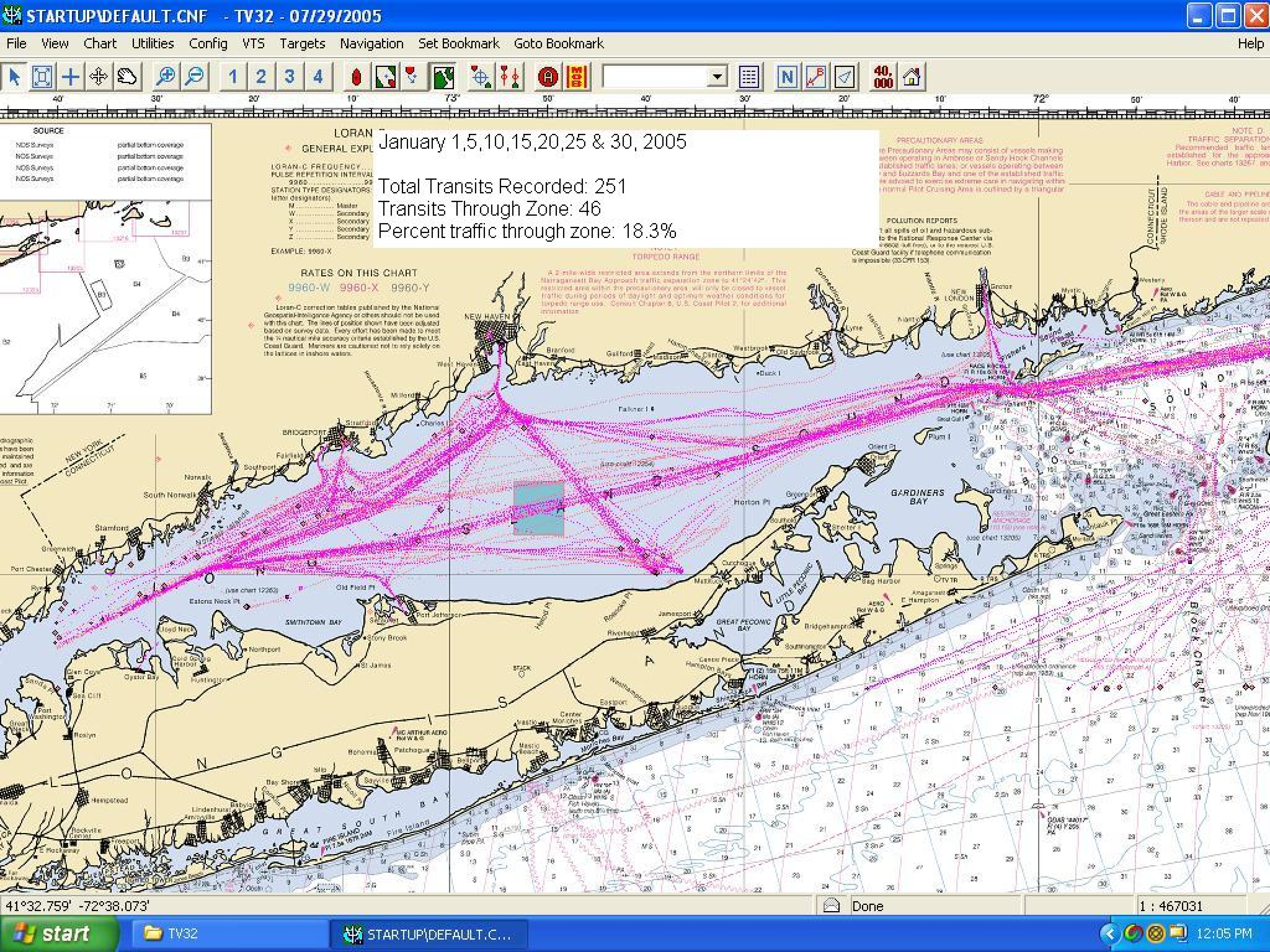
Copy: Mr. James Martin, Federal Energy Regulatory Commission
Docket USCG-2005-21863

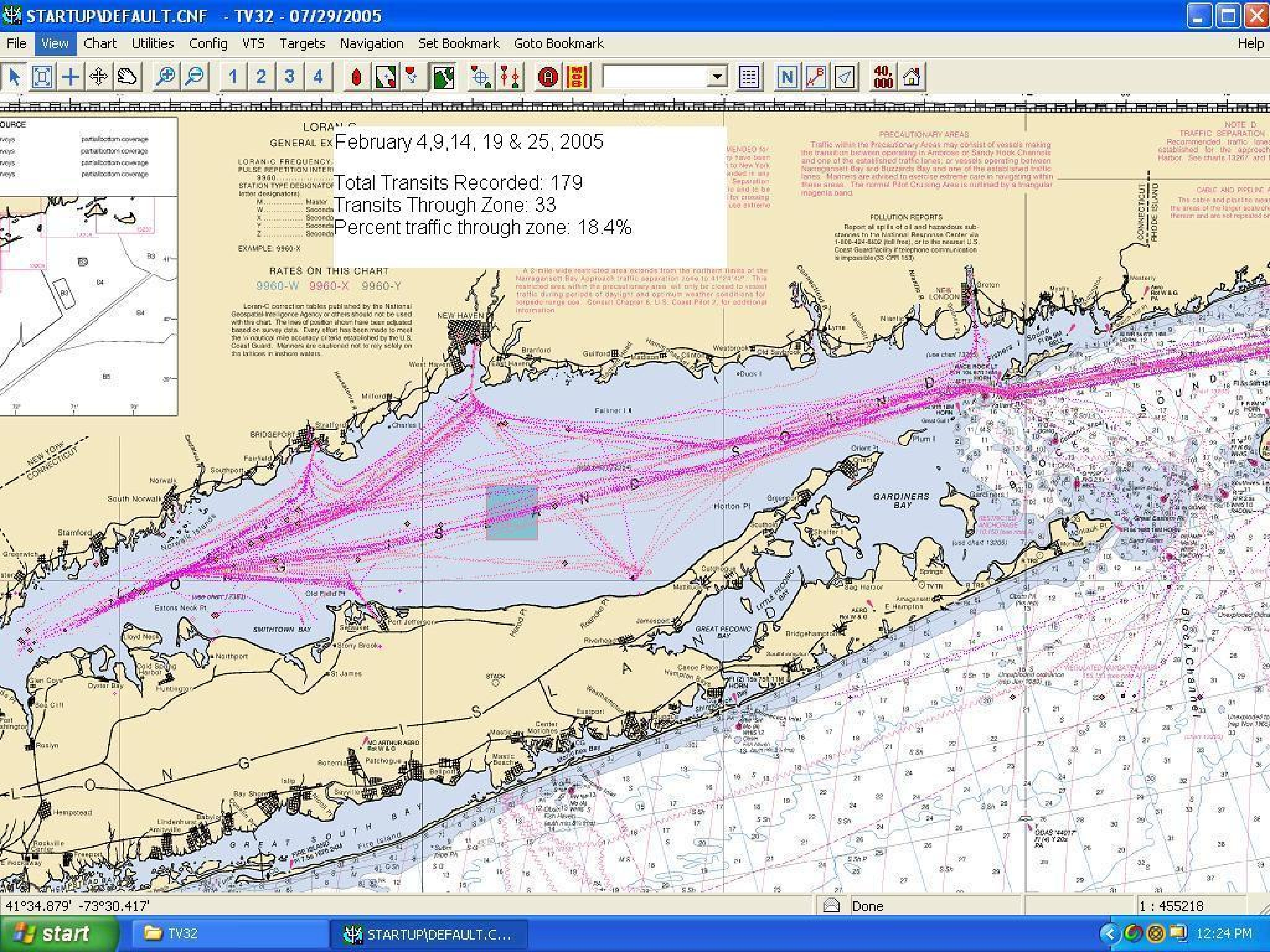
Long Island Sound AIS Data

Date	Total Transits	Transits Through Site
01/01/2005	22	2
01/05/2005	46	11
01/10/2005	35	8
01/15/2005	41	4
01/20/2005	37	9
01/25/2005	34	6
01/30/2005	36	6
Total	**251**	**46**
02/04/2005	35	0
02/09/2005	39	11
02/14/2005	32	7
02/19/2005	44	9
02/24/2005	29	6
Total	**179**	**33**
03/01/2005	40	5
03/05/2005	37	8
03/10/2005	46	6
03/15/2005	35	5
03/20/2005	39	9
03/25/2005	39	9
03/30/2005	39	6
Total	**275**	**48**
04/04/2005	39	10
04/09/2005	34	4
04/14/2005	32	7
04/19/2005	41	6
04/24/2005	41	5
04/29/2005	43	6
Total	**230**	**38**

Date	Total Transits	Transits Through Site
05/04/2005	31	6
05/09/2005	39	7
05/14/2005	42	9
05/19/2005	41	5
05/24/2005	32	7
05/29/2005	31	4
Total	**216**	**38**
06/03/2005	41	6
06/08/2005	48	10
06/13/2005	35	9
06/18/2005	46	8
06/23/2005	40	8
06/28/2005	42	5
Total	**252**	**46**
Year Total	**1403**	**249**
Percent Transits Through Zone:		**17.75%**

ENCLOSURE (1)


STARTUP\DEFAULT.CNF - TV32 - 07/29/2005
File View Chart Utilities Config VTS Targets Navigation Set Bookmark Goto Bookmark Help
January 1,5,10,15,20,25 & 30, 2005
Total Transits Recorded: 251
Transits Through Zone: 46
Percent traffic through zone: 18.3%
RATES ON THIS CHART
9960-W 9960-X 9960-Y
NEW HAVEN
BRIDGEPORT
NEW LONDON
GARDINERS BAY
GREAT SOUTH BAY
41°32.759' -72°38.073'
Done
1 : 467031
start
TV32
STARTUP\DEFAULT.C...
12:05 PM


STARTUP\DEFAULT.CNF - TV32 - 07/29/2005
File View Chart Utilities Config VTS Targets Navigation Set Bookmark Goto Bookmark Help
February 4,9,14, 19 & 25, 2005
Total Transits Recorded: 179
Transits Through Zone: 33
Percent traffic through zone: 18.4%
41°34.879' -73°30.417'
Done
1 : 455218
start
TV32
STARTUP\DEFAULT.C...
12:24 PM

U.S. Department of Homeland Security

United States Coast Guard

Commander
U.S. Coast Guard
Sector Long Island Sound

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16600/05-068
December 19, 2005

Broadwater Energy
Attn: Mr. Stephen Marr, Permit Application Manager
777 Walker Street, 22nd Floor
Houston, TX 77002

Dear Mr. Marr:

The Coast Guard is continuing our assessment of the potential waterway safety and port security assessments for the liquified natural gas (LNG) floating, storage, regasification, and storage (FSRU) unit Broadwater has proposed to construct and operate on Long Island Sound. Insofar as the location of shore side support facility has implications for waterway safety and port security, as well as for consequence management, it is necessary to know the potential locations of the FSRU's shore side support facility in order to ensure these assessments are as complete as possible.

Information regarding the potential shore side support facility that is required includes:

1. Will there be a single facility or multiple facilities? Please identify the potential location or locations of the facility or facilities.
2. Will Broadwater be the sole operator of the shore side support facility or will it be shared with other operators? If the facility will be shared, please describe the nature of that operation.
3. Please describe the operational and logistics functions that the shore side support facility would provide, including the communication and coordination capabilities that could be used to support response operations in the event of either a safety or security incident on board the FSRU. In addition, please describe any capabilities the shore side support facility may have to remotely monitor and control vital systems on the FSRU in the event the FSRU's control room cannot be occupied or the FSRU is evacuated. If you do not intend to provide the shore side support facility with these capabilities, please describe the basis for this decision.

This information is required for both the safety and the security assessment. Therefore, please provide your response in two parts: the first should contain information that can be released to the public; the second should contain information that is considered sensitive security information in accordance with 49 C.F.R. part 1520.

Please contact Lieutenant Commander Alan Blume, Chief of the Prevention Department, at the above number if you have questions.

Sincerely,

PETER J. BOYNTON
Captain, U.S. Coast Guard
Captain of the Port, Long Island Sound

Copy: Mr. James Martin, Federal Energy Regulatory Commission
Docket USCG-2005-21863

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

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16600/06-072
December 21, 2005

Broadwater Energy
Attn: Mr. Stephen Marr, Permit Application Manager
777 Walker Street, 22nd Floor
Houston, TX 77002

Dear Mr. Marr:

The Coast Guard has reviewed the report prepared by Det Norske Veritas (DNV) that was submitted on behalf of Broadwater Energy on November 18, 2005. This report, which is marked as containing sensitive security information, was provided in response to question 16 in our letter of October 5, 2005 that required Broadwater "to conduct modeling specific to the site, the proposed FSRU (floating, storage and regasification unit) as well as the future generation of LNG carriers and provide the analysis and the following results…" Based on our review, we have determined that the DNV report does not sufficiently validate the applicability of the Sandia National Laboratories Report SAND2004-6258 (Sandia Report) to the FSRU or to the future generation of LNG carriers.

The following issues must be addressed in order for the Coast Guard to make an evaluation whether the Sandia Report is applicable to the site, the FSRU and the future generation of LNG carriers:

1. Although its is understood that the structural design of an LNG carrier and the FSRU will be similar, insufficient information was provided in the DNV report to assess whether the breach sizes that were determined as part of the Sandia Laboratory's study can be used as inputs for the modeling required by our letter of October 5, 2005. Therefore, Broadwater must provide a qualitative comparison of the thickness and material strength of the outer and inner hull plating as well as the horizontal distance between the outer and inner hulls that was used for the Sandia Report and for both the FSRU and LNG carriers with a capacity of 250,000 m^3. Please reference the applicable ABS Rules used to determine the dimensions and materials for the FSRU. You may reference the appropriate rules of any member of the International Association of Classification Societies for the 250,000 m^3 LNG carriers.

2. The Sandia Report is based on spill volumes of approximately 12,500 m^3 of liquefied natural gas (LNG), which is approximately half of the contents of the cargo tanks on LNG carriers currently in service. This is not consistent with information regarding the capacity of the FSRU's LNG storage tanks provided by Broadwater Energy in the draft of Resource Report 13 that was submitted to the Federal Energy Regulatory Commission (FERC) in September 2005. It is also not consistent with the LNG storage tank capacity information provided in the DNV report. In addition, the DNV report does not establish whether the 15 meter initial height of the LNG above the breach that was used in the Sandia Report is appropriate for the FSRU or future generations of LNG carriers. Similarly, it does not establish the relationship between the dimensions of the LNG cargo tanks used for the Sandia Report and the expected dimensions of the LNG storage tanks on the FSRU or cargo tanks on future generation LNG carriers. As is apparent based on an examination of the equations in Appendix D of the Sandia Report, this information is a

required input for calculating factors related to LNG spill volumes and dispersion. In order to establish that the Sandia Report is applicable to the FSRU and 250,000 m^3 LNG carriers, the modeling required by our letter of October 5, 2005 must be based on the volume of the FSRU's LNG storage tanks as well as the expected volume of cargo tanks on 250,000 m^3 LNG carriers.

3. A critical element of the Sandia Report for assessing potential risks to public safety from LNG spills on water is the guidance related to the hazard zones for accidental and intentional discharges of LNG. The sizes of these hazard zones, which were determined based on thermal exposures, are also an important input for assessing the appropriate size of the safety zones that will be established around the FSRU and LNG carrier. Based on the information provided in the DNV Report, it is not possible to determine whether the sizes of the hazard zones in the Sandia Report are applicable to the FSRU or 250,000 m^3 LNG carriers. Refer to Appendix D of the Sandia Report for the analysis that must be conducted in order to establish whether the sizes of the hazard zones in Sandia Report are applicable to the FSRU or 250,000 m^3 LNG carriers.

4. Although we concur with your assessment that more stable atmospheric conditions do result in larger dispersion distances than unstable conditions, e.g., hurricanes or Northeastern gales, it is noted that the dispersion modeling was conducted using atmospheric data for Baltimore, Maryland. This is not acceptable. As stated in our letter of October 5, 2005, the vapor cloud dispersion modeling should be based on "site specific, seasonal environmental and weather factors..." Therefore, you must conduct this modeling using atmospheric data for central Long Island Sound.

This information is required as an input for both the safety and security assessment. Therefore, please provide your response in two parts: the first should contain information that can be released to the public; the second should contain information that is considered sensitive security information in accordance with 49 Code of Federal Regulations (CFR)., Part 1520. Be aware that much of the information in the DNV report does not appear to meet the definition of sensitive security information in 49 CFR § 1520.5. Therefore, Broadwater in coordination with DNV should review the report and remark it appropriately. A copy of the remarked report should be submitted.

Please contact Lieutenant Commander Alan Blume, Chief of the Prevention Department, at the above number if you have any questions regarding the requirements in this letter.

Sincerely,

PETER J. BOYNTON
Captain, U.S. Coast Guard
Captain of the Port, Long Island Sound

Copy: Mr. James Martin, Federal Energy Regulatory Commission
Docket USCG-2005-21863

LeBoeuf, Lamb, Greene & MacRae LLP

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BEIJING

January 25, 2006

SENSITIVE SECURITY INFORMATION HAS BEEN REMOVED FROM THE ATTACHMENT

VIA FEDERAL EXPRESS

Peter J. Boynton
Captain of the Port, Long Island Sound
United States Coast Guard
120 Woodward Avenue
New Haven, Connecticut 06512

RE: Broadwater Energy: USCG Docket USCG-2005-21863
FERC Docket PF05-4-000

Dear Captain Boynton:

Broadwater Energy (Broadwater) received your request, dated December 19, 2005, for additional information related to the shore side support facilities associated with the Broadwater project, to be located within Long Island Sound. It is our understanding that this information is needed to allow the U.S. Coast Guard to complete its assessment of the potential risks to waterway safety and port security associated with the project.

Responses to the majority of the questions outlined in your December 19th request are enclosed in the Attachment.

It should be noted that the response to Question B.2.3. contains Sensitive Security Information (SSI) as defined within 49 C.F.R. §1520 and NVIC 9-02. This response has been clearly indicated as containing SSI. Disclosure of this SSI material is therefore prohibited to persons without a "need to know." Accordingly, the SSI has been removed from the public version of the Attachment.

If there are any questions or concerns, please have your staff contact Mr. David Thomson of Broadwater at (713) 241-8931.

Respectfully submitted,

Bruce W. Neely
Attorney for Broadwater Energy

cc: Mr. James Martin

SENSITIVE SECURITY INFORMATION HAS BEEN REMOVED

Response of Broadwater Energy to US Coast Guard's December 19, 2005 Request for Information

1. Will there be a single facility or multiple facilities? Please identify the potential location or locations of the facility or facilities.

In addition to the FSRU, Broadwater's operations will require a facility for the transfer of equipment, consumables and personnel between the shore and boats for transport to and from the FSRU. Tugboats are required to assist with the Broadwater operation which will require permanent, sheltered moorings during idle periods. Typically, the marine support function is a contracted for service that includes the tug operation and offshore logistics. Broadwater will confirm the scope of these contract services when tug services are finalized during the FSRU construction period. The marine services contractor will likely perform the following services:

- Provide tug services (purpose-built tugs may be able to deliver normal supplies and equipment to the FSRU, otherwise a supply boat or barge will be required);
- Provide a crew boat for personnel transfers;
- Provide moorings for all marine support craft;
- Arrange for local refueling and minor maintenance of support craft;
- Provide a waterfront area with a lifting capability (i.e. a crane) for equipment and stores transfer; and
- Provide a waterfront area with safe access for personnel transfers.

While the FSRU will retain spares on board, an onshore warehouse will also be required to hold spares, special tools and equipment. Equipment sent to shore for repair would be transferred to appropriate contractor repair facilities. Therefore, onshore workshops are not contemplated. However, the warehouse would most likely be used as a secure holding point for all goods in transit to the FSRU. Ideally, the warehouse would be located at the waterfront but this is not essential and inland storage is also possible.

Broadwater will require office accommodation for the support of the offshore activities. This office will support normal FSRU operations and will also be the onshore Emergency Co-ordination centre. The number of office staff are expected to be less than ten persons. The office and warehouse would preferably be co-located, but this is not essential.

To date, Broadwater has identified two locations on Long Island as having the necessary infrastructure to provide marine access as described above. Port Jefferson and Greenport have historically both supported this type of activity and

SENSITIVE SECURITY INFORMATION HAS BEEN REMOVED

Response of Broadwater Energy to US Coast Guard's December 19, 2005 Request for Information

either location is capable of providing the described FSRU support. From a security perspective, a single location is preferable but the most likely scenario will be a single waterfront location and a separate warehouse/office location, based upon Broadwater's survey of potential sites in the area. As the support services are not required until 2010, Broadwater is currently not in a position to contract services or secure land options.

Further details are provided in the *Onshore Facility Resource Reports* dated January, 2006 filed with the FERC.

2. ***Will Broadwater be the sole operator of the shore side support facility or will it be shared with other operators? If the facility will be shared, please describe the nature of that operation.***

Broadwater and/or the Marine Services contractor are expected to be the sole user of the waterfront facility but if a shared facility is only available, the area used for Broadwater purposes will be securely isolated from other users. For example, although access to the site may be controlled by shared security, Broadwater will ensure dedicated security measures are in place for its own activities. A similar arrangement will apply to the warehouse/office location.

The support craft designated for Broadwater will be for the sole use of the facility. However, Broadwater's management may, at its discretion, allow the support craft to perform other activities when appropriate.

3. ***Please describe the operational and logistics functions that the shore side support facility would provide, including the communication and coordination capability that could be used to support response operations in the event of either a safety or security incident on board the FSRU. In addition, please describe any capabilities the shore side support facilities may have to remotely monitor and control vital systems on the FSRU in the event the FSRU's control room cannot be occupied or the FSRU is evacuated. If you do not intend to provide the shore side support facility with these capabilities, please describe the basis for the decision.***

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The functions of the onshore facilities are as described below:

A. Waterfront Facilities

A.1 Tugs

- Berthing for tug boats.
  - Secure mooring for up to four tugs (30 m long x 10 m beam x 4 m draft). Gated access will be implemented with security controls in place.
  - Electrical supply.
  - Marine communications equipment.
- Routine tug boat maintenance.
  - Small workshop and ready use stores (10 m x 10 m with forklift access).
- Tug boat bunkering
  - Fuel transfer capability from road tanker or bulk storage (typical tug capacity is 100 m^3).
  - Potable fresh water supply.
  - Lubricating oil drum handling.

A.2 Personnel Transfer

- Personnel transfer between shore and crewboat.
  - Waiting room area.
  - Safe boarding access taking into account tidal changes.
- Security control point for FSRU access
  - Gated access.
  - Manned by security staff.
  - Persons on board management control.
  - Security inspection space (overall 10 m x 10 m space requirement).

A.3 Materials Transfer

- Materials including spares, consumables and liquid containers transfer to tug boats, supply boats or barges.
  - Dockside crane capacity capable of transferring 20 ft containers and palletized equipment. Normal lifting capacity 30 tonnes (for 20 ft isotank odorant or ammonia containers).
- Truck access
  - Semi trailer access - normal maximum 20 ft trailers.
  - Drive through system preferred.
- Reception of waste materials.

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Response of Broadwater Energy to US Coast Guard's December 19, 2005 Request for Information

  - Direct transfer to appropriate trucks for skips and drum wastes.
  - Storage at waterfront is not preferred.
- Equipment unloading for onshore repair.
  - Direct transfer to workshop/storage by truck - items typically less than 5 tonnes.
- Security inspection and secure storage of all materials being transferred offshore.
  - Security inspection of all materials being brought on to site.

B. Other Facilities Which May Be Located at the Waterfront

Other potential facilities requirements, which may potentially be sited at the waterfront, are the following:

B.1 Warehousing

- FSRU spare gear, specialist tools and equipment storage and handling facilities.
- Tug boat spare gear storage.

B.2 Offices

B.2.1 FSRU Support Activities

- Office accommodation for Operations Manager, Engineering Manager, HSE Manager, Logistics Manager, Scheduler and administrative staff.
- Conference room.
- Training room (predominantly used for HSE induction training).

B.2.2 Communications Center

The shore side support facilities will include voice and data communication capabilities, linking to the FSRU equipment detailed in Resource Report 13, Appendix 13.10. Data transfer may include real time monitoring of the FSRU systems but remote operation of the facility is not proposed.

The main components of the communications system located onshore will comprise:

- Radio and telephone links to the FSRU;
- Direct link telecommunications with U.S. Coast Guard and Emergency Services;

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Response of Broadwater Energy to US Coast Guard's December 19, 2005 Request for Information

- VHF radio for contact with support vessels;
- Access to satellite phone links for contact with support vessels and LNG carriers;
- Data link with desktop applications and data transfer including, Information Management systems, Training systems, Integrated Business Management system, Maintenance Management system and a Hydrocarbon Accounting system;
- Videoconference capabilities; and
- Manpower tracking system to identify all personnel in transit to, from or onboard the FSRU.

Reliable communications between the shore and FSRU are essential and redundant systems will be incorporated within the design to achieve the required level of service.

SENSITIVE SECURITY INFORMATION BEGINS

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February 17, 2006

Captain Peter J. Boynton
Captain of the Port, Long Island Sound
120 Woodward Avenue
New Haven, Connecticut 06512

Re: Broadwater Energy LLC Docket USC6-2005-21865

Dear Captain Boynton:

Broadwater Energy LLC (Broadwater) hereby encloses a report prepared by Det Norske Veritas (DNV), dated February 13, 2006, in response to your letter dated December 21, 2005. A copy of your letter is included in the subject report.

The DNV report addresses the four questions in your letter, regarding:

(1) A comparison between the assumptions in the Sandia National Laboratory Report SAND2004-6258 (Sandia Report) and for the Broadwater FSRU and LNG carriers of a potential capacity of up to 250,000 m^3;
(2) A comparison of the potential spill volumes for the Broadwater FSRU and LNG carriers of a potential capacity up to 250,000 m^3 with the assumptions contained in the Sandia Report;
(3) An assessment of vapor dispersion results using the spill volumes in Question (2) with those of the Sandia Report; and
(4) A summary of historical atmospheric conditions for the Long Island Sound region.

Broadwater also is in receipt of your letter dated February 16, 2006 to the Federal Energy Regulatory Commission (FERC) requesting additional information with respect to Resource Report 13 in Broadwater's January 30, 2006 FERC filing in Docket No. CP06-54-000. The DNV report above addresses the vapor dispersion issue, which is typically the condition that generates the largest hazard zones. Another item mentioned in your February 16 letter to FERC is a thermal radiation analysis for accidental and intentional breaches of the cargo tanks. To facilitate the Coast Guard's review of Broadwater's application, Broadwater will provide the thermal radiation analysis at the earliest opportunity.

If there are any questions concerning the above provided above or in the attached report, please contact Mr. David Thomson of Broadwater at 713-241-8971.

Sincerely,

Bruce W. Neely
Attorney for Broadwater Energy LLC

cc: Lieutenant Commander Alan Blume
Chief of the Prevention Department, Long Island Sound

James Martin
Federal Energy Regulatory Commission

Ms. Magalie R. Salas
Federal Energy Regulatory Commission

Cooperating Agencies

DNV CONSULTING

Broadwater LNG: Response to U.S. Coast Guard Letter Dated December 21, 2005:

Report for TransCanada PipeLines Limited
Report no.: 70014347
Rev 1, 13 February 2006

MANAGING RISK DNV

Broadwater LNG: Response to U.S. Coast Guard Letter Dated December 21, 2005

for

TransCanada PipeLines Limited
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Client ref:

Report No.: 70014347

Subject Group:

Indexing terms:

Summary: The objective of this report is to provide comprehensive answers to the four US Coast Guard queries outlined in their letter (ref. 02) dated December 21, 2005. Broadwater Energy will review the DNV report and may mark certain information as Sensitive Security Information (SSI) in accordance with 49 Code of Federal Regulations (CFR), Part 1520.

	Name and position	Signature
Prepared by:	Goran Andreassen, Senior Consultant	
	Madeline Brien, Senior Consultant	
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	Susan Norman, Administrative Assistant	
Approved by:	Ernst A. Meyer, Principal Consultant	

Date of issue: 13 February 2006

Project No: 70014347

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Contents:

1.0 Introduction

As part of the permitting process for Broadwater Energy's (henceforth, Broadwater) proposed Floating Production, Storage and Regasification Unit (FSRU) in Long Island Sound, the United States Coast Guard (henceforth, USCG) issued a letter in October 2005 (ref.07) containing queries directed at Broadwater. In response, Broadwater requested that Det Norske Veritas (USA), Inc. (henceforth, DNV) respond to the USCG based on DNV's risk analysis experience with LNG terminals The DNV response was issued in a report, "Broadwater LNG – U.S. Coast Guard Queries," dated November 16, 2005 (ref.01).

The USCG then issued a subsequent letter to Broadwater Energy (ref.02) outlining queries concerning the DNV report. The letter is attached to this report as Appendix I and the queries are summarized at the beginning of each section in this report.

The USCG stated that the issues outlined in their letter need to be addressed "in order for the Coast Guard to make an evaluation whether the Sandia Report is applicable to the site, the FSRU and the future generation of LNG carriers." Broadwater has requested that DNV issue this report in response to the USCG letter.

2.0 Objective

The objective of this report is to provide comprehensive answers to the four USCG queries outlined in their letter (ref. 02) dated December 21, 2005. Broadwater Energy will review the DNV report and may mark certain information as Sensitive Security Information (SSI) in accordance with 49 Code of Federal Regulations (CFR), Part 1520.

3.0 Query 1

3.1 Summary of Query

DNV has been requested to provide a qualitative comparison of the thickness and material strength of the outer and inner hull plating as well as the horizontal distance between the outer and inner hulls that was used for the Sandia Report versus the future generation of LNG carriers and FSRU. The future generation of LNG carriers to consider will have a capacity of up to approximately 250,000 m^3 and the FSRU will have a capacity of 350,000 m^3. This will form the basis to evaluate whether the breach sizes that were determined as part of the Sandia Report can be applied to the FSRU and the future generation of LNG carriers.

3.2 Response to Query

DNV Maritime was contracted to perform a study to respond to Query 1. DNV Maritime is one of the world's leading classification societies, and has worked to improve safety at sea since 1864.

The study was sub-divided into two tasks:

1. Qualitative comparison of particulars for different sized LNG carriers and the FSRU.
2. Collision vulnerability analysis, to determine side impact energies that can be absorbed for different sized LNG carriers and the FSRU before deformation of the tank shell is initiated.

DNV Maritime reviewed data on LNG carriers that they have available through previous project work in order to find vessels that are representative of the current standard for LNG carriers and the future generation of LNG carriers. Membrane carriers with 145,700 m^3 and 216,000 m^3 capacity, the FSRU with 360,000 m^3 capacity, and spherical carriers with 125,000 m^3 and 235,000 m^3 capacity are examined in this study. The drawings used by DNV Maritime are proprietary information belonging to the ship owner and cannot be made public. At the time of this study, the specific design for the Broadwater LNG carriers had not been determined; however, preliminary drawings for the FSRU were available. The project requested that DNV assume an LNG carrier capacity of 250,000 m^3. The following analysis is based on this information. Even if the final design varies in capacity, it is expected that the FSRU and future LNG carriers delivering LNG to the FSRU will have hull spacing and material thickness similar to the future generation of LNG carriers examined in this study.

3.2.1 Qualitative Comparison of Different Sized LNG Carriers

The FSRU and four different LNG carrier designs were evaluated and the general conclusion is that larger "future generation" vessels have thicker inner and outer hull plate thickness and a larger horizontal distance between the outer and inner hulls compared to smaller LNG carriers currently in service. Table 3-1 presents the particulars for the FSRU and four LNG carrier designs. The designs are further categorized by hull type (membrane carriers and spherical carriers).

Table 3-1 Vessel Design Particulars

	Membrane Carrier			Spherical Carrier	
LNG Carrier Capacity [m3]	**145700**	**216000**	**(FSRU) 350000**	**125000**	**235000**
L - length bp [m]	277.2	303.0	366	282.0	328.5
B - breadth [m]	43.4	50.0	60	41.6	55.0
D - depth moulded [m]	26.0	27.0	27	25.0	32.5
Dt- depth trunk [m]	33.7	35.1	37.14	-	-
Top of tank abv B.L. [m]	31.0	33.2	34.40	37.7	49.0
T - draft moulded [m]	12.3	12.5	12.3	11.5	12.5
Cb - Block coef	0.8	0.8	.96	0.7	0.8
Displacement [tonnes]	116941	151599	266048	99130	178247
Double bottom height [m]	3.2	3.4	3.5	1.4	1.6
Double side width [m]	2.2	2.6	4.8	2.4	3.0
Outer side plate thickness [mm]	17-18	16-21	15.5-21	19	18-20
Inner side plate thickness [mm]	14-18	18-19	15.5	14-18	14.5-16.5
Transverse frame space [mm]	2800	4105	4240	4180	4130
Cargo Tank dimensions					
L - length [m]	47.6	41.0	33.9	-	-
H - Height [m]	27.7	29.8	30.9	-	-
B - Breadth [m]	39.0	44.8	50.2	-	-
Tank diameter [m]	-	-	-	35	46
Approx. Volume of tank [m3]	43504	48174	44,850	22449	50965

As shown in Table 3-1, a 145,700 m^3 membrane carrier is expected to have a distance between the inner and outer hull (i.e., double side width) of 2.2 m while the 216,000 m^3 membrane carrier has a distance between the hulls of 2.6 m. The proposed 250000 m^3 membrane carrier is expected to have a double side width between that of the 216,000 m^3 carrier and the FSRU. The plate thickness and distance between the hulls are critical factors in determining the vulnerability (i.e., how likely there is a breach). This is further discussed in the following section.

3.2.2 Collision Vulnerability Analysis

A collision vulnerability analysis was performed to determine side impact energies that can be absorbed by different sized LNG carriers and the FSRU before deformation of the tank shell is initiated. The higher the impact energy that is required before deformation occurs, the less vulnerable the specific LNG carrier design is to collisions (Table 3-2).

The purpose of the analysis is to evaluate collision vulnerabilities for different sized LNG carriers and the FSRU. The results should not be used as absolute values. The impact energies should be viewed in context for comparison purposes only. The assumptions for these calculations are as follows:

- The bow of the striking ship is taken as infinitely stiff, i.e. no energy is absorbed in the bow (very conservative).
- The LNG carriers are considered in a "free float" condition with zero speed being hit by the striking ship in the flotation centre at 90 degrees angle to the side, hence moving sideways in the water with no rotation following the collision (conservative).
- The striking vessel is a 5,000 tonnes typical coastal vessel with a raking bow of 65.6 degrees. The raking bow shape is rather conservative, but the striking vessel itself should be representative for traffic in coastal waters. The speed of the striking vessel is based on engineering judgment and on average transiting speeds within coastal waters.

Using the assumptions above, the amount of energy the outer and inner hull could absorb before there was contact with the LNG tank was calculated as a function of striking ship energy and the displacement of both the striking ship and LNG vessel. The calculations were carried out with DAMAGE 5.0 computer code (ref. 08), which is widely used in the maritime industry.

Table 3-2 Collision Vulnerability Analysis

	Membrane Carrier			**Spherical Carrier**	
LNG Carrier Capacity [m3]	**145700**	**216000**	**FSRU 350000**	**125000**	**235000**
Striking ship					
Displacement [tons]	5000	5000	5000	5000	5000
Striking speed [Knots]	**3.48**	**4.83**	**8.62**	**5.75**	**8.47**
Striking speed [m/s]	1.79	2.48	4.43	2.96	4.35
Striking Energy [MJ]	8.8	17.0	54.1	24.1	52.2
Struck ship (LNG Carrier)					
Speed struck ship [Knots]	0.0	0.0	0	0.0	0.0
Speed struck ship [m/s]	0.0	0.0	0	0.0	0.0
Absorbed Collision Energy [MJ] before inner hull contact	**8.3**	**16.2**	**52.6**	**12.6**	**26.0**
Absorbed Collision Energy [MJ] before tank contact	**8.3**	**16.2**	**52.6**	**22.3**	**50.0**

Two critical indentation or deformation situations are shown:

- Inner hull contact: The stiff bow touches the inner hull. For membrane systems, deformation of the insulation system will then start with potential damage to the insulation system and ultimately causing LNG spill.

- LNG cargo tank contact: The spherical system is an independent system with a distance from the inner hull to the tank shell at equator of about 0.9 m. This allows for an additional 0.9 m of indentation before deformation of the tank shell is initiated.

Based on the above, the "critical" indentations are where the deformations of the tank system are initiated. Hence, the LNG cargo tank contact values should be used as the basis for comparisons.

From the results, it is clear that the larger carriers absorb approximately twice the collision energy compared to smaller carriers. A larger membrane carrier is able to absorb 16.2 MJ while the smaller membrane carrier can only absorb 8.3 MJ. The FSRU can absorb approximately 52.6 MJ. Collision energy can be directly related to breach sizes of carriers. Thus the more energy a carrier is able to absorb, the smaller the breach size.

The USCG requested that DNV perform a qualitative analysis, thus the numbers presented in this report should not be used as absolute values but should be used for comparison purposes.

Based on the above discussion it can be concluded that large LNG carriers in the 200,000 m^3 to 250,000 m^3 range and the FSRU at 350,000 m^3 will generally be less vulnerable to side impact collisions compared to smaller LNG carriers (capacities of 125,000 to 150,000 m^3).

Smaller LNG carriers (currently in service) are hence expected to experience larger breach sizes than larger (future generations of) LNG carriers given the same impact energies. The Sandia Report breach sizes are based on smaller LNG carriers and are therefore conservatively (based on equal impact energies) applicable to the proposed Broadwater FSRU and LNG carriers.

4.0 Query 2

4.1 Summary of Query 2

The results from the Sandia Report are based on spill volumes of approximately 12,500 m^3 from a cargo tank with a volume of 25,000 m^3 and an initial liquid height in the cargo tank above the breach of 15 m. The above cargo tank volume reflects an LNG carrier capacity of 100,000 to 125,000 m^3 depending on the number of cargo tanks. Further comparisons must be made to decide credible spill volumes and initial liquid heights above the breach for larger cargo tanks relevant for the FSRU and future LNG carriers.

4.2 Response to Query 2

The following section discusses the basis for the DNV consequence modeling which includes cargo tank volumes, liquid height in the cargo tank, and carrier size.

The DNV consequence modeling is based on site specific information while the Sandia study is based on generic data. The release rate is largely dependent on the amount of LNG head above the breach. A breach in both the FSRU and LNG carrier has been assumed to occur just above the water line. This assumption results in the largest LNG head and release volume and consequently the most conservative results. A simplification of the LNG head in a tank is illustrated in Figure 4-1.

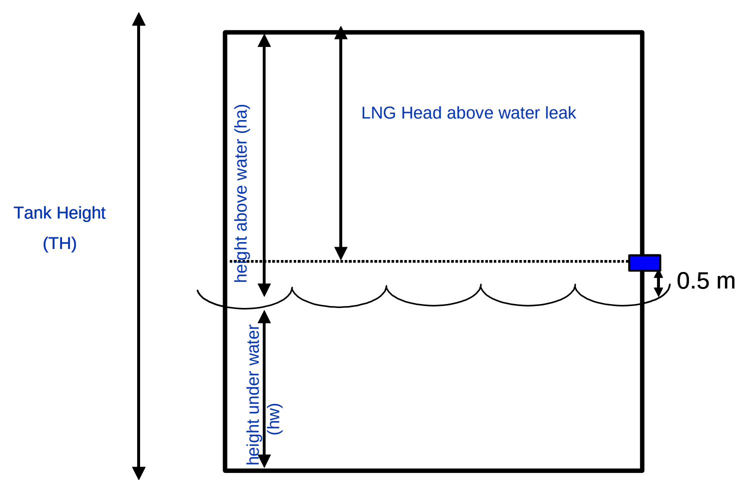

Figure 4-1 LNG Head above Water Leak

The Broadwater project is currently considering an FSRU with eight tanks that each hold a volume of approximately 45,000 m^3 of LNG. The LNG carriers that unload at the Broadwater facility may vary in size. This study attempted to be conservative in its assumptions; therefore, one of the largest sized carriers was chosen as a base case (250,000 m^3 carrier with six storage tanks). The tank volumes, release volumes and LNG head that have been used as the basis for the Broadwater site specific evaluations are presented in Table 4-1, together with the data use in the Sandia Report.

Table 4-1 Consequence Modeling Input

Consequence Input	Sandia	Broadwater FSRU	Broadwater LNG Carrier
Tank Volume (m^3)	25, 000	44, 850	42, 000
Release Volume (m^3) (above water release)	12, 500	35, 560	27, 300
LNG Head (m)	15	21	20.3
Draft (fully loaded) (m)	Not Specified	12.3	12

In order to be conservative on the amount of tank volume released, it was assumed that the FSRU tanks are 98% full and that the LNG carrier tanks are 95% full (this will be the case upon arrival of the carrier) during a release.

As can be seen from Table 4-1, Sandia assumed that 50% of the tank volume would be released. DNV calculated the release volume based on the amount of draft when the vessel is fully loaded and the LNG head above the release. This resulted in a larger release volume than assuming a uniform 50% of the volume is released.

There is uncertainty within the industry on determining total release volume for a large LNG leak. This is due to a number of phenomenon that are difficult to determine for such large scale leaks such as, possible water ingress into the tank, LNG or water ingress into the space between the inner and out hulls, cryogenic effects on the tanker hull, etc. The DNV site specific release volumes are larger than Sandia's since the Broadwater LNG tanks are larger than the tanks considered by Sandia.

Due to the increased tank size there is a larger LNG head which will result in a larger release rate and larger dispersion distances (dispersion cloud lengths are discussed in Section 5.2.3). It is possible that the future generation of larger carriers will be able to withstand a greater impact than existing carriers which could result in smaller hole sizes. If the FSRU or the Broadwater LNG carriers were exposed to the same impact energies as used in Sandia, then the hole size is expected to be smaller since the larger vessels are able to withstand a larger impact energy.

5.0 Query 3

5.1 Summary of Query 3

Sandia provides guidance for assessing hazard zones for accidental and intentional discharges of LNG. The size of the hazard zones are used as input to determine safety zones for the FSRU and LNG carriers. The USCG requests that this report provide a conclusive analysis on whether the Sandia hazard zones are applicable to the Broadwater FSRU and LNG carriers based on the Sandia methodology as presented in Appendix D of the Sandia Report.

5.2 Response to Query 3

The size of the hazard zones as described in the Sandia Report is a function of hole size, LNG head above the breach, release rate, volume released and weather conditions.

5.2.1 Hole Sizes

DNV and Sandia have performed extensive project work with LNG, examining possible breach sizes for LNG tanks. DNV issued a paper based on a joint industry project (ref.04) that identified the three most credible hole sizes for an accidental breach in an LNG tank as 250 mm, 750 mm and 1500 mm holes. This conclusion was a judgment-based approach developed by Classification engineers experienced in collision and grounding studies.

Sandia used 1120 mm (1 m^2 hole area) and 1600 mm (2 m^2 hole area) as nominal hole sizes for accidental scenarios. Sandia also focused on intentional acts where it is believed the hole sizes (diameters) can be larger. Sandia concluded that the nominal credible hole diameter for intentional acts is 2523 mm (5 m^2 hole area), as discussed in Chapter 5 of the Sandia report (ref. 03). Based on the findings in Section 3.2 (and the assumption that a given intentional act would apply the same impact energy to a larger carrier as it would to a small carrier), then the Sandia hole sizes can be considered a conservative assumption and are thus applied in this Broadwater study.

DNV has run dispersion modeling for the three Sandia hole sizes (diameters) combined with Broadwater project specific information, as presented in Table 4-1, in order to determine if the Sandia hazard zones are applicable to Broadwater.

5.2.2 Consequence Modeling Basis

For most credible scenarios (accidental or intentional), the thermal hazards from a spill are expected to manifest as a pool fire, based on the high probability that an ignition source will be available. In some instances, an immediate ignition source might not be available and the spilled LNG could therefore disperse as a vapor cloud. In congested or highly populated areas, an ignition source would be likely, as opposed to remote areas in which an ignition source might be less likely (ref. 03). The thermal hazard zones from a vapor cloud dispersion with late ignition have the potential of extending significantly longer than the thermal hazard zones from a pool fire. Hence this study focus on thermal hazard zones from vapor clouds with late ignition.

The basis for consequence modeling is presented in Table 4-1 of this report.

5.2.3 Consequence Modeling Results

Table 5-1 presents the results of both Sandia's consequence modeling and DNV's consequence modeling.

Table 5-1 Consequence Modeling Results

	Distance to LFL (m)						
Hole Size (mm)	**Sandia**	**FSRU**			**LNG Carrier**		
	F 2.33 m/s	**F 2 m/s**	**D 3.5 m/s**	**D 7 m/s**	**F 2 m/s**	**D 3.5 m/s**	**D 7 m/s**
1120	1536 m	1870 m	1030 m	1100 m	1890 m	1020 m	1090 m
1600	1710 m	2280 m	1390 m	1570 m	1990 m	1370 m	1560 m
2523	2450 m	3320 m	2050 m	2360 m	3290 m	2030 m	2340 m

Sandia used the Computational Fluid Dynamics (CFD) tool VULCAN to perform their modeling. DNV has used PHAST, a point source similarity model to perform dispersion modeling. Previous examination of both Sandia and DNV results demonstrated that PHAST results are generally more conservative than CFD results (ref 05). A CFD model takes into account topography and obstacles and changes in surface conditions. A similarity model does not take into account effects that will limit dispersion but is widely accepted by regulators and industry stakeholders in documenting industrial hazard zones. A CFD model is extremely detailed in its structure and thus time consuming to set up and requires specific modeling knowledge to provide reliable results. A similarity model is more practical to use and is validated for small scale LNG releases over water. A similarity model has been previously shown, however, to give conservative results for large scale releases, and in particular when dispersion takes place onshore. There is a degree of uncertainty in both the CFD model and PHAST when predicting large size LNG releases in F stability with low wind speeds. To date, there is a lack of large scale experiments with which the models can be calibrated. However, these are the industry's leading tools for dispersion modeling. Thus the results that are predicted by both PHAST and VULCAN can be considered best available knowledge to date.

As can be seen from the table above, the category F 2 m/s weather conditions result in a greater hazard distance than the Sandia results. This can be attributed to the larger volumes and higher LNG head used in the Broadwater modeling. Also the conservatism that is intrinsic to the PHAST model increases with the size of release because there are fewer field tests with which to calibrate the model.

The largest dispersion release from the FSRU has been calculated to extend 3320 m (2 miles) while the closest land is approximately 14,500 m, or 9 miles. The largest dispersion cloud for the LNG carrier is calculated to be 3290 m (2 miles) and the closest passage of the LNG carrier to land is at the race where the carrier will be approximately within 1610 m (1mile) from shore.

The most frequently occurring weather condition in the sound is D stability which occurs approximately 49% of the time (whereas F stability only occurs 15% of the time). The site specific weather conditions are discussed in further detail in Section 6.2.

As part of planned operations, LNG carriers may transit the Sound at night time when marine traffic is at a minimum.. F stability occurs only at night and accounts for approximately 30% of the night weather conditions. D stability accounts for 46% of the night weather conditions and D stability consequence results are in the same order of magnitude as the Sandia results.

It can be concluded that when establishing the hazard zones for Broadwater, the F stability results will provide the most conservative result. However, the results for D stability are the most probable results.

6.0 Query 4

6.1 Summary of USCG Query

The dispersion modeling performed and documented in the DNV Report of November 16, 2005, applies atmospheric data for Baltimore, Maryland, because of the lack of site specific atmospheric data. The USCG letter of December 21, 2005, states that it is not acceptable and that “the vapor cloud dispersion modeling should be based on site specific, seasonal environmental and weather factors…” for Long Island Sound.

6.2 Response to Query 4

DNV has acquired site specific weather data from the National Climatic Data Center (NCDC). The closest weather data station to the proposed FSRU and LNG Carrier Route locations that provides stability class information was the New Haven, Connecticut airport. New Haven is marked by a red “X” in Figure 6-1 and an approximation of the proposed LNG carrier route and FSRU location are drawn as black lines.

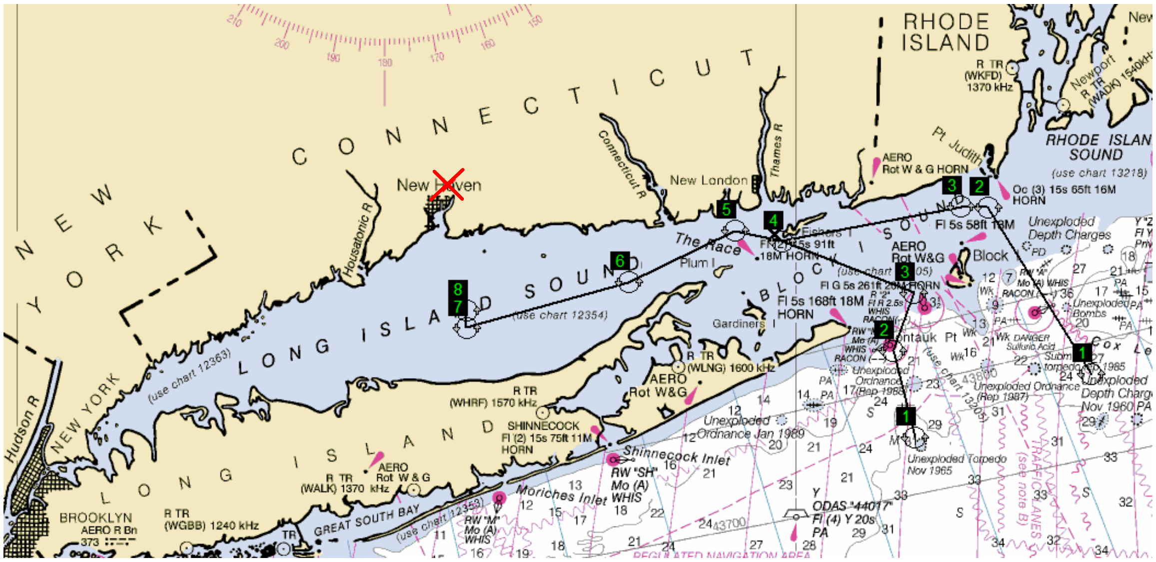

Figure 6-1 Location of NCDC nearest to LNG Carrier Route and FSRU

DNV received weather data over a ten-year time span, from 1995-2004 from NCDC.

6.2.1 Characteristics of Meteorological Data

The atmospheric stability is important to dispersion as it defines the amount of turbulent mixing that takes place. The six most common stability classes are given in Table 6-1.

MANAGING RISK DNV

Table 6-1 Atmospheric Stability

Stability Class	Description
A	Very Unstable – Sunny light winds
B	Moderately Unstable – Less sunny and more winds than A
C	Slightly Unstable – very windy/sunny or overcast/light wind
D	Neutral – little sun and high wind or overcast/windy night
E	Slightly Stable – less overcast and less windy than D
F	Stable – night with moderate clouds and light/moderate winds

Stability class F is the most conservative of the atmospheric conditions since there is limited mixing of the released gas with air under stable conditions. In Long Island Sound, the dominant atmospheric behaviors consist of "neutral" stabilities 70% of the time; there is very little "unstable" atmospheric condition.

The annual average data for 1994 to 2004 was used in this study. The data for an average day in the Long Island Sound is given in Table 6-2.

Table 6-2 Wind Rose Data

Direction	Stability Class and Wind Speed (% time of 1 day)						
	Day			Night			
	B 2.8 m/s	C/D 3.7 m/s	D 7.2 m/s	D 3.5 m/s	D 7.2 m/s	E 3.8 m/s	F 2 m/s
N	0.33%	3.80%	2.05%	2.24%	1.75%	1.65%	2.63%
NNE	0.19%	2.92%	0.93%	1.71%	0.44%	0.58%	1.02%
NE	0.16%	1.96%	0.41%	1.18%	0.23%	0.31%	0.52%
ENE	0.07%	1.06%	0.24%	0.74%	0.14%	0.19%	0.28%
E	0.12%	1.55%	0.43%	1.12%	0.28%	0.28%	0.40%
ESE	0.20%	1.33%	0.40%	0.65%	0.09%	0.20%	0.31%
SE	0.20%	1.55%	0.39%	0.60%	0.10%	0.19%	0.31%
SSE	0.39%	1.36%	0.19%	0.48%	0.08%	0.28%	0.46%
S	0.96%	3.82%	0.57%	1.17%	0.22%	0.80%	1.40%
SSW	0.72%	2.65%	0.71%	0.75%	0.29%	0.55%	1.02%
SW	0.39%	2.69%	1.24%	0.72%	0.48%	0.83%	0.63%
WSW	0.46%	3.04%	1.20%	0.80%	0.32%	0.89%	0.56%
W	0.29%	1.50%	0.54%	0.59%	0.45%	0.98%	0.99%
WNW	0.22%	1.60%	0.99%	0.53%	0.59%	0.83%	0.90%
NW	0.13%	1.89%	1.84%	0.74%	0.77%	1.17%	1.57%
NNW	0.11%	1.50%	1.59%	0.65%	0.84%	1.03%	1.60%
SUM	**5%**	**34%**	**14%**	**15%**	**7 %**	**10.5%**	**14.5%**

As can be seen from Table 6-2, stability class D is predominant in the Long Island Sound. From the data in Table 6-2, the three most common combinations of wind speed and stability class were determined. These three representative weather conditions for the Broadwater study are presented in Table 6-3.

Table 6-3 Representative Weather Conditions

Stability Class	Average Wind Speed	Percent of Day
F	2 m/s	15%
D	3.5 m/s	49%
D	7 m/s	21%

Other meteorological conditions include the following assumptions:

- Relative Humidity – 70% (recommended for releases over open water)
- Temperature – 20 C
- Surface Roughness Length – 0.3 mm (roughness length of open sea)

Sandia (ref. 03) presented results based on a stability class and wind speed of F 2.33 m/s. The DNV results for F 2/ms can be used for comparison purposes. It should be noted that the Sandia results represent smaller LNG tank sizes than the proposed Broadwater tank sizes. Also, the more likely scenario will be category D stability in Long Island Sound.

The dispersion distance results are presented in **Table 5-1** of this report.

7.0 Conclusions

By evaluating design data from different sized LNG carriers, it is clear that larger future generation LNG carriers and the FSRU have thicker inner and outer hull plate thickness and a larger horizontal distance between the outer and inner hulls compared to smaller LNG carriers currently in service.

Collision vulnerability analysis was performed for different LNG carrier design and sizes. The analysis indicates that the larger LNG carriers and FSRU are less vulnerable to collision damage than smaller sized LNG carriers. Hence, the smaller LNG carriers are expected to experience larger breach sizes than larger LNG carriers if they are exposed to the same impact energy. The Sandia breach sizes are based on smaller sized LNG carriers (capacity of 125,000 m^3) and are therefore conservatively (given the same impact energy) assumed to be applicable for larger sized LNG Carriers and the FSRU.

Both DNV and Sandia recommend a risk based approach which includes consequence calculations along with frequency estimates to determine overall risk for specific scenarios. This report only presents consequence evaluations.

A risk assessment combines factors such as initiating event frequency, probability of a given wind direction, probability of a given weather stability, etc to determine the likelihood of a defined consequence. The hazard zones presented in this report are based on the hole sizes that Sandia concludes are representative for intentional acts combined with site specific weather data and worst case spill volumes for future generations of LNG carriers and the FSRU. Frequencies for the various scenarios have not been addressed in this study.

It can be concluded that the Broadwater site specific consequence zones are larger than the Sandia hazard zones under worst case stability class F conditions. This is expected since the Broadwater FSRU and LNG carrier tank sizes and LNG head are larger than the Sandia LNG tank size and LNG head. However, F stability occurs only at night and accounts for approximately 30% of the night weather conditions and 15% of an average twenty-four hour day. If the most probable weather stability for Broadwater, stability class D, is considered then the Sandia hazard zones can be directly applied to the Broadwater facility.

8.0 References

01 DNV Report, "Broadwater LNG – US Coast Guard Queries," report no. 70012855, rev. 2 November 16, 2005. Report contains Sensitive Security Information

02 U.S. Coast Guard letter to Broadwater Energy, dated December 21, 2005, no. 16600/06-072, written by Peter J. Boynton of the U.S. Coast Guard.

03 "Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water," Sandia Report SAND2004-6258, Sandia National Laboratories, December 2004.

04 "LNG Decision Making Approaches Compared," paper prepared by DNV- Pitblado, Robin; Baik, John; Raghunathan, Vijay. Presented at Mary Kay O'Connor Process Safety Symposium 2004

05 "Consequence Modeling of LNG Marine Incidents," paper prepared by Baik, John; Raghunathan, Vijay; Witlox, Henk presented at American Society of Safety Engineers conference, March 2005

06 DNV Report "Long Island Sound LNG FSRU: Public Safety Assessment," report no. 70004605, dated April 30, 2004.

07 U.S. Coast Guard letter to Broadwater Energy, dated October 5, 2005.

08 DAMAGE 5.0 computer code developed for "Joint M.I.T. Industry Project on Tanker Safety," developed by Wlodek Abramowicz, Bo Cerup Simonsen, Tomas Wierzbicki and Monique V. Sinamo.

Appendix I – US Coast Guard Letter to Broadwater Energy

U.S. Department of Homeland Security

United States Coast Guard

Commander
U.S. Coast Guard
Sector Long Island Sound

120 Woodward Ave.
New Haven, CT 06512
Staff Symbol: Prevention
Phone: (203) 468-4504
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Email: ablume@sectorlis.uscg.mil

16600/06-072
December 21, 2005

Broadwater Energy
Attn: Mr. Stephen Marr, Permit Application Manager
777 Walker Street, 22nd Floor
Houston, TX 77002

Dear Mr. Marr:

The Coast Guard has reviewed the report prepared by Det Norske Veritas (DNV) that was submitted on behalf of Broadwater Energy on November 18, 2005. This report, which is marked as containing sensitive security information, was provided in response to question 16 in our letter of October 5, 2005 that required Broadwater "to conduct modeling specific to the site, the proposed FSRU (floating, storage and regasification unit) as well as the future generation of LNG carriers and provide the analysis and the following results..." Based on our review, we have determined that the DNV report does not sufficiently validate the applicability of the Sandia National Laboratories Report SAND2004-6258 (Sandia Report) to the FSRU or to the future generation of LNG carriers.

The following issues must be addressed in order for the Coast Guard to make an evaluation whether the Sandia Report is applicable to the site, the FSRU and the future generation of LNG carriers:

1. Although its is understood that the structural design of an LNG carrier and the FSRU will be similar, insufficient information was provided in the DNV report to assess whether the breach sizes that were determined as part of the Sandia Laboratory's study can be used as inputs for the modeling required by our letter of October 5, 2005. Therefore, Broadwater must provide a qualitative comparison of the thickness and material strength of the outer and inner hull plating as well as the horizontal distance between the outer and inner hulls that was used for the Sandia Report and for both the FSRU and LNG carriers with a capacity of 250,000 m^3. Please reference the applicable ABS Rules used to determine the dimensions and materials for the FSRU. You may reference the appropriate rules of any member of the International Association of Classification Societies for the 250,000 m^3 LNG carriers.

2. The Sandia Report is based on spill volumes of approximately 12,500 m^3 of liquefied natural gas (LNG), which is approximately half of the contents of the cargo tanks on LNG carriers currently in service. This is not consistent with information regarding the capacity of the FSRU's LNG storage tanks provided by Broadwater Energy in the draft of Resource Report 13 that was submitted to the Federal Energy Regulatory Commission (FERC) in September 2005. It is also not consistent with the LNG storage tank capacity information provided in the DNV report. In addition, the DNV report does not establish whether the 15 meter initial height of the LNG above the breach that was used in the Sandia Report is appropriate for the FSRU or future generations of LNG carriers. Similarly, it does not establish the relationship between the dimensions of the LNG cargo tanks used for the Sandia Report and the expected dimensions of the LNG storage tanks on the FSRU or cargo tanks on future generation LNG carriers. As is apparent based on an examination of the equations in Appendix D of the Sandia Report, this information is a

required input for calculating factors related to LNG spill volumes and dispersion. In order to establish that the Sandia Report is applicable to the FSRU and 250,000 m^3 LNG carriers, the modeling required by our letter of October 5, 2005 must be based on the volume of the FSRU's LNG storage tanks as well as the expected volume of cargo tanks on 250,000 m^3 LNG carriers.

3. A critical element of the Sandia Report for assessing potential risks to public safety from LNG spills on water is the guidance related to the hazard zones for accidental and intentional discharges of LNG. The sizes of these hazard zones, which were determined based on thermal exposures, are also an important input for assessing the appropriate size of the safety zones that will be established around the FSRU and LNG carrier. Based on the information provided in the DNV Report, it is not possible to determine whether the sizes of the hazard zones in the Sandia Report are applicable to the FSRU or 250,000 m^3 LNG carriers. Refer to Appendix D of the Sandia Report for the analysis that must be conducted in order to establish whether the sizes of the hazard zones in Sandia Report are applicable to the FSRU or 250,000 m^3 LNG carriers.

4. Although we concur with your assessment that more stable atmospheric conditions do result in larger dispersion distances than unstable conditions, e.g., hurricanes or Northeastern gales, it is noted that the dispersion modeling was conducted using atmospheric data for Baltimore, Maryland. This is not acceptable. As stated in our letter of October 5, 2005, the vapor cloud dispersion modeling should be based on "site specific, seasonal environmental and weather factors..." Therefore, you must conduct this modeling using atmospheric data for central Long Island Sound.

This information is required as an input for both the safety and security assessment. Therefore, please provide your response in two parts: the first should contain information that can be released to the public; the second should contain information that is considered sensitive security information in accordance with 49 Code of Federal Regulations (CFR)., Part 1520. Be aware that much of the information in the DNV report does not appear to meet the definition of sensitive security information in 49 CFR § 1520.5. Therefore, Broadwater in coordination with DNV should review the report and remark it appropriately. A copy of the remarked report should be submitted.

Please contact Lieutenant Commander Alan Blume, Chief of the Prevention Department, at the above number if you have any questions regarding the requirements in this letter.

Sincerely,

PETER J. BOYNTON
Captain, U.S. Coast Guard
Captain of the Port, Long Island Sound

Copy: Mr. James Martin, Federal Energy Regulatory Commission
Docket USCG-2005-21863

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March 14, 2006

Captain Peter J. Boynton
Captain of the Port, Long Island Sound
120 Woodward Avenue
New Haven, Connecticut 06512

Subject: Broadwater Energy Project:
USCG Docket USCG-2005-21863
FERC Docket CP06-54

Dear Captain Boynton:

Broadwater Energy is in receipt of the U.S. Coast Guard's letter of February 16, 2006 to Mr. Richard R. Hoffman of the Federal Energy Regulatory Commission (FERC) concerning additional information requirements arising from the Coast Guard's review of Broadwater's Resource Report No. 13. The additional information requested falls into two general categories.

The first request was for a description of the process used to determine which code, rule or standard was applied to the design of the FSRU and yoke mooring system when more than one code or standard was applicable. The second request was for thermal radiation and vapor dispersion calculations for LNG spills based on both accidental and intentional breaches of the cargo tanks for the FSRU and for a LNG carrier of a 250,000 m^3 capacity, which corresponds to the largest carrier size contemplated in Broadwater's future operations.

On February 17, 2006, Broadwater filed a report prepared by Det Norske Veritas (DNV) dated February 13, 2006 which addressed most of the questions raised in prior correspondence from the Coast Guard dated December 21, 2005. At that time, Broadwater noted that the thermal modelling results noted in the Coast Guard's February 16th letter were not available and would be provided at the earliest opportunity. This was acknowledged in the Coast Guard's letter of February 21, 2006.

In response to the Coast Guard's February 16, 2006 letter to FERC, Broadwater encloses two reports:

1. A report by Det Norske Veritas dated March 10, 2006, which provides the thermal radiation results for accidental and intentional breaches of the FSRU and LNG carrier cargo tanks.

2. A report summarizing the process used by Broadwater to establish the codes and standards which were applied to the design of the FSRU and yoke mooring system. The precise codes and standards applied to the facility design are documented in Resource Report No. 13. The attached report also provides a discussion of the design of the yoke mooring system relative to the Saffir-Simpson Hurricane Scale.

We trust that these reports provide the information you have requested and will facilitate establishment of the project review schedule by the FERC.

If there are any questions concerning the above or the attached report, please contact Mr. David Thomson of Broadwater at 713-241-8931.

Very truly yours,

Lawrence G. Acker
Brett A. Snyder
Counsel for Broadwater

cc:
Lieutenant Commander Alan Blume
Chief of the Prevention Department, Long Island Sound

James Martin
Federal Regulatory Energy Commission

Ms. Magalie R. Salas
Federal Regulatory Energy Commission

Cooperating Agencies

DNV CONSULTING

Broadwater Fire Modeling:

Report for TransCanada PipeLines Limited
Report no.: 70015341
Rev 1, 10 March 2006

MANAGING RISK

Broadwater Fire Modeling

for

TransCanada PipeLines Limited
450 - 1st Street S.W.
T2P 5H1 Calgary, Alberta
CANADA

DET NORSKE VERITAS (U.S.A.), INC.
DNV Consulting
16340 Park Ten Place
Suite 100
Houston, TX 77084
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Client ref:	Captain David Thomson
Report No.:	70015341
Subject Group:	
Indexing terms:	

Summary: This study will mainly focus on thermal hazard zones from pool fires due to immediate ignition to supplement the previous DNV Report, ref. 03, which focused on the thermal hazard zones from vapor cloud dispersion with late ignition.

	Name and position	Signature
Prepared by:	Goran Andreassen, Senior Consultant	
	Cindy Wei, Consultant	
Verified by:	Madeline Brien, Senior Consultant	
	Susan Norman Administrative Assistant	
Approved by:	Ernst Meyer, Principal Consultant	

Date of issue: 10 March 2006

Project No: 70015341

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Contents:

1.0 Introduction

As part of the permitting process for Broadwater Energy's (henceforth, Broadwater) proposed Floating Production, Storage and Regasification Unit (FSRU) in Long Island Sound, the United States Coast Guard (USCG) in February of 2006 issued a letter (ref.01) requesting thermal radiation analysis for accidental and intentional breaches (as defined by Sandia, ref.02). In response, Broadwater requested that Det Norske Veritas (USA), Inc. (DNV) respond to the USCG based on DNV's risk analysis experience with LNG terminals.

This study will mainly focus on thermal hazard zones from pool fires due to immediate ignition to supplement the previous DNV Report, ref. 03, which focused on the thermal hazard zones from vapor cloud dispersion.

2.0 Objective

The objective of this study is to provide site specific thermal hazard zones resulting from pool fires for the hole sizes defined by Sandia, ref.02, for both intentional and accidental breaches, using the DNV software PHAST v6.42. This study will also compare the site specific and model specific parameters used as the basis for the results with the parameters used in the Sandia study. In addition, this study also documents dispersion results for a $0.5m^2$ hole to further supplement the results from previous vapor cloud dispersion analysis, as documented in the previously issued DNV report, ref. 03.

3.0 Consequence Modeling Basis

The following section covers the basis for the DNV consequence modeling and includes discussions on cargo tank volumes, volume released, LNG head above the breach, and weather conditions.

3.1 Site Specific LNG Spills

The DNV consequence modeling is based on site specific information while the Sandia study is based on generic data. The release rate is largely dependent on the amount of LNG head above the breach. A breach in both the FSRU and LNG carrier has been assumed to occur just above the water line. This assumption results in the largest LNG head and release volume, and consequently the most conservative results. A simplification of the LNG head in a tank is illustrated in Figure 3-1.

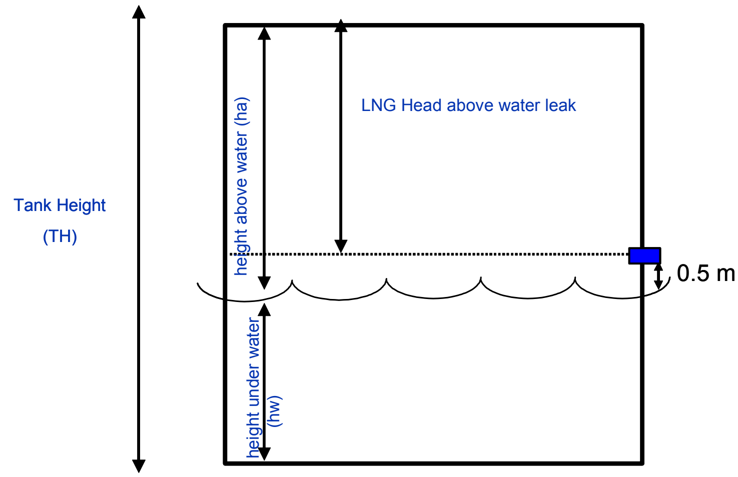

Figure 3-1 LNG Head above Water Leak

The Broadwater project is currently considering an FSRU with eight cargo tanks that each holds a volume of approximately 45,000 m^3 of LNG. The LNG carriers that unload at the Broadwater facility may vary in size. This study attempts to be conservative in its assumptions; therefore, one of the largest sized carriers was chosen as a base case (250,000 m^3 carrier with six storage tanks). The tank volumes, release volumes and LNG head that have been used as the basis for the Broadwater site specific evaluations are presented in Table 3-1, together with the data use in the Sandia study for comparison purposes.

Table 3-1 Consequence Modeling Input

Consequence Input	Sandia	Broadwater FSRU	Broadwater LNG Carrier
Tank Volume (m^3)	25, 000	44, 850	42, 000
Release Volume (m^3) (above water release)	12, 500	35, 560	27, 300
LNG Head (m)	15	21	20.3
Draft (fully loaded) (m)	Not Specified	12.3	12

In order to be conservative on the amount of cargo tank volume released, it is assumed that the FSRU tanks are 98% full. This will be the case just after being visited by an LNG carrier. The LNG carrier cargo tanks are assumed to be 95% full.

As can be seen from Table 3-1, Sandia assumed that 50% of the LNG cargo tank volume would be released during a spill. DNV calculated the site specific release volumes based on the amount of draft when the vessel is fully loaded and the LNG head above the release. This resulted in a larger release volume than assuming a uniform 50% of the volume is released.

There is uncertainty within the industry on determining total release volume for a large LNG leak. This is due to a number of phenomenon that are difficult to determine for such large scale leaks, such as possible water ingress into the tank, LNG or water ingress into the space between the inner and outer hulls, cryogenic effects on the tanker hull, etc.

The DNV site specific release volumes are larger than Sandia's for two reasons:

1. The Broadwater LNG carrier cargo tanks and the FSRU cargo tanks are larger than the cargo tanks considered by Sandia.
2. The DNV approach used to calculate site specific release volumes is more conservative than the approach used in the Sandia study.

Also, it is assumed that all released materials will be spilled outside the FSRU or LNG carrier into the environment.

Previously documented collision vulnerability analysis, ref. 03, indicates that the larger LNG carriers are less vulnerable to collision damage than smaller sized (current generation) LNG carriers, given the same impact energies, predominantly as a result of the increased separation distance between the inner and outer hulls. The Sandia Report breach sizes are based on smaller LNG carriers and are therefore conservatively (based on equal impact energies) applicable to the proposed Broadwater FSRU and LNG carriers.

3.2 Site Specific Meteorological Conditions

Based on the site specific weather data received from the National Climatic Data Center (NCDC), the three most common combinations of wind speed and stability class were determined. These three representative weather conditions for the Broadwater study are presented in Table 3-2 (see ref. 03)

Table 3-2 Representative Weather Conditions

Stability Class	Average Wind Speed	Percent of Day
F	2 m/s	15%
D	3.5 m/s	49%
D	7 m/s	21%

Other meteorological conditions include the following assumptions:

- Relative Humidity – 70% (recommended for releases over open water)
- Temperature – 20 °C
- Surface Roughness Length – 0.3 mm (roughness length of open sea)

3.3 Pool Fire Parameters

This section discusses some of the key parameters that have a significant impact in the LNG pool fire consequences. Also, the parameters used by DNV and Sandia, respectively, are compared in ref. 05 (attached as Appendix I).

3.3.1 Hole Size

The hole sizes of accidental ($1m^2$ and $2m^2$) and intentional ($5m^2$) breaches are the same as applied in the Sandia Report, ref. 02. In addition, a $0.5m^2$ breach is studied to further supplement the results from previous vapor cloud dispersion analysis, as documented in the previous DNV report, ref. 03.

As previously documented in ref. 03, the FSRU and larger (future generations of) LNG carriers are expected to experience smaller breach sizes than smaller LNG carriers (currently in service) given the same impact energies, The Sandia study breach sizes are based on smaller LNG carriers and are therefore conservatively applicable (based on equal impact energies) to the proposed Broadwater FSRU and LNG carriers.

3.3.2 Discharge Coefficient

The DNV model approach documented in this study and Sandia, ref. 02, use a similar approach for discharge modeling. The Bernoulli equation (Eqn. 1) was used to estimate the discharge rate through the hole. DNV and Sandia use the same discharge coefficient of 0.6.

$$Q = C_d\, A\, \rho[2\,(P_i - P_o)/\,\rho \;+\; 2gH]^{0.5} \quad \text{(Eqn. 1)}$$

Where: P_i = LNG vapor space pressure
H = LNG liquid head
P_o = Atmospheric Pressure

3.3.3 Burning Rate

The burning rate is a critical parameter in pool fire modeling since it determines the amount of material which burns per unit area and per unit time. Table 3-3 shows the burning rates used by DNV and Sandia, respectively. DNV uses a corrected burning rate for pool fires occurring over water, while Sandia has no indication of a correction for releases over water.

Table 3-3 Burning Rate Over Water

Study	Burning Rate ($kg/m^2/s$)	Reference
DNV	0.353	Cook et al. 1990
Sandia	0.128	Not provided

The burning rate of methane on land is known to be 0.141 $kg/m^2/s$. In case of fires on the water surface, the burning rate increases due to heat transfer from water. According to Cook et al. ref. 04, the burning rate on water is 2.5 times greater than the burning rate on land.

3.3.4 Surface Emissive Power

The Surface Emissive Power (E) is the energy that is radiated per unit surface at the surface of the fire. The intensity of thermal radiation (Q) that an individual may receive from a pool fire is directly proportional to the surface emissive power (E):

$$Q = E\, F\, \tau \quad \text{(Eqn. 2)}$$

where E is the Surface emissive power, F is the Geometrical view factor and τ is the transmissivity of atmosphere. DNV and Sandia used the same surface emissive power of 220kW/m^2.

3.3.5 Pool Radius

Pool radius and burning rate are competing factors. If the burning rate is higher, then the pool size would be smaller and vice versa. The size of the pool and the burning rate both have direct effect on the predicted thermal radiation levels and hazard distances and are very critical parameters in pool fire modeling.

The Sandia study uses a lower burning rate compared to the DNV approach. However, Sandia uses the same pool size for ignited pools and un-ignited pools, while DNV calculates larger pool sizes for an un-ignited pool compared to an ignited pool. The pool fire results in this study are based on pool size from an ignited pool.

4.0 Consequence Modeling Results

4.1 Vapor Cloud Dispersion

The results for dispersion modeling as documented in the previous DNV report, ref.03, along with results for the additional 0.5m^2 (800 mm) hole are given in Table 4-1**.**

Table 4-1 Vapor Cloud Dispersion Modeling Results

	Distance to LFL (m)						
Hole Size (mm)	**Sandia**	**FSRU**			**LNG Carrier**		
	F 2.33 m/s	**F 2 m/s**	**D 3.5 m/s**	**D 7 m/s**	**F 2 m/s**	**D 3.5 m/s**	**D 7 m/s**
800 (0.5 m^2)		1430 m	785 m	825 m	1410 m	780 m	820 m
1120 (1 m^2)	1536 m	1870 m	1030 m	1100 m	1890 m	1020 m	1090 m
1600 (2 m^2)	1710 m	2280 m	1390 m	1570 m	1990 m	1370 m	1560 m
2523 (5 m^2)	2450 m	3320 m	2050 m	2360 m	3290 m	2030 m	2340 m

The results for vapor cloud dispersion modeling were discussed in the previous DNV report, ref.03.

4.2 Pool Fires

The extent of personal injury due to thermal radiation is determined by the radiation exposure level duration and type of personal protection. Radiation levels resulting from a specific pool fire are a function of distance from the pool. The further away from the fire, the lower the thermal radiation levels. DNV presents three thermal radiation levels whereas Sandia presents results for only 5 kW/m^2 and 37.5 kW/m^2. The general type of thermal radiation damage from a fire is discussed as following:

37.5 kW/m^2 – (Immediate effects)
It is assumed to result in immediate fatality for all exposed persons and possible damage to structures and equipment.

12.5 kW/m^2 – Exposure time of up to 1 minute
This heat load can result in pain after 4 seconds and a high level of pain within 20 seconds. Second degree burns and burns which may result in death can occur after approximately 40 seconds. Generally used in risk analysis to determine impact on populations.

5 kW/m^2 – Exposure time for up to 10 minutes
This heat load can result in pain after 16 seconds. Normal work clothing would protect for several minutes. It is generally assumed escape is possible.

People located indoors or within sheltered areas will obtain additional protection against heat loads, the extent of which is dependent on the structure and composition of the protected areas, such as the building material, windows, etc.

The thermal radiation distances resulting from pool fires, as presented in Table 4-2 and Table 4-3, are measured from the center of the pool (point of release). Also, the thermal radiation levels and distances documented in the Sandia report, ref.02, are listed for comparison.

Table 4-2 FSRU Pool Fire Modeling Results

		FSRU Fire Modeling									
Hole Size (mm)	Sandia (m)	Distance to 5 kW/m^2 (m)			Distance to 12.5 kW/m^2 (m)			Sandia (m)	Distance to 37.5 kW/m^2 (m)		
	F 2.33 m/s 5 kW/m^2	F 2m/s	D 3.5 m/s	D 7 m/s	F 2m/s	D 3.5 m/s	D 7 m/s	F 2.33 m/s 37.5 kW/m^2	F 2m/s	D 3.5 m/s	D 7 m/s
800 (0.5 m^2)	-	470	484	507	303	330	357	-	148	172	210
1120 (1 m^2)	554	606	629	655	392	425	462	177	193	222	270
1600 (2 m^2)	784	797	826	858	515	557	604	250	255	292	354
2523 (5 m^2)	1305	1127	1167	1211	730	786	852	391	366	415	498

Table 4-3 LNG Carrier Pool Fire Modeling Results

		LNG Carrier Fire Modeling									
Hole Size (mm)	Sandia (m)	Distance to 5 kW/m^2 (m)			Distance to 12.5 kW/m^2 (m)			Sandia (m)	Distance to 37.5 kW/m^2 (m)		
	F 2.33 m/s 5 kW/m^2	F 2m/s	D 3.5 m/s	D 7 m/s	F 2m/s	D 3.5 m/s	D 7 m/s	F 2.33 m/s 37.5 kW/m^2	F 2m/s	D 3.5 m/s	D 7 m/s
800 (0.5 m^2)	-	466	482	504	301	329	356	-	147	171	209
1120 (1 m^2)	554	602	624	650	389	423	459	177	191	221	269
1600 (2 m^2)	784	791	820	852	511	553	600	250	253	290	352
2523 (5 m^2)	1305	1120	1160	1202	725	780	846	391	363	411	495

As can be seen from the results above, the effects of wind speeds and stability class on the thermal radiation distances are not significant. The LNG carrier results are slightly lower than FSRU results, because the LNG carrier has a smaller liquid head and therefore smaller discharge rate.

The largest pool fire radiation ellipse (5 kW/m^2) resulting from spill from the LNG carrier is calculated to be 1202 m (0.7 mile). The closest passage of the LNG carrier to land is at the race where the carrier will be approximately within 1610 m (1mile) from shore. The largest pool fire radiation distance resulting from spill from the FSRU has been calculated to extend 1211 m (0.7 miles) while the closest land is approximately 14,500 m (9 miles).

The duration of a pool fire depends on hole size, release rate, burning rate and volume released. The durations of the pool fires presented in Table 4-2 and Table 4-3 are expected to be within the interval of approximately 15 minutes for the $5m^{2,}$ hole size to approximately 1.5 hours for the $0.5m^2$ hole size.

Comparing with Sandia results, the radiation distances in Table 4-2 and Table 4-3 are slightly larger for accidental breaches, but shorter for intentional breach (2523 mm hole). A sensitivity study was carried out to investigate the effects of parameters on radiation distance.

4.3 Sensitivity Analysis

As discussed in Section 3.3, the major difference in the parameters used by DNV and Sandia is the burning rate over water. A sensitivity analysis is carried out by using the same burning rate as used in the Sandia study (0.128 $kg/m^2/s$). Table 4-4 and Table 4-5 show the thermal radiation distances resulting from pool fires using a burning rate of 0.128 $kg/m^2/s$. Also, the radiation results as documented in the Sandia study, ref.02, are listed for comparison.

Table 4-4 FSRU Pool Fire Modeling Results – Sensitivity Analysis

		FSRU Fire Modeling									
Hole Size (mm)	Sandia (m)	Distance to 5 kW/m^2 (m)			Distance to 12.5 kW/m^2 (m)			Sandia (m)	Distance to 37.5 kW/m^2 (m)		
	F 2.33 m/s 5 kW/m^2	F 2m/s	D 3.5 m/s	D 7 m/s	F 2m/s	D 3.5 m/s	D 7 m/s	F 2.33 m/s 37.5 kW/m^2	F 2m/s	D 3.5 m/s	D 7 m/s
800	-	529	539	549	358	374	389		205	229	258
1120	554	689	701	715	467	488	505	177	269	297	335
1600	784	910	924	944	618	644	666	250	358	393	441
2523	1305	1297	1318	1344	885	919	953	391	518	563	629

Table 4-5 LNG Carrier Pool Fire Modeling Results – Sensitivity Analysis

		LNG Carrier Fire Modeling									
Hole Size (mm)	Sandia (m)	Distance to 5 kW/m^2 (m)			Distance to 12.5 kW/m^2 (m)			Sandia (m)	Distance to 37.5 kW/m^2 (m)		
	F 2.33 m/s 5 kW/m^2	F 2m/s	D 3.5 m/s	D 7 m/s	F 2m/s	D 3.5 m/s	D 7 m/s	F 2.33 m/s 37.5 kW/m^2	F 2m/s	D 3.5 m/s	D 7 m/s
800	-	526	536	546	356	373	387		205	228	257
1120	554	684	696	710	464	484	502	177	267	295	333
1600	784	904	918	938	614	640	662	250	355	390	438
2523	1305	1288	1308	1335	878	913	946	391	514	559	624

The results from the sensitivity analysis show a slight increase in hazard distances compared to the base case results. This trend is expected because larger steady state pools will be generated with a smaller burning rate.

There are many uncertainties for modeling large pool fires, especially for intentional breaches, because there is no large-scale experimental testing available to validate the theoretical models. The Sandia Report (Section 5.5.1, page 51, last paragraph) discusses that for large pool fires, it is expected that they will break up into smaller pool fires because the center of the pool will not have enough oxygen to burn. The pool will then break up into “flamelets” which will have shorter flame heights and diameters and thus smaller radiation ellipses. This report has not modeled pool fire break-up but assumed a conservative large pool fire.

5.0 Conclusions

Previously documented collision vulnerability analysis, ref. 03, indicates that the larger LNG carriers are less vulnerable to collision damage than smaller sized (current generation) LNG carriers. Hence, the smaller LNG carriers are expected to experience larger breach sizes than larger LNG carriers if they are exposed to the same impact energy. The Sandia breach sizes are based on smaller sized LNG carriers (capacity of 125,000 m^3) and are therefore conservatively (given the same impact energy) assumed to be applicable for larger sized LNG Carriers and the FSRU.

Both DNV and Sandia recommend a risk based approach which includes consequence calculations along with frequency estimates to determine overall risk for specific scenarios. This report only presents consequence evaluations.

The hazard zones presented in this report are based on the hole sizes that Sandia concludes are representative for accidental and intentional acts combined with site specific weather data and worst case spill volumes for future generations of LNG carriers and the FSRU. Frequencies for the various scenarios have not been addressed in this study.

It can be concluded that the Broadwater site specific radiation distances from accidental breaches are slightly larger compared to the radiation distances documented in the Sandia study, but shorter for intentional breach (2523 mm hole). The difference in the Sandia and the Broadwater site specific results performed by DNV is believed to be within the margin of uncertainty for both Sandia’s CFD model and DNV’s PHAST model.

The largest pool fire radiation ellipse (5 kW/m^2) resulting from spill from the LNG carrier is calculated to be 1202 m (0.7 mile). The closest passage of the LNG carrier to land is at the race where the carrier will be approximately within 1610 m (1mile) from shore. The largest pool fire radiation distance resulting from spill from the FSRU has been calculated to extend 1211 m (0.7 miles) while the closest land is approximately 14,500 m (9 miles).

6.0 References

01 U.S. Coast Guard letter to Broadwater Energy, dated February 21st, 2006, no. 16211/06-119, written by Peter J. Boynton of the U.S. Coast Guard.

02 "Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water," Sandia Report SAND2004-6258, Sandia National Laboratories, December 2004.

03 DNV Report, "Broadwater LNG: Response to U.S. Coast Guard Letter Dated December 21, 2005," Report no. 70014347 ,Rev. 1 February 13, 2006.

04 Cook, J., Bahrami, Z., Whitehouse, R. J., "A comprehensive program for calculation of flame radiation levels", J. Loss Prev. Process Ind., 3, pp 150-155, 1990

05 "Consequence Modeling of LNG Marine Incidents," paper prepared by Baik, John; Raghunathan, Vijay; Witlox, Henk, to be presented in March 2006 at American Society of Safety Engineers conference. Attached as Appendix I

06 "LNG Marine Release Consequence Assessment," Joint Sponsor Project, April 21, 2004, DNV report no. 70004197.

Appendix I – Consequence Modeling of LNG Incidents

American Society of Safety Engineers
Middle East Chapter
7th Professional Development Conference & Exhibition
Kingdom of Bahrain, March 18-22, 2006

CONSEQUENCE MODELING OF LNG MARINE INCIDENTS

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Abstract

The LNG consequence analysis studies related to marine incidents are gaining prominence in the U.S. and some other countries due to the potential increase in LNG trade in the near future. To address the issues of LNG hazards associated with marine transportation, many safety assessment studies have been performed by various companies and organizations. These recently conducted studies related to LNG employ different methodologies and have published varying results. The disparity in results is mainly due to the difference in release sizes, modeling parameter assumptions and modeling tools used in calculating the hazard zone.

This paper reviews the modeling approaches used by different companies and organizations. A detailed discussion on critical modeling parameters and assumptions affecting the consequence analysis results are also presented in this paper.

Keywords: LNG, consequence modelling

1. INTRODUCTION

There has been substantial debate in the U.S. over the potential consequences of a marine accident involving an LNG vessel at or approaching one of the four current U.S. import terminals or one of the up to 45 proposed new terminals in North America. This debate has occurred at public meetings associated with the approval process, in conferences, and published technical papers. Some recent publications on this topic include: Quest (Cornwell, 2001), Fay (Fay, 2003), ABS (ABS, 2004), DNV (Pitblado et al., 2004) and Sandia (Hightower et al., 2004).

The hazard zone distances reported from the above studies are quite varying. The disparity in results is due to the difference in release sizes, modeling parameter assumptions and somewhat due to modeling tools used in calculating the hazard zone distances. DNV and Sandia studies have a stronger basis for the hole size selection, while other studies do not provide the basis for the hole size selection. ABS used the discharge coefficient of 1.0 in estimating the release rate, while DNV and Sandia used 0.6 for discharge coefficient. Therefore, ABS's result is a conservative one.

There are many other critical parameters that affect the consequence modeling results. Investigation of these critical parameters provides better understanding and confidence on the results reported by different companies and organizations. This paper provides detailed discussions on the modeling approaches used by ABS, DNV, Sandia and Quest. The study done by Fay is excluded since the detail parameters used in the modeling are not available.

2. RESULTS OF RECENT STUDIES

The four recent studies reviewed in this paper are:

- DNV - A Joint Sponsor Project that involved a credible risk assessment approach of marine LNG release scenarios subject to external peer review.
- ABS - Federal Energy Regulatory Commission (FERC) sponsored this study with the goal of estimating flammable vapor and thermal radiation hazard distances for potential LNG cargo releases.
- Sandia - A work sponsored by the U.S. Department of Energy that provides guidance on appropriateness of models, assumptions and risk management to address

public safety relative to a potential LNG spill over water.

- Quest - Quest Consultants Inc. provided a letter to the U.S. Department of Energy regarding the consequence of a potential release of LNG from a ship.

More details on the above studies including adopted modeling tools are given in Section 3. The latter section also includes further details of the modeling approaches for LNG discharge onto water, subsequent pool spreading/evaporation, the pool fire (case of ignition) and vapor cloud dispersion (case of no ignition).

The consequence results analyzed in this paper include:

- Thermal radiation hazard zones – distance to 5 kW/m^2 and 37.5 kW/m^2
- Flammability hazard zone – distance to LFL

Pool Fire Results

The pool fire radiation results from the above mentioned studies are presented below in Table 1 and also in the form of a graph in Figure 1 and Figure 2.

Hole size (mm)	Study	Pool Radius for Radiation (m)	Burning Rate (kg/m^2s)	Radiation Distance	
				5 kW/m^2	37.5 kW/m^2
250	DNV	15	0.353	194 m	70 m
750	DNV	43	0.353	451 m	169 m
1000	ABS	74	0.282	860 m	370 m
	Quest	n/a	0.089	433 m	n/a
1120	Sandia	74	0.128	554 m	177 m
1500	DNV	86	0.353	761 m	289 m
1600	Sandia	105	0.128	784 m	250 m
2523	Sandia	165	0.128	1305 m	391 m
5000	ABS	130	0.282	1400 m	600 m
	Quest	n/a	0.089	540 m	n/a

Table 1. Pool Fire Results

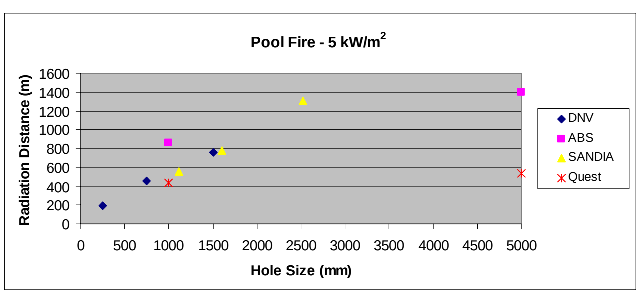

Figure 1. Pool Fire Results – 5 kW/m^2

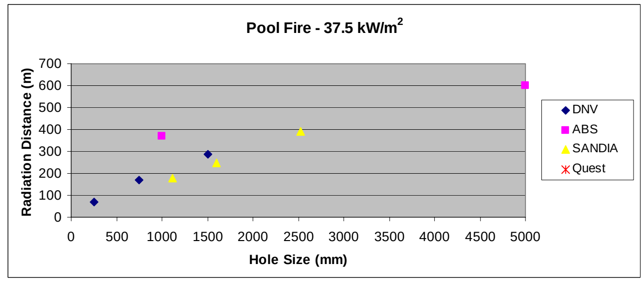

Figure 2. Pool Fire Results - 37.5 kW/m^2

As shown in Table 1, Figure 1 and Figure 2, each study used different hole sizes for their analysis. Therefore, a direct comparison of results is not possible.

Dispersion Results

The pool spreading/evaporation and dispersion results for all four cases are summarized below in Table 2 and also presented graphically in Figure 3. The graph shown below compares only the results for F stability and 2 m/s atmospheric conditions for all four studies, as Sandia provides the dispersion results only for that condition.

Hole size (mm)	Study	Pool Radius for dispersion (m)	Evaporation Flux (kg/m2s)	LFL distance (m)		
				F-2 m/s	D-3 m/s	D-5 m/s
250	DNV	29	0.179	790 m	370 m	380 m
750	DNV	59	0.179	1800 m	850 m	870 m
1000	ABS	130	0.072	3300 m	2000 m	n/a
	Quest	n/a	0.2	3733 m*	n/a	783 m
1120	Sandia	74	n/a	1536 m*	n/a	n/a
1500	DNV	117	0.185	3400 m	1600 m	1700 m
1600	Sandia	105	n/a	1710 m*	n/a	n/a
2523	Sandia	165	n/a	2450 m*	n/a	n/a
5000	ABS	170	0.075	3900 m	n/a	n/a
	Quest	253	0.2	4076 m*	n/a	1002 m

* Sandia and Quest modeled with F-2.33, F-1.5 respectively instead of F/2

Table 2. Dispersion Results

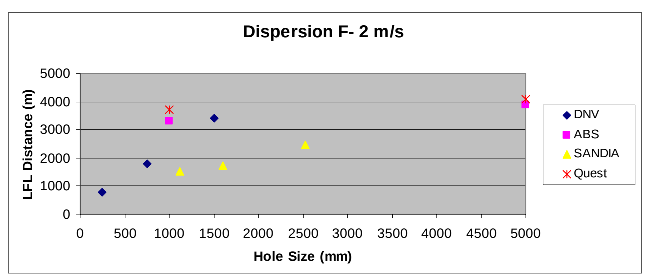

Figure 3. Dispersion Results for F stability and 2 m/s

Similar to the pool fire case, each study used different hole sizes for their analysis as shown in Table 2 and Figure 3. Therefore, a direct comparison of results is not possible.

3. CRITICAL PARAMETERS AFFECTING CONSEQUENCE RESULTS

The purpose of this paper is to analyze the results of the different studies based on the critical parameters affecting the consequence results. There are many parameters that could impact the final results. This paper will discuss the key modeling parameters used in each study and the significance of those key parameters on the consequence results.

The consequence models used for dispersion analysis in the four studies are listed as follows:

- DNV - PHAST
- ABS - DEGADIS
- Quest - CANARY
- Sandia - VULCAN

Of the four different studies, only Sandia used a CFD code (VULCAN) while others used similarity models. Both types of models are known to be adequate for modeling of dispersion over flat terrain.

For pool fire modeling, DNV, ABS and Quest used similar solid flame models, while Sandia used a CFD code, VULCAN.

3.1 Discharge Modeling

As shown in the tables and figures in Section 2, each study used different holes sizes for consequence modeling. Therefore, a direct comparison of the results is not possible. In general, DNV and Sandia studies have a stronger basis on the selection of hole sizes, while ABS and Quest studies used hole sizes selected purely based on the judgement. DNV determined the credible hole sizes based on the collision damage graph from IMO/MARPOL and Sandia determined the holes sizes based on the finite element modelling of ship collisions.

The discharge modeling for each study was performed using a similar approach. Bernoulli's equation was used in all these studies to estimate the discharge rate through the hole. However, the discharge coefficient used in the calculation was quite different.

Bernoulli Equation

$$Q = C_d A \rho [2 (Pi-Po)/ \rho + 2gH]^{0.5}$$

Where C_d is the discharge coefficient, A is the hole area, ρ the LNG liquid density, P_i is the storage pressure at the top of the LNG liquid, H is the LNG liquid head above the release height and P_o is the atmospheric pressure.

Table 3 shows the discharge coefficient C_d used in each study.

Study	Discharge Coefficient (C_d)
DNV	0.6
ABS	1
Sandia	0.6
Quest	n/a

Table 3 Discharge Coefficient Used in Each Study

As shown in Table 3, ABS used a discharge coefficient of 1.0, while DNV and Sandia used 0.6. The discharge coefficient of 0.6 and 1.0 represents a sharp-edged orifice (TNO, 1999) and a perfect discharge without any restriction, respectively. The ABS discharge rate was 40% greater than DNV and Sandia studies. This may be one of the reasons why the ABS result is more conservative than others. The information on discharge coefficient was not available from the Quest study.

3.2 Pool Fire Parameters

Some of the key parameters that have a significant impact in the LNG pool fire modeling have been identified to analyze the radiation hazard distance results published in these four studies.

Burning Rate

The burning rate is a critical parameter in pool fire modeling since it determines the amount of material which burns per unit area and per unit time. A higher burning rate provides a higher thermal radiation result. Table 4 shows the burning rates used in each study.

Study	Burning Rate ($kg/m^2/s$	Reference
DNV	0.353	Cook et al. 1990
ABS	0.282	Rew 1996
Sandia	0.128	Not provided
Quest	0.089	Not Provided

Table 4 Burning Rate Values

The burning rate of methane on land is known to be 0.141 $kg/m^2/s$. In case of fires on the water surface, the burning rate increases due to heat transfer from water. According to Cook et al. (1990), the burning rate on water is 2.5 times greater than the burning rate on land.

The DNV and ABS studies used a corrected burning rate in the pool modeling, while others had no indication of those corrections.

Surface Emissive Power

The Surface Emissive Power (E) is the power that is radiated per unit surface at the surface of the fireball. The intensity of thermal radiation (Q) that an individual may receive from a pool fire is directly proportional to the surface emissive power (E):

$$Q = E\, F\, \tau$$

where E is the Surface emissive power, F is the Geometrical view factor and τ is the transmissivity of atmosphere.

Table 5 summarizes the surface emissive power used in different studies and values obtained from LNG pool fire experiments.

Study	Surface Emissive Power (kW/m^2)
ABS	265
DNV	220
Sandia	220
Quest	Not available
USCG China Lake tests	220 ± 30
Maplin Sands	178 to 248

Table 5. Surface Emissive Power Values

As shown in Table 5, the ABS study used higher values than other studies. This can be a part of the reason why the ABS result is more conservative than others.

Pool Radius

Pool radius and burning rate are competing factors and if the burning rate is higher, then the pool size would be smaller and vice versa. The size of the pool has a direct effect on the predicted hazard distances and is very critical in pool fire modeling.

The pool size of an ignited pool is much smaller than that of an un-ignited pool due to the termination of pool spreading upon ignition. Therefore, the pool size needs to be corrected for an ignited pool. The simplest way of correcting the pool size is to use a burning rate assuming a steady state pool.

The DNV and ABS studies used similar approaches in correcting the pool size for hazard distance calculation of pool fires. However, Sandia used the same pool size for ignited pools and un-ignited pools. The information about the pool size is not available in the Quest study.

Wave Effect

The presence of waves on water will affect the spreading of LNG on its surface. The Quest study has incorporated this wave effect by using a conditional statement at the boundary of the pool; namely, the pool will stop spreading once the LNG drops below 60% of the wave height. Therefore, the wave effect would decrease the pool radius as the wave breaks the liquid pool formed on the surface and results in reduced thermal radiation hazard zone. This could possibly explain why Quest reported smaller thermal radiation hazard zone results compared to other studies.

Atmospheric Conditions

Atmospheric wind speed also has an effect on the predicted hazard distances in the case of pool fire modeling. The worst case atmospheric conditions for pool fires are during high winds. The wind allows the flame to tilt, thus allowing the flame to move further downwind. This results in higher downwind radiation flux levels than those attained under low wind conditions. All four studies used similar atmospheric conditions for pool fire modeling.

3.3 Vapor Cloud Dispersion Parameters

Pool Evaporation

In the case of vapor cloud dispersion, pool vaporization rate is one of the most critical parameters in estimating the hazard zone distance since it determines the mass that enters into the dispersion. The approaches used in the four studies for pool evaporation are quite different and this is an area that needs further improvement.

Table 6 shows the evaporation flux used in the different studies. Evaporation flux decides the amount of material that goes in to the vapor cloud dispersion calculations and this depends on the size of the pool.

Study	Source	Pool Size Used	Evaporation Flux ($kg/m^2/s$)
DNV	Dodge et al. method	Steady state pool size	0.182 (based on steady state evaporation rate)
ABS	Webber's method	Maximum pool size	0.072 (based on maximum evaporation rate)
Sandia	Vulcan CFD model has built in spreading model.	Maximum pool size	Not Available
Quest	Mechanism not known but includes wave effect.	Not Available	0.2 (based on maximum evaporation rate)

Table 6. Pool Spreading and Evaporation

As shown in Table 6, the evaporation flux used in dispersion modeling is quite varying. ABS and Quest used evaporation flux based on the maximum values, while DNV used the evaporation flux based on steady state value.

It should be noted that the amount of material that goes into the atmospheric dispersion is also dependent on the size of the pool. Therefore, the higher evaporation flux does not necessarily mean greater evaporation from the pool. When DNV's evaporation rate is re-estimated based on the maximum pool, the evaporation flux gets closer to the values reported by ABS.

The evaporation rate calculated based on the flux and pool size reported show that DNV's evaporation rate is little bit higher than ABS's value.

Atmospheric Conditions

In case of dispersion, an unstable atmospheric condition (higher wind speed) causes more turbulence and in turn results in quicker dilution of the hazardous material. In a stable atmospheric condition (lower wind speed), the hazard zone distances usually increase due to reduced mixing of hazardous materials in the air.

All four studies used similar atmospheric conditions for dispersion analysis as shown in Table 7.

Study	Atmospheric Stability and Wind Speed	Surface Roughness Length	Relative Humidity
DNV	F-2, D-3 ,D-5 m/s	0.3 mm	70 %
ABS	F-2, D-3 m/s	10 mm	50 %
Sandia	F-2.33 m/s	0.2 mm	Not available
Quest	F 1.5 ,D-5 m/s	Not available	70 %

Table 7. Atmospheric Conditions

Surface Roughness Length

The surface roughness length describes the roughness of the surface over which the cloud disperses. It alters wind velocity profile and consequently affects the dispersion result significantly. Therefore, it is important that proper roughness lengths are used in the dispersion analysis.

Review of the four studies shows that the roughness length values used in the different studies are quite varying. DNV and Sandia used a roughness length of 0.2 mm to 0.3 mm, while ABS used 10 mm.

According to literature, the roughness lengths of open sea are 0.1 mm to 1.0 mm, depending on weather conditions (Ermak, 1990) (EPA, 1995) (EPA, 2004). Therefore, the values used by DNV and Sandia are more appropriate than a value used by ABS for dispersion over open sea.

The surface roughness used in the four different studies is presented above in Table 7 for comparison.

Relative Humidity

The humidity is used in the dispersion calculations to determine the properties of the atmosphere (mainly the density of the air) and the density of the cloud. The higher the humidity, the sooner the plume becomes buoyant due to the heat transfer from moisture. Therefore, the hazard zone distance decreases with increased humidity.

The humidity varies a lot depending on the site location. Therefore, it is best to use the site specific data for humidity, particularly in cases where the site is located in an extremely humid or dry location. In open sea, the relative humidity is normally 70% or higher.

The atmospheric conditions used in the four different studies are presented in Table 7 for comparison.

4. SENSITIVITY ANALYSIS

In order to investigate the effect of different modeling parameters on the consequence results, a few sensitivity runs were performed.

Pool Fire

The pool fire scenario of 1 m hole reported by ABS was modelled using DNV's PHAST program, with same pool radii as ABS and by setting the burning rate, surface emissive power and wind-speed equal to the ABS value. The same modeling was performed using PHAST for pool fire scenario of 1.12 m reported by Sandia and the results are shown in Figure 4 and Figure 5.

The result clearly shows a drastic reduction in the deviation of ABS and Sandia's results from the DNV value for the same hole size. The circled points show the change in ABS and Sandia values. At this stage, there is still a small deviation in results between ABS and DNV after fixing the parameters and this difference can be clearly attributed to the difference in the consequence models used in these studies. However, the DNV and Sandia results become almost the same when the same modeling parameters are used.

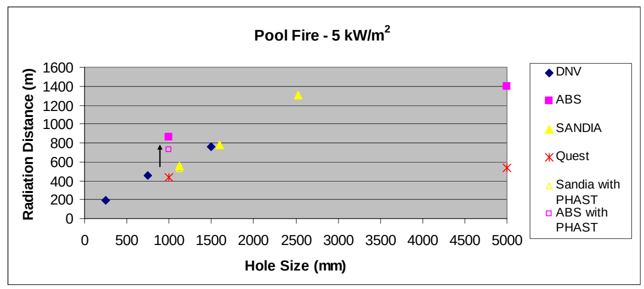

Figure 4. 5 kW/m^2 Sensitivity Run

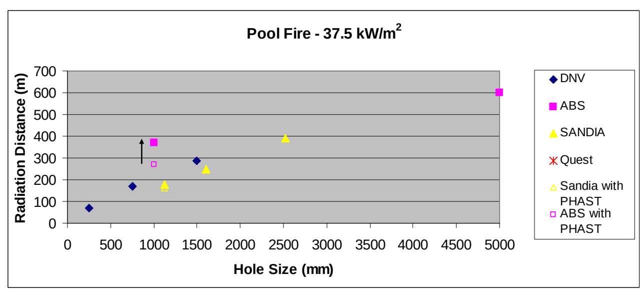

Figure 5. 37.5 kW/m^2 Sensitivity Run

Dispersion

For the dispersion modeling, ABS and Sandia cases were modeled using DNV's PHAST program by fixing the evaporation rate and atmospheric conditions such as surface roughness, relative humidity, stability wind speeds.

The dispersion scenarios of 1m hole reported by ABS and 1.12 m hole reported by Sandia were modeled using SAFETI and the result is presented in Figure 6.

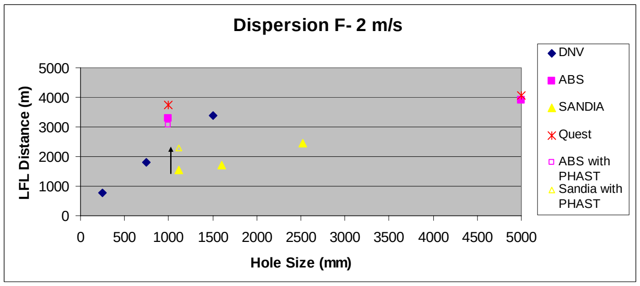

Figure 6. Dispersion Results Sensitivity Run

As shown in Figure 6, the dispersion case re-runs also showed a reduction in the deviation of results when the same modeling parameters are used. The DNV and ABS results become almost the same when the same modeling parameters are used. However, there is still a quite large deviation in results between DNV and Sandia even though the same modeling parameters are used.

This difference can be clearly attributed to the difference in the consequence models used in these studies. Sandia used a CFD code in the dispersion calculation, while others used similarity models. In order to answer whether this difference in results is due to the difference between similarity and CFD codes, further study is required.

5. CONCLUSIONS

The detailed investigation for consequence modeling approaches of recent studies shows that the varying results are due to the differences in modeling assumptions and the modeling tools used in estimating the hazard zone distances. The deviation in results between the studies reduces significantly when the same modeling assumptions are used. Therefore selection of the appropriate modeling parameters is a critical step in consequence modeling.

Further, the deviation of dispersion results between Sandia and others were significant. It may be due to the difference between models used (CFD vs. similarity). However, further study is required to confirm this.

Moreover, the scales of LNG releases modeled in these studies are much less than the scale of existing field experimental data. Therefore, additional large scale experiments will provide more confidence in the modeling methods. However, that should not prevent valid decision making today, since uncertainties that exist here are no worse than the uncertainties in many other high hazard activities.

References

ABS Consulting, "Consequence Assessment Methods for Incidents Involving Releases from Liquefied natural Gas Carriers," Report# GEMS 1288209 to Federal Energy Regulatory Commission, Washington, DC, May 2004.

Baik J., V. Raghunathan, and E. A. Meyer, "Parameter Comparison of Recent LNG Consequence Studies," LNG Conference, Vancouver, September 12-14, 2005.

Cornwell J., Letter to Mr. Don Juckett, United States Department of Energy, October 2, 2001.

Cook, J., Bahrami, Z., Whitehouse, R. J., "A comprehensive program for calculation of flame radiation levels", J. Loss Prev. Process Ind., 3, pp 150-155, 1990

Ermak, D. L., "User Manual for SLAB: An Atmospheric Dispersion Model for Denser-Than-Air Releases", Lawrence Livermore National Laboratory, 1990.

U.S. Environmental Protection Angency (EPA), "User's Guide for the Industrial Source Complex Dispersion Model, Volume I, User Instructions", EPA-454/B-95-003a, September, 1995.

U.S. Environmental Protection Angency (EPA), "ALOHA User's Manual", March 2004.

Fay, J.A., "Model of Spills and Fires from LNG and Oil Tankers," J. Haz Mat, v B96, p171-188, Jan 2003

Hightower, M, L. Gritzo, A. Luketa-Hanlin, J. Covan, S.Tieszen, G. Wellman, M. Irwin, M. Kaneshige, B. Melof, C.Morrow, and D. Ragland, "Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water," Sandia National Laboratory Rep.# SAND2004-6258, U.S. Department of Energy, Washington, DC, Dec 2004.

Pitblado R., J. Baik J, G. Hughes, C. Ferro, and S. Shaw S., "Consequences of LNG Marine Incidents," Center for Chemical Process Safety Conference, Orlando, Jun 30-July 2, 2004.

Pitblado R., J. Baik, and V. Raghunathan, "LNG Decision Making Approaches Compared," Mary Kay O'Connor Process Safety Center Conference, Texas A&M Univ., Oct 26-27, 2004.

TNO, "Guideline for Quantitative Risk Assessment – Purple Book", CPR 18E, Committee for the Prevention of Disasters, 1999.

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MANAGING RISK

Response to U.S Coast Guard

Letter of February 16, 2006

Codes and Standards Development

Broadwater Energy LLC

March 10, 2006

PUBLIC

1.0 Background

Compliance with applicable codes and standards is of paramount importance to ensuring a safe and reliable facility design. To ensure that appropriate codes, regulations and standards are applied to the design, construction and operation of the facility, the Floating Storage and Regasification Unit and associated mooring has been characterized as essentially an LNG carrier, with additional regasification equipment, moored at a fixed location.

Given the marine nature of the proposed facility and its similarities with LNG carrier design and operation, a ship classification society will be involved in the oversight throughout the project design and construction process. Classification societies are organizations that establish and apply technical standards in relation to the design and construction of marine-related facilities, including ships and offshore structures. These standards are issued by the classification society as published Rules. As an independent, self-regulating body, a classification society has no commercial interests related to ship design, building, ownership, operation, management, maintenance or repairs, insurance or chartering. In establishing its Rules, each classification society may draw upon the advice of members of the industry who are considered expert in their field. Classification societies also maintain significant research departments that contribute towards the ongoing development of appropriate, advanced technical standards.

LNG carrier design, construction, and operation are comprehensively covered by rules and guidelines and the legislative requirements of national and international authorities. An LNG carrier is typically constructed according to “Classification Society Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk,” also known as the Gas Ship Rules. Compliance with the Gas Ship Rules is ensured through design appraisal and survey during building and commissioning. Although legislative requirements are not, strictly speaking, a classification issue, it is usual for the classification society to make compliance with legislative requirements a prerequisite for compliance with its Rules.

Classification Society Gas Ship Rules incorporate the requirements of the International Maritime Organization’s *International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* (generally known as the IGC Code). The IGC Code is a *de facto* international standard by virtue of its adoption by the industry and regulatory bodies.

For this project, an extensive array of standards have been assembled based on federal and state standards, classification society Rules, and, as appropriate, international standards for design and construction that incorporate appropriate federal, state, national and international requirements.

Broadwater engaged the services of the American Bureau of Shipping (ABS), one of the world’s leading ship classification societies, to ensure that all applicable standards are incorporated within the facility design. On July 27, 2005, Broadwater received an

"Approval in Principle" for the Broadwater FSRU from ABS, based on its review of the conceptual design.

2.0 Description of Codes and Standards Selection Process

The selection of the appropriate codes and standards evolved during the technical development of the FSRU. The resultant design is documented in Resource Report 13. Within each section of Resource Report 13 which deals with a major equipment item, the applicable codes and standards used to guide the design process are documented.

The process adopted for codes and standards selection is outlined in the attached flowchart, of which an integral component was the design review activities completed by the American Bureau of Shipping (ABS).

Selection of the project codes and standards was initiated by Broadwater Energy at the start of concept design development, when a Basis of Design Document was prepared. At this stage the technical advisors to the Broadwater project (Shell Global Solutions US), which included a broad range of discipline engineers, proposed indicative codes and standards that would normally be considered appropriate based on their experience of preparing design documents and specifications for both onshore and marine projects.

In the first quarter of 2005, Broadwater selected engineering contractors (including hull, containment, LNG process and mooring system disciplines) to complete the initial design of the facility. These contactors then reviewed and appended as considered appropriate the preliminary list of codes and standards which formed the basis for the detailed listing in Resource Report 13. Broadwater deliberately selected these contractors on the basis of their global expertise in their respective fields:

(1) Samsung Heavy Industries, which is an experienced shipbuilder, for its ability to design and construct LNG Carriers and expertise with hull, LNG membrane containment and in-hull systems;
(2) Saipem America Inc. which has experience with onshore LNG terminal projects and offshore engineering; and
(3) SBM-IMODCO, Inc., which is one of the world leaders in mooring systems and FPSO (Floating, Production, Storage and Offtake) systems.

By combining these capabilities within a review of the standards, the managing contractor, Saipem, was able to confirm compatibility between the hull, topside process equipment and yoke mooring components of the project, as well as the related codes and standards to be applied.

Broadwater Energy met with the USCG and FERC representatives on June 29, 2005 and a document entitled "*Resource Report 13 – Indicative Codes and Standards*" was left with the agencies to provide an indication of the direction that Broadwater proposed to take with respect to this issue.

A draft version of Resource Report 13, including Section 13.12 (Design Codes and Standards) and related Appendices, was submitted to ABS for review to permit its issuance of an Approval in Principle for the LNG import facility concept.

A key element of ABS' Approval in Principle was its review against the criteria specified in its *Guidance Notes on Review and Approval of Novel Concepts* dated June 2003. ABS requires applicants to provide "Support Information" which is identified in its Guidance Notes as:

> "(i) List of reference codes and standards to be applied to the application and the technical justification for selection of those standards if not readily apparent." (Page 17)

ABS issued its Approval in Principle Letter on July 27, 2005. ABS goes further in its issued Approval in Principle to make clear that the technologies employed are not in themselves novel, and are covered by established Rule criteria.

Broadwater Energy has defined in its FERC application that appropriate marine standards such as IMO Codes and classification society Rules will apply for the hull, LNG containment system and ship related systems; and that standards normally considered appropriate to land-based terminals would be applied to the extent practicable for the LNG regasification plant and related process systems operating in an offshore floating environment. This approach is consistent both with ABS' *Guidance Notes on Review and Approval of Novel Concepts* (June 2003) and the *Guide for Building and Classing Offshore LNG Terminals* (April 2004).

Attached is a letter and related material from ABS, dated March 9, 2006 which details the involvement of ABS in the review of codes and standards for the project.

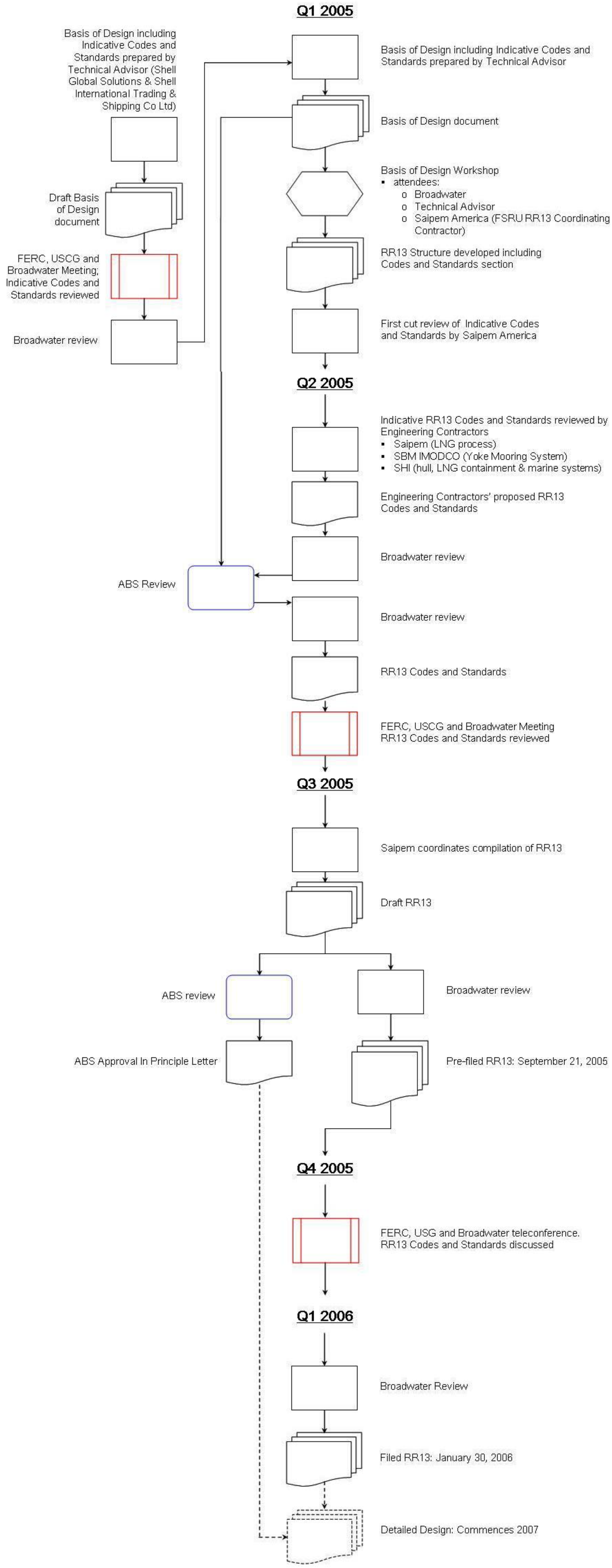
In its review of the codes and standards for the proposed facility, Broadwater has addressed issues of the appropriateness of overlapping codes and standards, and selected whichever applicable code or standard is more stringent. Two such examples are described as follows:

1. Resource Report 13, Section13.14 (Regulatory Compliance) that discusses the application of traditional land-based regulations, as outlined in 49 CFR 193 and NFPA 59A, to an offshore floating environment. The relevance of each section has been analyzed and the results documented in this section.

2. The proposed design for the Yoke Mooring System is an example of the selection of a more stringent design criterion. The normal design for an offshore structure is based on environmental criteria with a 1:100 year return period (a return period is the frequency with which an event would be expected, on average, to recur). The 1938 hurricane affecting Long Island Sound was classed as a Category 3 or 4 hurricane, but in design terms would have only been considered a 1:50 year event.

Broadwater chose an extremely conservative design significantly in excess of the 1:100 year standard. The specified extreme 1 hour average wind speed of 56.8 m/s (approximately 110 knots or 127 miles per hour) was chosen, based on analysis of historical wind data in the region. This design criterion is for an average 1 hour wind speed, which differs from the Saffir-Simpson Hurricane Scale, which is based on wind speeds of 1 minute average duration. When converted using available Gust Factor Curves, this aligns with a 1 minute average wind speed of 88.5 m/s (approximately 172 knots or 198 miles per hour), which is substantially in excess of the minimum wind speed for a Category 5 hurricane (winds greater than 155 miles per hour). Only three Category 5 hurricanes have made landfall in the United States since records began, all of these occurring in the southern U.S. A Category 5 hurricane has never been experienced in the vicinity of Long Island Sound.

RR13 Selection of FSRU Codes & Standards



FOUNDED 1862 ABS

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ABS Plaza,
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9 March 2006

Shell Trading US Co
Two Shell Plaza
Floor 22 Room 2258
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Houston 77002
Texas, USA.

For the attention of Mr.W. Gray, Technical Manger

ABS Involvement
Broadwater Project

Dear Sir,

Further to recent correspondence we are pleased to confirm the extent and involvement of the American Bureau of Shipping (ABS) with the Broadwater Project.

The timetable and extent of ABS involvement has been agreed and documented in various flowcharts indicating project milestones from Q1/2005 onwards (it is noted that the initial ABS Meeting with Broadwater Team members was actually held in November 2004). ABS "scope of work" related to the Broadwater Project was documented in our "ABS Approval-in-Principle (AIP) for LNG FSRU / Gas Import Facility" Revisions 0 and 1, dated March 2005.

The methodology applied by the ABS Team in coming up with the deliverables agreed in the terms of the AIP proposals was consistent with the processes described in our publication "ABS Guidance Notes on Review and Approval of Novel Concepts", June 2003 – details of the publication are attached as Appendix "A" to this letter. The constitution of the ABS Team working on the Team was documented in the provided "ABS Review Team Organization" diagram. – attached as Appendix "B" to this letter; all members of the ABS Team were suitably qualified and knowledgeable for the part or parts reviewed and commented upon as required by our internal processes in accordance with the ABS ISO 9001, externally issued certification.

ABS confirms that it was satisfied that due consideration of standards and Codes had been made by the Broadwater Team during "basic design" process and was comfortable with respect to the use of the individual proposed components of the project in the intended project execution upon further development towards final project final design.

ABS
AMERICAS DIVISION

The general premise that the Broadwater Team were intending to apply proven technology from the marine and gas transportation industries was noted throughout the ABS involvement and our focus in reviewing the overall project was with respect the degree of novelty of the individual components in their specific and intended application. The ABS review process was completed with no major comments and the AIP letter was issued on or around 27th July 2005.

The application of Classification requirements and systematics during future stages of the project provide a clear path to proceed with as far as the marine aspects of the project are concerned and ABS are confident that they would be able to complete Classification process for the project in compliance with our published Rules and Guides; compliance with other performance standards, additional to those required by Class process, may additionally be confirmed by ABS during design, fabrication and installation/commissioning stages of the project as they occur.

We hope the foregoing meets your needs at this time; should additional details or information be required please do not hesitate to contact the undersigned or:

Mr. Phillip Rynn:– Senior Staff Consultant (Broadwater AIP Project Manager)
Tel: 281-877-6415

or

Mr. Harish Patel - Principal Engineer (Broadwater AIP Asst. Project Manager)
Tel:- 281-877-6469

We wish everyone a safe and successful project. Thank you for the trust you have placed in ABS at this time.

Very truly yours,
William J. Sember
Vice President

By: [signature]
Ian A. Simpson
Manager - Energy Project Development

Attachments Appendix "A"
Appendix "B"

APPENDIX “A”

ABS Novel Concepts Guidelines

Motivation for Guide

- Many new offshore and marine concepts being proposed by industry
  - GTL FPSOs
  - LNG FPSOs
  - CNG Carriers
  - Floating and Fixed Base Gas Terminals
  - New Types of Offloading Systems
  - Use of composites

- Need to provide a general road map to client's on how ABS will evaluate and approve proposed novel concepts or applications

Key Aspects of Guide

- Outlines an ABS process to obtaining Class Approval for a Novel Concept
- Includes an intermediate step covering Approval In Principle
- Requires ABS and its clients to agree on the appropriate risk and engineering analysis techniques and justification to be employed
- Enables both Client and ABS to demonstrate the methodology used to establish fitness for purpose

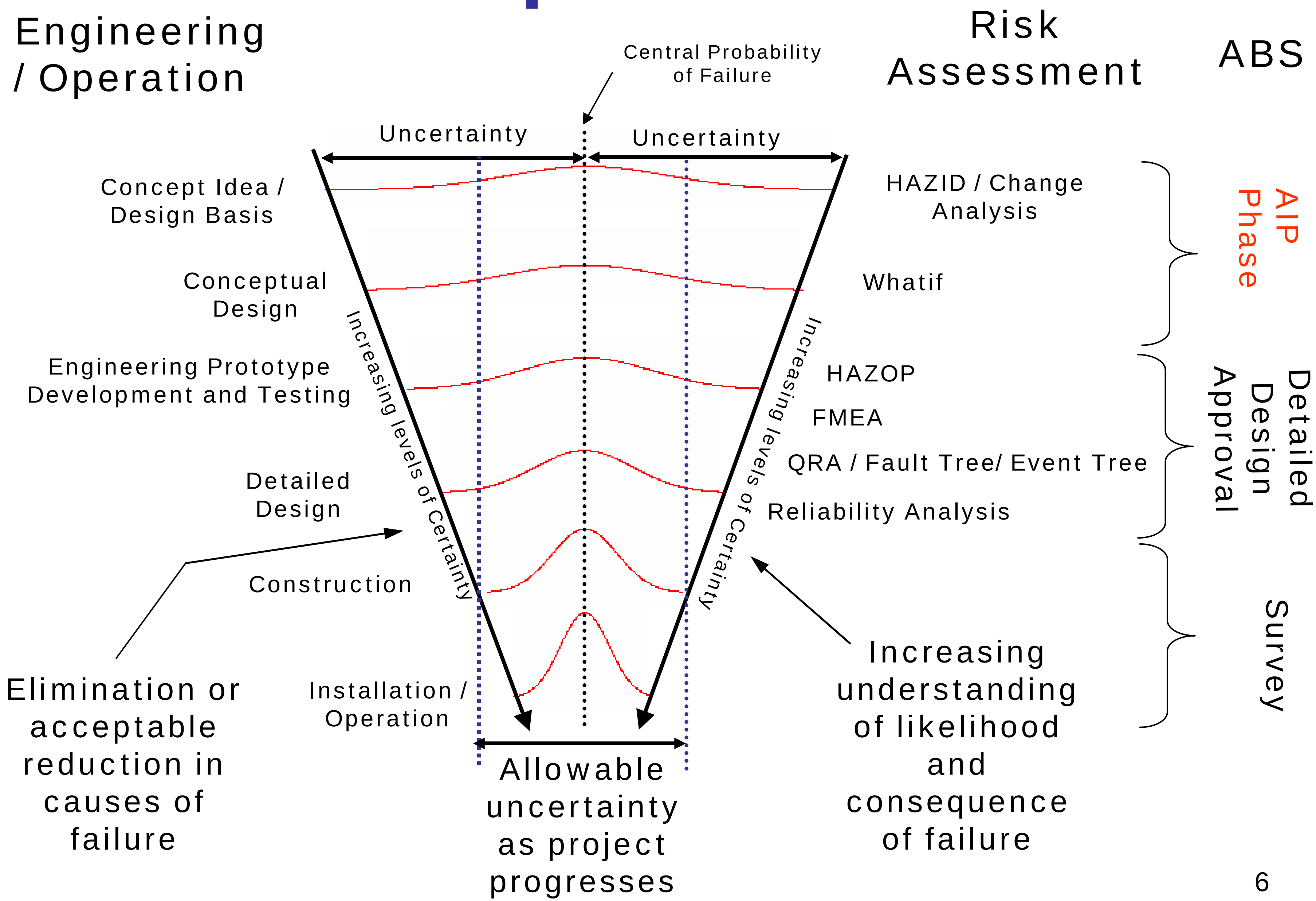
Guidance Note Outline

- Objective
- Definitions
- Applicability - checklist approach
- Process to obtain Approval In Principle (AIP)
  - Documentation to be submitted
  - Concept Engineering Evaluation
  - Concept Risk Assessments
- Process to Full Class Approval
  - Documentation to be submitted
  - Design Evaluation
  - Risk Assessments
- Special Consideration for Maintenance of Class

Guidance Notes Objectives

- Provide guidance to ABS clients related to the ABS methodology for review and approval of novel concepts
- Provide process and responsibilities for ABS review of proposed novel concepts from the project concept stage through maintaining Classification.
- Outline documentation requirements

Concept Evolution



Key Definitions

- Novel Concept: A design or process that has no previous experience in the environment being proposed.

- Approval in Principle (AIP): Process by which ABS issues a statement that a proposed concept design complies with the intent of ABS Rules and/or appropriate codes, subject to a list of conditions that must be addressed in the final design stage.

Key Definitions

- Classification is a representation by ABS as to the fitness for a particular use or service in accordance with its Rules and standards. For *novel concept*, this would also mean that the conditions outlined within the approval road map identified during the AIP stage have been demonstrated to the satisfaction of ABS.
- Maintenance of Classification: The fulfillment of the requirements for surveys after construction. For *novel concept*, this would mean all requirements within the applicable ABS Rules, plus any additional requirements outlined in the conditions of class for the concept.

Guide Applicability

- Define when use of this guideline is appropriate
- Guideline meant to help identify:
  - Existing design/process/procedure in new or novel application or when challenging boundaries/envelope of current applications
  - Existing design / process / procedures challenging the present boundaries/envelope of current offshore or marine applications.
  - New or novel design / process / procedures in existing applications
- Checklist approach - if answers to queries is “yes”, then this guideline may apply.

Applicability Checklists

- Questions related to system broken up into categories
  - Stationkeeping
  - Marine
  - Structural
  - Process
  - Cargo/Storage
  - Other (e.g., concept not directly covered under Class but the performance of that system could impact vessel structural integrity, stability or safety of the classed components)

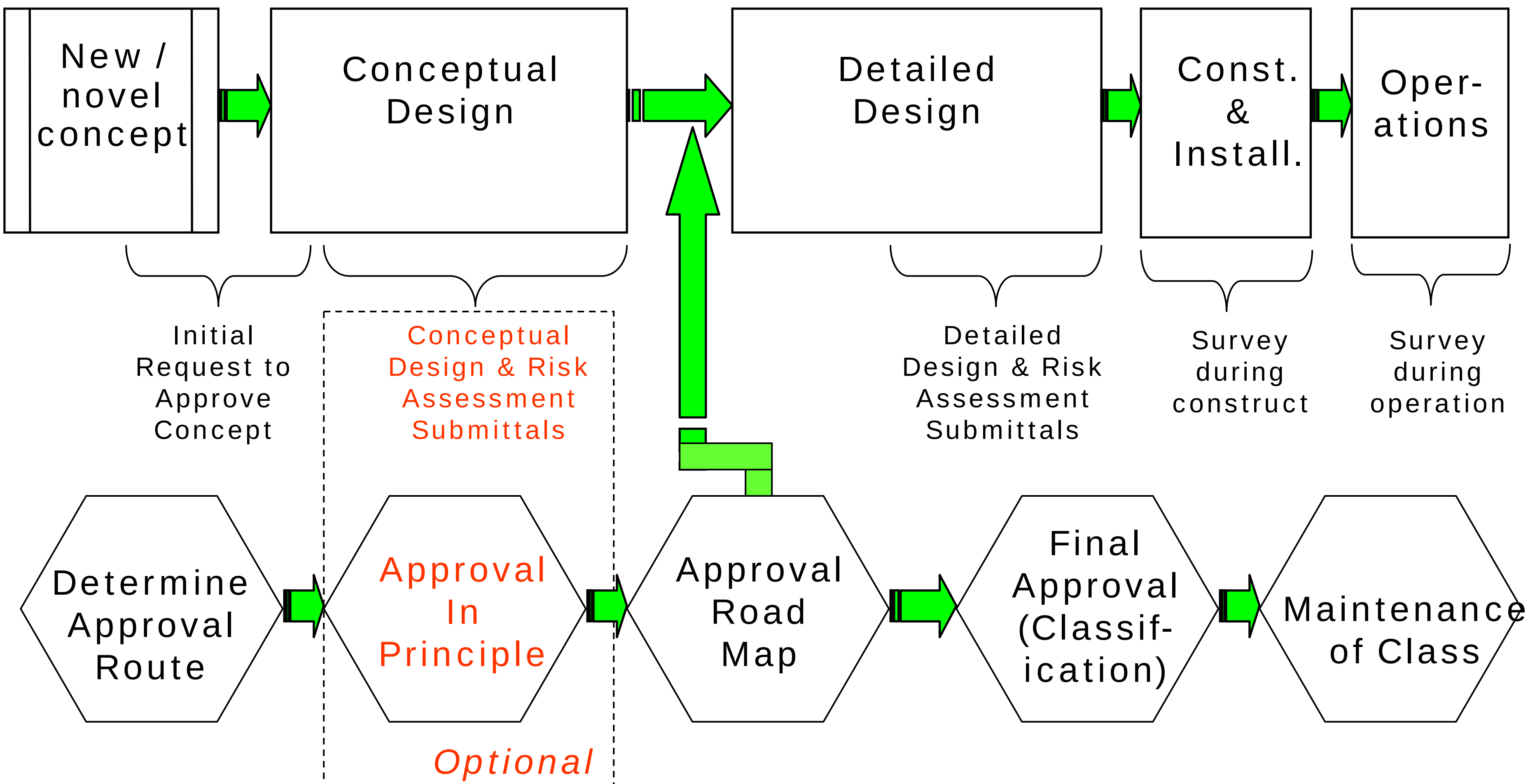
Applicability Checklists

- Example Questions
  - Is the vessel or offshore facility design basis considered within current experience boundaries for this application?
  - Are there marine or *offshore* applications of the proposed storage systems that will be on the vessel or offshore facility?
  - Are there existing *onshore* applications of the proposed storage systems that will be on the vessel or offshore facility?
  - Are there any *existing commercial applications* of the proposed storage systems similar to that which will be used on the vessel or offshore facility?

Approval Process Approach

- Provide ABS clients with a consistent evaluation approach for novel concepts
  - requires ABS and its clients to agree on appropriate engineering assessments to be conducted for **AIP** and Class
  - requires ABS and its clients to agree on appropriate risk analyses to be employed and when they should be applied for **AIP** and Class
  - requires ABS and its clients to agree on appropriate data collection and testing to be carried out to assist in proving the technology for **AIP** and Class

Approval Process Flowchart



Determine Approval Route

- Initial discussions between client and ABS on proposed concept
  - ABS gains general understanding of concept
  - Determine if AIP route will be taken
- If AIP route taken
  - Agree upon most appropriate plan for achieving AIP.
  - Outline the necessary engineering and risk assessments to be conducted on the novel features
  - Agree upon appropriate to the level of design evolution expected in the conceptual design stage in order to achieve AIP.

Approval In Principle

- Concept Engineering Evaluation:
  - Verify that the design is feasible in all phases of operation (such as in-transit, installation, commissioning, and operation for an offshore application) as far as practical within the concept phase.
  - Concept Design Verification
    - Conventional Features
    - Novel Features
    - Operability
    - Interface Issues
    - Inspectability and Maintainability

Approval In Principle

- Concept Risk Assessments:
  - At a minimum, a qualitative risk assessment (e.g., HAZID) will be conducted to identify all potential failure scenarios and associated risks (i.e., generate Hazard Register)
  - Following the qualitative risk assessment an agreed upon Risk Assessment Plan (roadmap) will be developed and carry forward into Full Approval Phase
  - Roadmap will
    - Address findings of Hazard Register
    - Identify additional detailed risk assessments, as required

Approval In Principle Conditions

- Concept engineering evaluations and risk assessments did not identified any "showstoppers"
  - No abnormal hazards
  - No excessively onerous failure mode
- Concept deemed suitable for use within a marine or offshore environment without the need for excessive or onerous monitoring during operation or maintenance/inspection considered atypical for such applications.

Approval Road Map

- Design Assessment Plan:
  - Describes the proposed means of justification for all relevant features of the novel application, their associated failure modes, and the means proposed to assess the engineering suitability
  - Outlines how consensus will be reached for what is deemed to be acceptable results for the design analyses
  - Identifies required steps to be taken in the concept evaluation as well as in the full approval phase

Approval Road Map

- Risk Assessment Plan:
  - Identifies the appropriate type of assessment techniques for the AIP phase and full approval phase
  - Describes how the team envisions a holistic approach to risk assessment for all phases of the concept development
  - Identifies how consensus will be reached on risk acceptance criteria
  - Understanding that as the team gains knowledge of the application, modifications to plan may be warranted

Full Class Approval

- Engineering Review and Verification of Design:
  - Reconfirmation of Relevant Design Codes and Standards Applied
  - Calculation Dossier
  - Confirmation of Interface Issues
  - Confirmation of Inspectability and Maintainability
- Specifies submittal requirements related to novel concept

Full Class Approval

- Detailed Risk Assessments:
  - Quantitative risk methods
    - Types (Event Trees, Fault Trees, Structural Reliability)
    - Uses and limitations
    - Submittal requirements prior to initiating risk assessments
  - Selection of target reliability and risk acceptance criteria
    - Difficulties in criteria selection for novel concepts
    - Backup and justification requirements prior to accepting risk acceptance criteria
  - Comparative risk assessments
  - Risk submittal requirements
- Review of Hazard Register to ensure all identified hazard addressed
- Review of final design to ensure no new hazards created

Survey/Maintenance of Class

- Input to Survey During Construction
  - Critical Areas
  - Verification and Witness of Testing
- Input to Survey During In-Service Operation
  - Maintenance schedules
  - Inspection scope/frequency
  - Conditional failure probabilities
  - Pilot Testing of Novel Features

Broadwater Energy

ABS Review Team Organization

18MAR05

APPENDIX "B"