Sentinel Midstream, LLC
Attn: Captain Dan Harris
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Your ref TGL Deepwater Port, Manuevering Area Risk Assessment

Our ref PRJ11100412210

16 June 2023

Dear Captain Harris,

This letter summarizes Lloyd's Register (LR) findings on the minimum maneuvering area (MMA) for the Texas GulfLink Deepwater Port (TGL DWP) based on a preliminary risk assessment carried out according to the anticipated risk informed criteria of Sentinel Midstream; supermajor Independent Oil Companies ("IOCs" or "majors"); and what is expected by the US regulatory space, specifically the US Coast Guard. The risk vectors were safety, environment, and asset which is common in the regulatory space and industry practice.

The TGL DWP is proposed for a location approximately 28 nautical miles offshore Freeport, Texas in about 32 meter water depth. The MMA is effectively defined by the location of the fixed platform relative to the single point moorings (SPM) at about 1.25 nautical mile separation. Other fixed obstacles, such as water depth less than 23 meter, where a ship will ground, or other fixed obstacles are several miles away.

The TGL DWP field arrangement is modeled on the Louisiana Offshore Oil Port (LOOP) Terminal arrangement, located offshore Louisiana. LOOP is generally considered as a reference standard for SPMs around the world because of its successful operation for over 40 years with no serious accidents. The ABS *Rules for Building and Classing Single Point Moorings* use the LOOP Terminal as a basis for establishing the MMA. The TGL DWP is designed to accommodate supertankers known as VLCCs of up to 320,000 DWT.

Sentinel Midstream requested two primary opinions:

1. LR's opinion on a generic MMA based on industry guidance and risk tolerance limits for the TGL DWP as located in what are defined as "exposed waters" (46 CFR 170.050) in the northern Gulf of Mexico for loading VLCCs;
2. LR's opinion and comments on the TGL DWP MMA of 1.25 nautical miles.

The risk assessment was simplified to bias towards conservative results:

1. Focus on "rough" departures or breakaways where a tanker comes off the SPM without full control in dynamic and dangerous conditions—by comparison, approaches to the SPM are under tight control with numerous safe exit opportunities;

2. Consideration of the guidelines and standards of the industry for SPMs which generally exceed regulatory requirements in risk informed safety cultures;
3. Use of consequence-based risk analysis—meaning that the assessment considers the event that a ship will break free and focuses on the use of mitigations to move the system to a safe state following an adverse event. The MMA is a primary mitigation because sea space provides time and space. Time and space are highly valued resources for the in-field team to recover from an event; and
4. An allision with the platform is considered a major accident in one or more of the risk vectors.

Opinions

LR recommends that a 1.1 nautical mile MMA is the minimum that would be considered acceptable in the northern Gulf of Mexico for an SPM terminal servicing VLCC Class tankers based on these acceptability criteria. LR specifically considered the guidance of ABS, PIANC, and OCIMF among others.

Sentinel Midstream's proposal of 1.25 nautical miles for the MMA exceeds the LR recommended minimum by about 85% of a ship length, which is highly valued in a rough departure or breakaway given the dynamic and ambiguous scenario.

Two elements are important to consider:

1. The OCIMF *Single Point Mooring Operations Guide* indicates the use of a "consequence" analysis besides a risk analysis. This simplifies the scenario in the sense that prevention barriers are to be ignored and the assumption is that an event will happen. Breakaways are real: They have happened and frequently enough that they cannot be explained away. LR endorses this view because it leads to a better safety system because the assumption is that something can and will happen rather than being so rare that people and organizations lose sight of the hazard potential.
2. Sentinel Midstream has requested a thoughtful consideration of expert mariner opinions on the MMA. This aspect is limited in the industry guidelines. This request inherently can make the MMA estimate more conservative because the minimum is effectively a calculation while the mariner opinions can only add to the MMA. LR endorses this view because human factors are a prominent aspect of accidents and the eventual outcomes of those accidents.

Lloyd's Register has made several recommendations on the TGL DWP proposition based on the Sentinel Midstream operating philosophy and the dynamics of fast rising and changing conditions in the TGL DWP field in extreme events. These recommendations serve to improve the TGL DWP proposition.

Best regards
Peter Wallace, PE, CEng, CMarEng
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Technical Advisory Services

Executive Summary--Risk Assessment of Maneuvering Area for the Texas GulfLink Deepwater Port

Report for: Sentinel Midstream LLC

Name of client: Sentinel Midstream LLC

Report no.: TR-23-28

Project no.: TGL DWP Assessment

Revision no.: 2

01 June 2023

Summary

Risk Assessment of Maneuvering Area for the Texas GulfLink Deepwater Port

Project Number: PRJ11100412210

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Document control

Revision history

Revision No.	Date	Revision
0	1 May 2023	Initial Issue
1	23 May 2023	Added section on Under Keel Clearance
2	1 Jun 2023	Clarified wording according to client comments

Proprietary Notice

This report was prepared under LR Proposal No. 23.027, Rev. 1, 27 March 2023 for Sentinel Midstream LLC.

The information contained herein may be used or further developed by Sentinel Midstream LLC for their purposes only.

Complete use and disclosure limitations are contained in Request for Advisory Services issued 23 March 2023.

Executive summary

Sentinel Midstream is planning to build and operate a deepwater terminal offshore Freeport, Texas to export crude oil to Very Large Crude Carriers (VLCCs) via single point moorings (SPMs).

Sentinel Midstream has requested Lloyd's Register (LR) to provide an independent assessment of the "maneuvering area" of the TGL DWP and provide an opinion on the minimum maneuvering area and what would be prudent for better operators that desire compatibility with requirements of an IOC super major.

Lloyd's Register was asked to provide opinions on four aspects:

1. What is the absolute minimum distance for the maneuvering area for the TGL DWP based on narrow reading of criteria which may not incorporate comprehensive mariner opinions or other qualitative experiences which lead to more conservative results;
2. A recommended minimum distance for maneuvering area that includes more realistic allowance for human factors in the face of dynamic and deteriorating conditions and generally meet the intent of IOC oil major terminal vetting criteria for technical and operational risk;
3. Direct comment on the TGL DWP proposal of 1.25 nm; and
4. Recommendations on controls necessary to use the 0.7 nm minimum distance as arrived at for protected water guidance.

A complete risk management program form is included in the full report, of which this is the executive summary.

Contents

1. Background

Sentinel Midstream is planning to build and operate a deepwater terminal offshore Freeport, Texas to export crude oil to large crude oil tankers known as Very Large Crude Carriers (VLCCs) via single point moorings (SPMs).

The Texas GulfLink Deepwater Port's (TGL DWP) design is proposed to be made up of two SPMs with an in-field manned platform. The SPMs and platform are connected to the shore infrastructure via 42-inch diameter subsea pipelines and conductors. The TGL DWP evaluated and modelled the LOOP Terminal port design.

Sentinel Midstream has requested Lloyd's Register (LR) to provide an independent assessment of the "maneuvering area" of the TGL DWP and provide an opinion on the minimum maneuvering area and what would be prudent for better operators that desire compatibility with requirements of an IOC super major (e.g. ExxonMobil, Shell, bp, Total, Chevron, ConocoPhillips, Phillips 66).

A complete risk management program form is included in the full report which includes recommendations on technical operations and human element.

1.1 Field Arrangement and VLCC Makeup

The TGL DWP field arrangement consists of two SPMs and a nearby manned platform. The TGL DWP is approximately 26 nautical miles offshore Freeport, Texas. Figure 1 illustrates the field arrangement. The water depth is about 32 meters throughout the field and the distance between the platform and the SPMs is 1.25 nautical miles.

A VLCC is connected to an SPM in a "conventional makeup" (Figure 2) consisting of mooring hawsers from the SPM to the VLCC, the VLCC, tow line, and station-keeping tug. The cargo is transferred through two floating hoses that run between the SPM and the midship manifold of the VLCC. The TGL DWP has a vapor recovery hose running from the midship manifold to a DP2 OSV that stands off the VLCC at 30 meters with specialized vapor capture equipment on board. The "conventional makeup" is consistent with OCIMF guidance on SPM operations and mooring guidelines. OCIMF *Guide for Offshore Tanker Operations* (GOTO) recommends static tow lines of about 1 ship length (~300+ meters) for station keeping at SPMs, as used in practice at the LOOP Terminal.

The TGL DWP is sized for VLCCs of up to 320,000 DWT, which equates to a ship of about 350,000 tonnes displacement, 330 meter length, and 23 meter full load draft. The dominant parameters for the manuevering area assessment are the length (330 meters) and draft (23 meters).

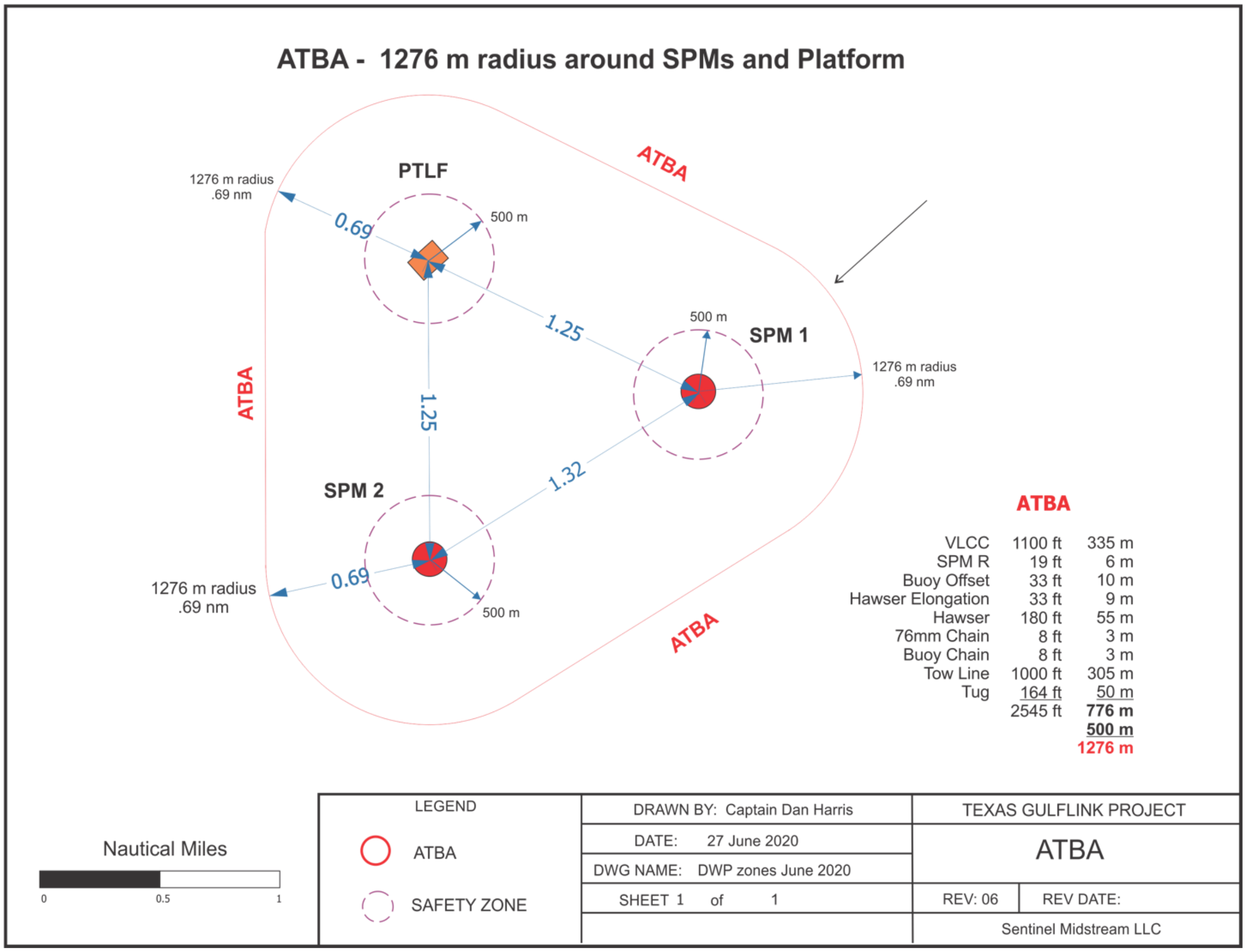

Figure 1: Texas GulfLink Deepwater Port Field Arrangement

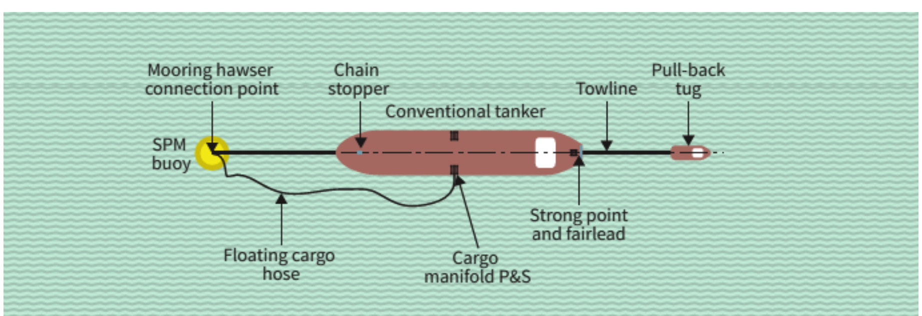

Figure 2: Conventional Makeup at SPM (Ref: OCIMF *Guidelines for Offshore Tanker Operations*)

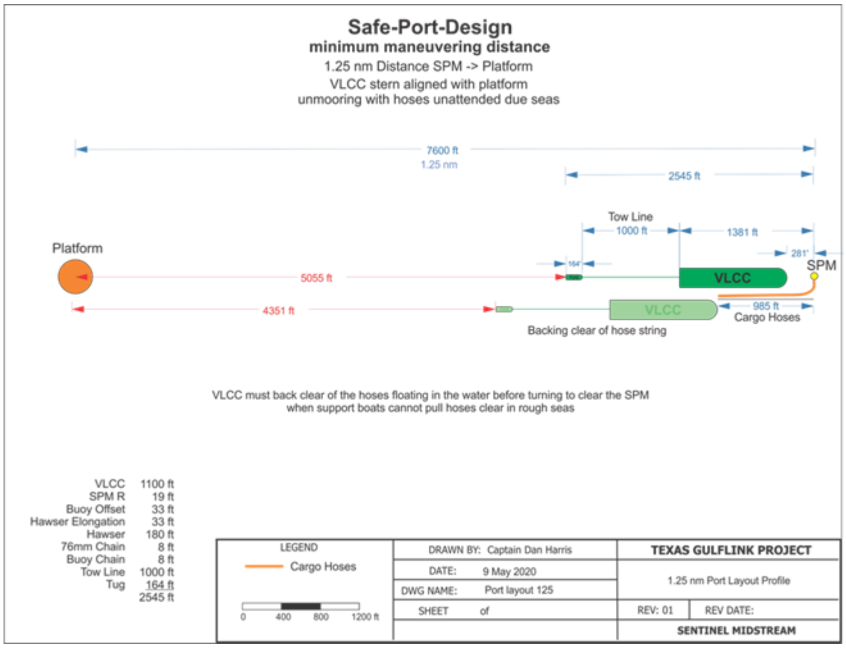

Figure 3: VLCC Conventional Makeup at TGL DWP (Ref: Sentinel Midstream)

1.1.1 Key parameters

Parameter	Value
VLCC Dimensions	330 meter length, 22.6 m draft, 320,000 DWT
VLCC Propulsion	Single screw, direct connect diesel drive on standby within 10 minutes (not immediate)
Cargo Hoses	Run from SPM to midship manifold with MBC at VLCC, hose length of 300 meters.
Vapor Recovery	Vapor recovery hose connected to OSV with MBC at the OSV. Hose length is 100 meters. OSV is DP2 rated. The hose does not get entangled in VLCC propulsion or navigation gear when fully extended.
Distance between SPM and platform	1.25 nautical miles (nm).

1.2 Operations of Interest and Battery Limits

Sentinal Midstream has requested LR to focus on "rough" departures, severe weather events, and breakaways because SPM approaches are highly controlled, occur in good conditions, and have multiple immediately available safe exit measures with sufficient time to coordinate and execute.

The operations of interest are assessed in terms of VLCC makeup arrangements, vessel handling, and human/system interactions for the watchkeeping and navigation personnel.

Rough departures are those that are made in haste in a fast rising condition before normal departure procedures can be completed or implemented.

Breakaways represent extreme events that can, and do, occur typically in fast rising storm conditions, but also at other times. The LOOP Terminal has had four known breakaways in its 40+ year operating history with one occurring in April 2021 during a microburst event. Certain events, such as microbursts, are not detectable by radar and raise conditions from "calm" to "heavy" weather in minutes with dynamic wind velocities.

Smaller vessels, such as Suezmaxes or Aframaxes, are not explicitly considered in this risk assessment because they are shorter, providing more relative maneuvering area, and are more easily handled by the in-field support vessels relative to VLCCs.

An allision with the other SPM is not considered because it is further away than the fixed platform.

The battery limits for this risk assessment are the maneuvering area for an SPM and the manned platform. The distance between the two SPMs is greater than the distance between an SPM and the platform and consequences of an allision with the platform are greater with the SPM; hence the focus on the platform scenarios.

Transient overpressures from sudden closures at the MBCs are handled by the overpressure protection system of the TGL terminal for the cargo hoses and shipboard pressure/vacuum system for the vapor recovery.

1.3 Summary Opinion

Lloyd's Register was asked to provide opinions on four aspects:

1. What is the absolute minimum distance for the maneuvering area for the TGL DWP based on narrow reading of criteria which may not incorporate comprehensive mariner opinions or other qualitative experiences which lead to more conservative results;
2. A recommended minimum distance for maneuvering area that includes more realistic allowance for human factors in the face of dynamic and deteriorating conditions and generally meet the intent of IOC oil major terminal vetting criteria for technical and operational risk;
3. Direct comment on the TGL DWP proposal of 1.25 nm; and
4. Recommendations on controls necessary to use the 0.7 nm minimum distance as arrived at for protected water guidance.

1.3.1 Opinion 1, Minimum Distance to Meet Minimum Requirements for Exposed Waters

The minimum distance to meet the general ABS SPM Rules, PIANC WG200, and OCIMF SMOG requirements for a facility located in the similar Gulf of Mexico location as the proposed TGL DWP would be about 0.98 nm based on the PIANC guidance of 4xL plus an additional 500 meters to allow for an "exclusion zone" around the platform.

A 500 meter exclusion zone is common practice in the offshore industry for an area that requires heightened awareness and procedures for the facility and vessels within that zone. This would meet the ABS, and OCIMF guidelines for minimum maneuvering area and is in line with established industry standards. It may potentially require enhanced active controls and metocean limits for operations to meet the risk/consequence assessment context of the SMOG.

1.3.2 Opinion 2, Minimum Recommended Distance for Exposed Waters

The minimum recommended distance in exposed waters to accommodate realistic human factors, common operating practice, and follow the intent of IOC oil major terminal vetting is based on the minimum with additional maneuvering area added to accommodate a "consequence" based risk tolerance and professional accounting for the interactions in terms of detection of a breakaway and recovery from a rough departure or breakaway in escalating and dynamic weather conditions.

This minimum maneuvering distance is more difficult to ascertain, but likely to be more in the range of 1.1 nm—inclusive of a 500 meter exclusion zone around the platform--or more to account for sea room to maneuver the vessel in a range of conditions and scenarios prior to entering the 500 meter exclusion zone. The distance of 1.1 nm is consistent with the LOOP Terminal maneuvering area scaled to a VLCC.[1]

This distance would be consistent with the minimum expectations of oil majors in general.

1.3.3 Opinion 3, TGL Proposal at 1.25 nautical miles

Sentinel Midstream has sought professional opinions and analyses from a range of experts on the maneuvering area. It has been a consistent finding that a distance of 0.65 nm is too close from a practical, risk based approach. The 0.65 nm distance is close to the ABS SPM Rules theoretical limit that might be applied in extreme cases of what would amount to low consequence events with consequences being assessed on safety, environmental, and asset damage vectors. An allision with a fixed platform or SPM is a high consequence event in multiple risk vectors.

The TGL DWP proposal of 1.25 nm is a reasonable distance based on the desktop and ship simulation work done to date to account for the exposed water location, metocean conditions, shallow water effects, and known incident experience from other SPMs. Other operations notes from Sentinel Midstream indicate a desire to conform to oil major expectations on safety culture and practices. The additional 0.15 nm above the minimum for better operators is about 85% of a VLCC ship length, which is highly valued sea room.

LR has several recommendations for potential improvement on the technical operations to enhance the safety of the TGL DWP within the proposed field arrangement and maneuvering area. Details are included in the full report.

1.3.4 Opinion 4, Minimum Distance based on Protected Waters Guidance

The minimum distance for *protected* waters based on ABS SPM Rules, OCIMF and PIANC is about 0.7 nautical miles.

This arrangement would not be prudent for exposed locations unless more protections and vessel limitations are in place.

These additional protections would be engineering, active, and operational controls including, but not limited to: Ships to have electric propulsion systems with on-line primer movers; potentially use North Sea type cargo hose bow couplings to limit the cargo hose length; several powerful escort tugs on standby to

[1] The LOOP Terminal was sized for ULCCs of 700,000 DWT which corresponds to a ship length in excess of 450 meters. A VLCC is typically around 330 meters in length. TGL DWP is located in similar site specific conditions as LOOP Terminal in terms of metocean and water depth.

assist in ship handling; more limitations on metocean conditions; smaller class of vessels (e.g. aframax); or emergency management protocols that differ from conventional ways of working.

These protections would lead to a substantially different terminal operation than envisioned from a conventional SPM arrangement.

2. Standards and Guidance

2.1 Introduction

The ABS SPM Rules, PIANC WG200, and OCIMF guidelines for exposed waters recommend or require maneuvering areas in excess of those required for protected waters.

The ABS *Rules for Building and Classing Single Point Moorings* (ABS SPM Rules) and PIANC guidelines are clear on the minimum distances for protected waters. Both ABS and PIANC state the maneuvering area should be substantially increased in exposed locations. They are both vague on the additional requirements. The intent is to invite careful consideration of the site specific installations contemplated under these rules.

Since there are no specified goal based or performance criteria, the additional maneuvering area is difficult to solve for in a definitive way. Industry practice has been to assess the field design and site specific conditions through bridge simulations that account for combinations of extreme and dynamic metocean conditions, mechanical failures, or human error. The bridge simulations are worked through with multiple experts present until a consensus is reached that the field arrangement is acceptable in the design stage. The bridge simulation must also take into account the minimum safety margin, exclusion zone, or buffer area that is prudent around a nearby manned platform in accepting a consensus. Reaction time in a planned simulation is keen with forethought compared to an unpredictable real life upset event with critical personnel out of position. Also, communications and situational understanding pauses, and other human factor will add delays to the real-life event. “Work as done” is slower in reaction than “work as imagined.”

Oil majors have little specific guidance for SPM terminals maneuvering other than use of industry rules and guidelines such as Class[2] rules (ABS), OCIMF, PIANC, and others. In the case of SPMs, ABS Class rules, OCIMF, and PIANC are dominant. Precedence, particularly from well established and well operated terminals plays a central role in helping an oil company determine if an SPM terminal is acceptable for its use. The LOOP Terminal is a well established reference for SPMs in exposed waters.

Oil majors have established safety cultures and requirements for subcontractors and industry partners to have safety management systems, quality systems, and operations plans to address routine operations and emergency situations.

2.2 ABS SPM Rules (2023)

ABS defines the “maneuvering area” “…as the area through which a vessel is to maneuver in making an approach to, or a departure from, the SPM.” (ABS SPM Rules, 3-1-2/3.5)

[2] Most IACS Class Societies have rules governing design, construction, and survey of SPMs. ABS is prominent in terms of having rules on maneuvering area.

The radius of the maneuvering area is to be at least [*3xL + hawser length + buoy offset*]. This can be modified to be smaller in certain site specific applications or "increased substantially" for offshore exposed waters or other conditions that make vessel maneuvering more difficult. Fixed items, such as platforms or other SPMs are not to be within the maneuvering area.

There are no specific criteria on what amounts to "increased substantially."

ABS indicated that the 2023 rule change to ABS SPM Rules, 3-1-2/3.5, Site and Environmental Conditions, is "To increase mooring distances for offshore buoys based on client experience at LOOP mooring tankers." (ABS Notices and General Information, Table 3).

The emphasized wording shows the changes from the 2014 to the 2023 version changes:

> Where mooring maneuvers are to be made in extreme environments, the minimum radius is to be increased." To "Where mooring maneuvers are to be made in extreme environments, *including offshore exposed waters where the prevailing environment (wind, waves, current, squalls, microbursts, rotary currents, and shallow water effect) unfavorably influences the mooring maneuver,* the minimum radius is to be increased *substantially to account for an additional safety allowance necessary for safe vessel maneuvering under those conditions.* (Ref: ABS SPM Rules, 3-1-2/3.5).

The rule change implies that offshore SPMs designers may use the LOOP arrangement as guidance and adjust the maneuvering area according to the site specific conditions.

2.3 PIANC

PIANC WG200 (March 2023) guidelines generally state 4xL for the minimum maneuvering area that should be "…significantly increased beyond the minimum recommendations due to the environmental conditions found in exposed waters." (Ref. PIANC WG200, 5.1.2.1)

Exposed waters include locations *where the prevailing environment (wind, waves, current, squalls, microbursts, rotary currents, and shallow water effect) unfavorably influences the mooring manoeuvre*. (Ref. PIANC 5.1.2.1)

The 4xL formulation is unknown in terms of provenance, but is a well established starting point. The precise maneuvering area is generally taken with 4xL as the starting point and studies, such as maneuvering simulations, are made for the site specific terminal with specific conditions and criteria. For an exposed location SPM servicing a VLCC, the minimum maneuvering area would be 1,320 meters (0.71 nm). The emphasized language was adopted from the ABS SPM Rules.

2.4 OCIMF

The OCIMF SMOG (SMOG, 2.2.2) does not have a fixed rule for calculation of the maneuvering area. SMOG recommends that the maneuvering area be sized according to a "risk/consequence assessment" that addresses a number of factors including distances to obstacles, metocean conditions, vessel sizing, use/non-use of tugs, etc.

SMOG does not put forward specific prescriptive or risk tolerance criteria other than "risk/consequence" assessment accounting for a number of factors. SMOG specifically uses the term "consequence" to describe the assessment; this implies that events can and do happen making the consequence analysis prominent as well as recovery from incidents such as breakaways. SMOG provides a drawing depicting the SPM manoeuvring area with a substantial increased “clearance” distance to a nearby platform (Figure 4), beyond the minimum manoeuvring area. Maneuvering studies, such as desktop simulations or bridge simulations, that specifically address conditions where rough departures or breakaways occur are recommended.

OCIMF guidelines are a primary requirement for oil company use of vessels and terminals.

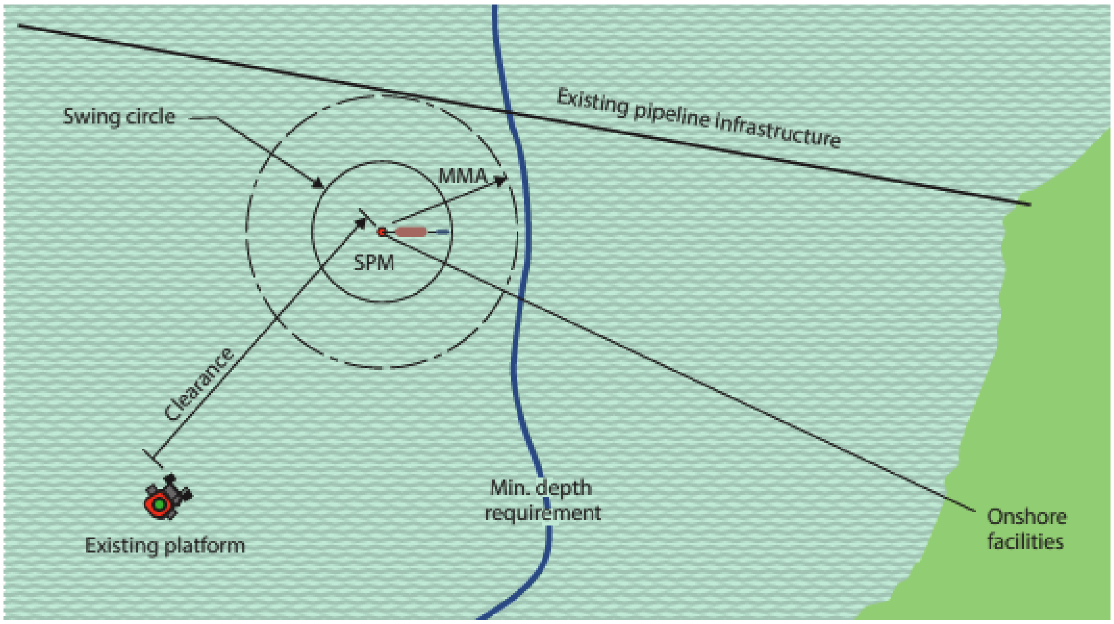

Figure 4: Additional Clearance for Platforms (Ref: OCIMF SMOG)

2.5 Summary Minimum Maneuvering Area Radius

The following are the summarized minima based on different requirement sets. The complete discussion is included in the full report.

Reference	Protected Waters	Exposed Waters	Notes
ABS SPM Rules (2023)	0.6 nm	1.1 nm	Exposed Waters based on LOOP Terminal
PIANC WG 200 (2023)	0.71 nm	0.98 nm	“substantial increase” is for a 500 meter exclusion zone around the platform
OCIMF SMOG	-	-	Risk/consequence assessment based Reference drawing provided

2.6 Comparison to Other Terminals for Maneuvering Area

Location	Type/Location	Distance	Notes
TGL DWP	CALM/Offshore US Gulf	1.25 nm	TGL DWP Proposal
LOOP Terminal	SALM/Offshore US Gulf	1.32 nm	Sized for ULCCs up to 700,000 DWT, which would be in excess of 450 meter length
NE Gateway	STL/Massachusetts Bay	1.0 nm	STL, LNG carriers. These are smaller vessels and the cargo connection is cleared once the buoy is cleared of the hull.
Exxon Hondo	Santa Barbara, California	1.50 nm	Decommissioned 12-year operation
Exxon West Africa	SPM/ West Africa	1.13 nm	Multiple locations, deepwater

2.6.1 LOOP (SALM SPMs, US Gulf)

The LOOP Terminal is the primary reference for TGL because of the similar arrangements, similar location, and proven history. The ABS Rules explicitly use LOOP Terminal as a primary reference for the maneuvering area.

The LOOP Terminal maneuvering area is 1.32 nm. Scaling for a VLCC vs. a ULCC would bring the maneuvering area to 1.13 nm.

2.6.2 NE Gateway (STL SPMs, Massachusetts Bay)

The Northeast Gateway is a submerged turret loading (STL) type of SPM located in Massachusetts Bay. It is used for transfer of LNG from LNG carriers to the shore terminals.

The NE Gateway uses a 1.0 nm maneuvering area, which is smaller than TGL. This is in line with the TGL proposal when considering the following differences between Northeast Gateway and TGL:

1. The LNG carriers are smaller than VLCCs. The LNG carriers are approximately 1/3 the displacement and ¾ the length of a VLCC.
2. LNG carriers have propulsion systems that can respond more quickly and with more effect than a conventional VLCC system.
3. There is no issue of hose entanglement once the LNG carrier is disconnected from the STL, meaning the LNG carrier can be shifted and turned at the buoy location instead of having to backdown almost 1 ship length to begin maneuvering.

3. Other Professional Reviews and Opinions

3.1 Summary

Sentinel Midstream has requested opinions or technical analyses from a variety of experts regarding the maneuvering area.

3.2 Glosten Associates

Glosten Associates, a naval architecture firm, ran several desktop maneuvering simulations of the TGL DWP. They found that in several simulations that the VLCC allided with the platform when using a 0.65 nm separation.

3.3 Locus/Maritime Pilots Institute

Locus, a firm that specializes in bridge and manned model simulations, summarized their findings as follows:

The further platform, located in the simulations at a location of 1.25nm distance from the SPM. was not in a risk hazard situation during any of the simulations. However, the alternate platform locations, located at 0.65nm from the SPM, was in a risk hazard during all simulations. (Ref: LOCUS/MPI Report, 4 August 2021).

3.4 Pilots

Several pilots and master mariners provided opinions on the 0.65 nm and 1.25 nm separation with consensus being 0.65 nm is too risky and 1.25 nm is a reasonable distance that a skilled and professional staff can maintain safe operations and recover from rough departures or breakaways.

Specific experts included:

- Sentinel Midstream/Captain Dan Harris (retired LOOP Mooring Master)
- Exxon/ Captain W.Deepe
- Sandy Hook Senior Pilot/ Captain T. Ferrie

3.5 Atlantic Technical Management

Atlantic Technical Management (ATM) reviewed the minimum maneuvering area obtained from ABS, PIANC, and OCIMF from a perspective of master mariners and arrived at a minimum maneuvering area of 1.0 nm for the TGL DWP. ATM had multiple in-house Captains review the port design.

4. Metocean

The TGL DWP is location is generally "benign," except for the winter months, with calm winds and seas well within operational limits of the SPM and ships. There are occasional storms, such as hurricanes, where sufficient advance warning is available to secure operations and move vessels to safe areas until the storm passes.

There are rare "microbursts" events with accompanying strong winds and increasing seas that may or may not be detectable by radar. The April 2021 microburst off Louisiana is such an example. This is the type of escalating condition that leads to rough departures or breakaways. Intense, and occasionally severe, summer squalls and thunderstorms occur regularly.

There is a steady current of less than 0.75 m/s (1.5 knots) with occasional loop current eddies passing through.

The fatigue life of mooring hawsers decreases with frequency and strength as the seas and swells build.

5. Under Keel Clearance

Shallow water effects have implications on the maneuvering performance of ships. The "Under Keel Clearance" (UKC) is a common measure of how "shallow" the water is and gives an indication of the general performance degradation of the vessel. The turning circle of the vessel—the most important maneuvering characteristic of the departing VLCC—increases as the water becomes shallower.

Generally, it is difficult to assess the precise changes based on a general vessel class because the effects are non-linear and coupled with a variety of factors. The general, net effect, can be inferred from descriptive ranges such as "shallow water," "medium depth," or "deep water." These descriptions, while hardly standardized, give a good description when matched to explicit UKC ratios.

The UKC ratio, defined as (h−T)/T where "h" is the water depth and "T" is the vessel draft, is about 40% for the fully laden VLCC at the TGL DWP. This is the conservative condition for consideration because the lighter draft conditions have tighter turning circles and higher UKC values. Figure 5 illustrates comparative turning circles for a vessel in various UKC ranges. For the VLCC at TGL DWP, these circles are at the following water depths for a 23 m draft VLCC: 25.3 m (10% UKC), 27.6 m (20% UKC), and 46 m (100% UKC). The degradation of the turning circle for waters shallower than 27.6 m is rapid while minimal by comparison for the 40-50% UKC for TGL DWP (32 meters).

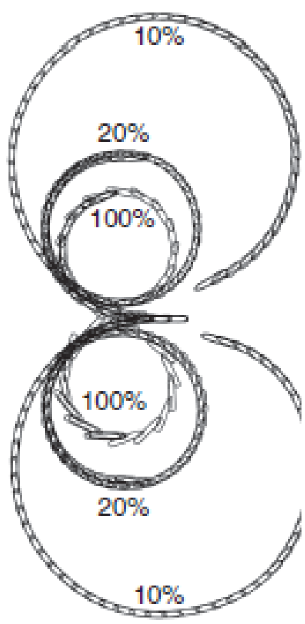

Figure 5: UKC Effect on Turning Circle (Ref: Vantorre, et al.)

Another aspect to consider is that many of the SPMs are in relatively shallow waters and the guidance that has developed over time inherently accounts for some degree of shallow water effect.

The minimum maneuvering area opinions considered the "medium" shallow water range of around 40%. The LOOP Terminal, the reference design, has a similar UKC limit for fully laden vessels. The TGL DWP specific studies by LOCUS/MPI studies were at UKC ~55%.

To reduce the maneuvering area based on having full deepwater performance characteristics would start to occur in about the 50-70 meter water depth, and even then the reduction on maneuvering area would be marginal.

The minimum maneuvering area would need to be increased if the UKC ratio started to approach 30% from a reference of about 40%-50%.

6. Abbreviations

ABS: American Bureau of Shipping

Aframax: Large crude oil tanker size of around 100,000 DWT

ATBA: Area to Be Avoided

CALM: Catenary Anchor Leg Mooring system

DP2: Dynamic Positioning, Class 2 which allows for a single fault or failure of an active component in the system and retain automatic stationkeeping capability.

DWT: Deadweight Tonnes, a measure of the cargo capacity of the ship and a general proxy for tanker size.

IOC: Independent Oil Company

LNG: Liquified Natural Gas

LOOP Terminal: Louisiana Offshore Oil Port

LR: Lloyd's Register

MBC: Marine Breakaway Coupling

Nm: nautical mile (1,852 meters)

OCIMF: Oil Companies International Marine Forum

OSV: Offshore Support Vessel

PIANC: The World Association for Waterborne Transport Infrastructure

SALM: Single Anchor Leg Mooring

SPM: Single Point Mooring

STL: Submerged Turret Loading

Suezmax: A large crude oil tanker of about 150,000 DWT

TGL DWP: Texas GulfLink Deepwater Port

UKC: Under Keel Clearance

ULCC: Ultra Large Crude Carrier, a large crude oil tanker of greater than 350,000 DWT.

VLCC: Very Large Crude Carrier, a large crude oil tanker ranging from 270,000-350,000 DWT.

7. References

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Risk Assessment of Maneuvering Area for the Texas GulfLink Deepwater Port in the Northern Gulf of Mexico

Report for: Sentinel Midstream LLC

Name of client: Sentinel Midstream LLC

Report no.: TR-23-32

Project no.: TGL DWP Assessment

Revision no.: 0

16 June 2023

Summary

Risk Assessment of Maneuvering Area for the Texas GulfLink Deepwater Port in the Northern Gulf of Mexico

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1.0	16 Jun 2023	Initial Issue

Proprietary Notice

This report was prepared under LR Proposal No. 23.027, Rev. 1, 27 March 2023 for Sentinel Midstream LLC.

The information contained herein may be used or further developed by Sentinel Midstream LLC for their purposes only.

Complete use and disclosure limitations are contained in Request for Advisory Servicers issued 23 March 2023.

Executive summary

Sentinel Midstream is planning to build and operate a deepwater terminal offshore near Freeport, Texas to export crude oil to Very Large Crude Carriers (VLCCs) via single point moorings (SPMs).

Lloyd's Register (LR) provided an independent assessment of the "maneuvering area" of the TGL DWP and provided an opinion on the minimum maneuvering area and what would be prudent for better operators that desire compatibility with requirements of an IOC super major.

Lloyd's Register provide opinions on four aspects:

1. A recommendation on the absolute minimum distance for the maneuvering area for the TGL DWP based on narrow reading of criteria which may not incorporate comprehensive mariner opinions or other qualitative experiences which may ultimately lead to more conservative results;
2. A recommended minimum distance for maneuvering area that includes more realistic allowance for human factors in the face of dynamic and deteriorating conditions and generally meet the intent of IOC oil major terminal vetting criteria for technical and operational risk;
3. Direct comment on the TGL DWP proposal of 1.25 nm; and
4. Recommendations on controls necessary to use the 0.7 nm minimum distance as arrived at for protected water guidance.

This risk assessment includes recommendations summarized in the Risk Management Recommendations section of this report.

A list of assumptions made in this assessment is included in the Assumptions section of this report.

Contents

List of Figures

List of Tables

1. Background

Sentinel Midstream is planning to build and operate a deepwater terminal offshore near Freeport, Texas to export crude oil to large crude oil tankers known as Very Large Crude Carriers (VLCCs) via single point moorings (SPMs).

The Texas GulfLink Deepwater Port's (TGL DWP) design is proposed to be made up of two SPMs with an in-field manned platform. The SPMs and platform are connected to the shore infrastructure via 42-inch diameter subsea pipelines and conductors. The TGL DWP evaluated and modelled the LOOP Terminal port design.

Sentinel Midstream has requested Lloyd's Register (LR) to provide an independent assessment of the "maneuvering area" of the TGL DWP and provide an opinion on the minimum maneuvering area (MMA) and what would be prudent for operators that desire compatibility with requirements of an IOC super major (e.g. ExxonMobil, Shell, BP, TotalEnergies, Chevron, ConocoPhillips, Phillips 66). This applies to the range of conditions that may arise during operations.

A risk management program form is included which includes recommendations related to technical operations and human factors.

1.1 Field Arrangement and VLCC Makeup

The TGL DWP field arrangement consists of two SPMs and a nearby fixed manned platform. The TGL DWP is approximately 28 nautical miles offshore Freeport, Texas. Figure 1 illustrates the field arrangement. Sentinel Midstream has indicated that the water depth is about 32 meters throughout the field and the distance between the platform and the SPMs is 1.25 nautical miles. The MMA is effectively defined as the distance between the SPM and the fixed platform because the water depth limitations for grounding or other fixed obstacles are further away than the platform to SPM distance.

A VLCC is connected to an SPM in an OCIMF compliant "conventional makeup" (Figure 2) consisting of mooring hawsers from the SPM to the VLCC, the VLCC, towline, and station-keeping tug. The cargo is transferred through two floating hoses that run between the SPM and the midship manifold of the VLCC. The TGL DWP has a vapor recovery hose running from the midship manifold to a DP2 OSV that stands off the VLCC at 30 meters with specialized vapor capture equipment on board. OCIMF *Guide for Offshore Tanker Operations* (GOTO) recommends static tow lines of about 1 ship length (~300+ meters) for station keeping at SPMs, as used in practice at the LOOP Terminal. The MMA must allow sufficient space for the tug to operate in an unrestricted manner when considering the tow line and VLCC.

The TGL DWP is sized for VLCCs of up to 320,000 DWT, which equates to a ship of about 350,000 tonnes displacement, 330 meter length, and 23 meter full load draft. The dominant parameters for the manuevering assessment are the length (330 meters), draft (23 meters), and fully laden displacement. The displacement of the VLCC effectively sizes the ship handling tug.

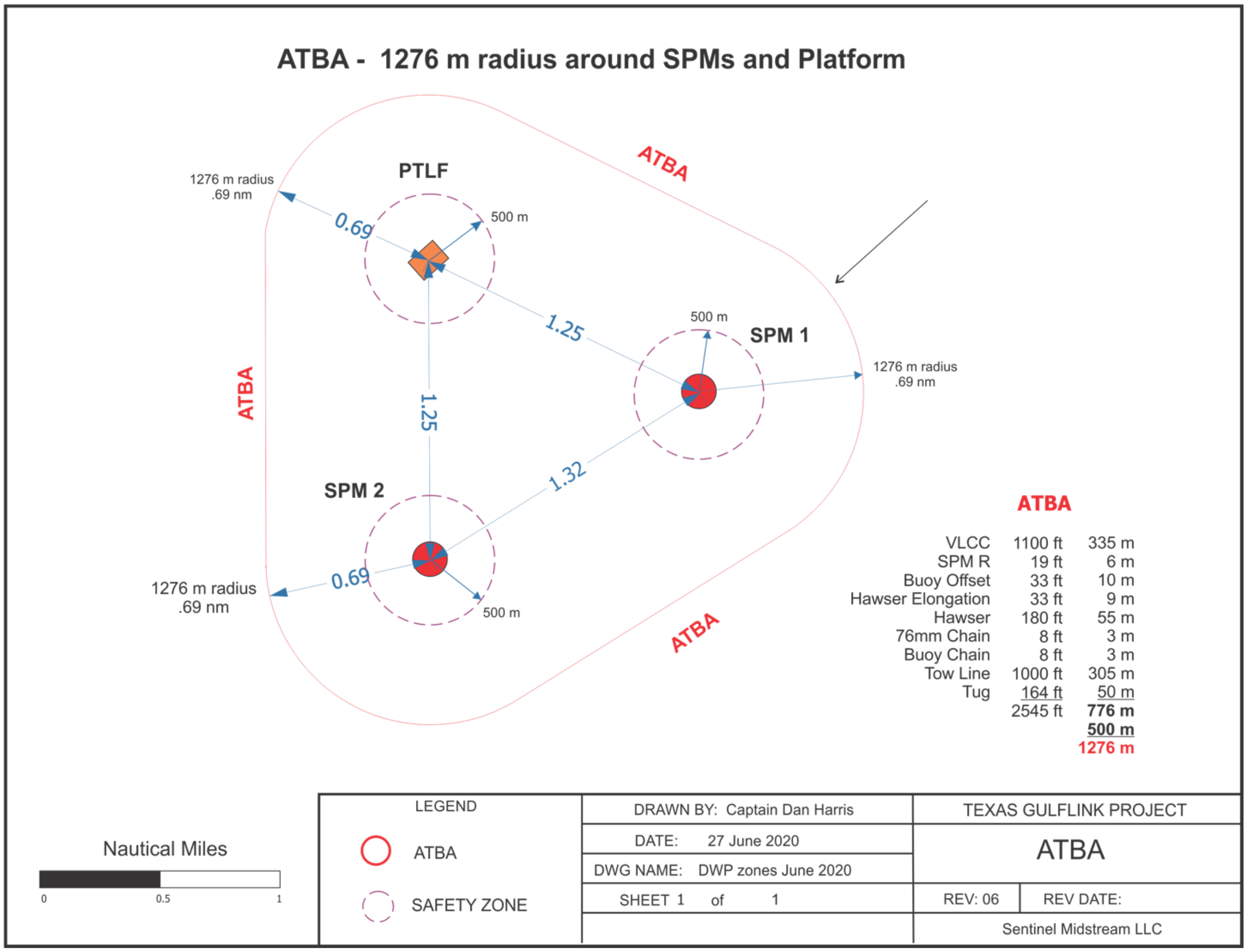

Figure 1: Texas GulfLink Deepwater Port Field Arrangement

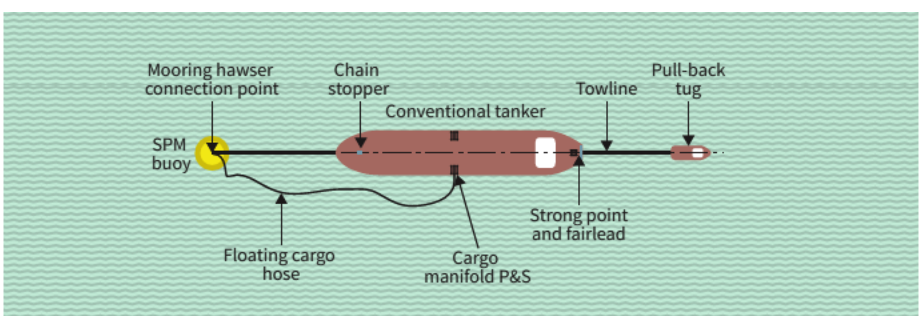

Figure 2: Conventional Makeup at SPM (Ref: OCIMF *Guidelines for Offshore Tanker Operations*)

1.1.1 Key parameters

Table 1: Key parameters for Minimum Maneuvering Area at TGL DWP

Parameter	Value
VLCC Dimensions	330 meter length, 22.6 m draft, 320,000 DWT
VLCC Propulsion	Single screw, direct connect diesel drive on standby within 10 minutes (not immediate)
Cargo Hoses	Run from SPM to midship manifold with MBC at VLCC, hose length of 300 meters.
Vapor Recovery	Vapor recovery hose connected to OSV with MBC at the OSV. Hose length is 100 meters. OSV is DP2 rated. The hose does not get entangled in VLCC propulsion or navigation gear when fully extended.
Distance between SPM and platform	1.25 nautical miles (nm).
Water Depth	~32 meters
Location	Exposed Waters, 46 CFR 170.050 Northern Gulf of Mexico
Mooring Hawser Makeup	In accordance with OCIMF MEG4
Station Keeping Tug Makeup	In accordance with OCIMF GOTO

1.2 Operations of Interest and Battery Limits

Sentinel Midstream has requested LR to focus on "rough" departures and breakaways because SPM approaches are highly controlled, occur in good conditions, and have immediate safe exit measures with sufficient time to coordinate and execute.

The operations of interest are assessed in terms of VLCC makeup arrangements, vessel handling, cargo hose arrangement, mooring arrangement, and human/system interactions for the watchkeeping and navigation personnel.

Rough departures are those that are made in haste in fast rising conditions before normal departure procedures can be completed or upset events such as failure of critical equipment. These departures often require the VLCC to back upwards of 350 meters from the SPM to clear the cargo hoses that were unattended by support boats due operational limits.

Breakaways represent extreme events that can, and do, occur typically in fast rising storm conditions. The LOOP Terminal has had four known breakaways in its 40+ year operating history with one occurring in April 2021 during a microburst event. Certain events, such as microbursts, might not be detectable by radar and raise conditions from "calm" to "heavy" weather in minutes with dynamic wind velocities.

Smaller vessels, such as Suezmaxes or Aframaxes, are not explicitly considered in this risk assessment because they are shorter, providing more relative maneuvering area, and are more easily handled by the in-field support vessels relative to VLCCs.

An allision with the other SPM is not considered because it is further away than the fixed platform.

The battery limits for this risk assessment are the maneuvering area for an SPM and the manned platform. The distance between the two SPMs is greater than the distance between an SPM and the platform and consequences of an allision with the platform are greater with the SPM; hence the focus on the platform scenario.

Transient overpressures from sudden closures at the MBCs are handled by the overpressure protection system of the TGL terminal for the cargo hoses and shipboard pressure/vacuum system for the vapor recovery.

1.3 Summary Opinion

Lloyd's Register was asked to provide opinions on four aspects:

1. What is the absolute minimum distance for the maneuvering area for the TGL DWP in the northern Gulf of Mexico based on narrow reading of criteria which may not incorporate comprehensive mariner opinions or other qualitative experiences which lead to more conservative results;

2. A recommended minimum distance for maneuvering area that includes more realistic allowance for human factors, upset events, or sudden severe weather events leading to dynamic and deteriorating conditions and generally meet the intent of IOC oil major terminal vetting criteria for technical and operational risk;

3. Direct comment on the TGL DWP proposal of 1.25 nm; and

4. Recommendations on controls necessary to use the 0.7 nm minimum distance as arrived at for protected water guidance.

1.3.1 Opinion 1, Minimum Distance to Meet Minimum Requirements for Exposed Waters

The bare minimum distance to meet the general ABS SPM Rules, PIANC WG200, and OCIMF SMOG requirements for a facility located in the similar northern Gulf of Mexico location as the proposed TGL DWP would be about 0.98 nm based on the PIANC guidance of 4xL including an additional 500 meters to allow for an "exclusion zone" around the platform.

A 500-meter exclusion zone is common practice in the offshore industry for an area that requires heightened awareness and procedures for the facility and vessels within that zone. This would meet the ABS, and OCIMF guidelines for minimum maneuvering area and is in line with established industry standards. It may potentially require enhanced active controls and metocean limits for operations to meet the risk/consequence assessment context of the SMOG.

1.3.2 Opinion 2, Minimum Recommended Distance for Exposed Waters

The minimum recommended distance in exposed waters to accommodate realistic human factors, common operating practice, and follow the intent of IOC oil major terminal vetting is based on the minimum with additional maneuvering area added to accommodate a "consequence" based risk tolerance and professional accounting for the interactions in terms of detection of a breakaway and recovery from a rough departure, upset event, or breakaway in escalating and dynamic weather conditions.

This minimum maneuvering distance is more difficult to ascertain, but likely to be more in the range of 1.1 nm—inclusive of a 500-meter exclusion zone around the platform--or more to account for sea room to maneuver the vessel in a range of conditions and scenarios prior to entering the 500-meter exclusion zone. The distance of 1.1 nm is consistent with the LOOP Terminal maneuvering area scaled to a VLCC.[1]

This distance would be consistent with the minimum expectations of oil majors in general.

1.3.3 Opinion 3, TGL Proposal at 1.25 nautical miles

Sentinel Midstream has sought professional opinions and analyses from a range of experts on the maneuvering area. It has been a consistent finding that a distance of 0.65 nm is too close from a practical, risk informed approach in exposed waters[2].

The TGL DWP proposal of 1.25 nm is a reasonable distance based on the desktop and ship simulation work done to date to account for the exposed water location, metocean conditions, shallow water effects, known incident experience from other SPMs, and professional mariner opinion. Other operations notes from Sentinel Midstream indicate a desire to conform to oil major expectations on safety culture, practices, and risk tolerance. The additional 0.15 nm above the minimum for exposed waters is about 85% of a VLCC ship length, which is highly valued sea room.

LR has several recommendations for potential improvement on the technical operations to enhance the safety of the TGL DWP within the proposed field arrangement and maneuvering area.

1.3.4 Opinion 4, Minimum Distance based on Protected Waters Guidance

The minimum distance for mooring VLCCs at an SPM in *protected* waters based on ABS SPM Rules, OCIMF and PIANC is about 0.7 nautical miles.

This arrangement would not be prudent for exposed waters in the northern Gulf of Mexico unless more protections and vessel limitations are in place.

These additional protections would be engineering, active, and operational controls including, but not limited to: Ships to have electric propulsion systems with on-line primer movers; potentially use North Sea type cargo hose bow couplings to limit the cargo hose length; several powerful escort tugs on standby to assist in ship handling; more limitations on metocean conditions; smaller class of vessels (e.g. aframax); or emergency management protocols that differ from conventional ways of working.

These protections would lead to a substantially different terminal design and operation than envisioned from a conventional SPM arrangement.

[1] The LOOP Terminal was sized for ULCCs of 700,000 DWT which corresponds to a ship length in excess of 450 meters. A VLCC is typically around 330 meters in length. TGL DWP is located in similar site specific conditions as LOOP Terminal in terms of metocean and water depth.

[2] The 0.65 nautical mile limit is based on the ABS SPM Rules calculation for protected waters. It is less than the 0.7 nm from the PIANC guidance.

2. Standards and Guidance

2.1 Introduction

The ABS SPM Rules, PIANC WG200, and OCIMF guidelines for exposed waters recommend or require maneuvering areas in excess of those required for protected waters. ABS, PIANC, and the CFRs make a clear distinction between protected waters and exposed water locations.

The ABS *Rules for Building and Classing Single Point Moorings* (ABS SPM Rules) and PIANC guidelines are clear on the minimum distances for protected waters. Both ABS and PIANC state the maneuvering area should be substantially increased in exposed locations. They are both vague on the “substantially increased” requirements. The intent is to invite careful consideration of the site-specific installations contemplated under these rules with consideration of the size of the vessels serviced.

Since there are no specified goal based or performance criteria, the additional maneuvering area is difficult to solve for in a definitive way. Industry practice has been to assess the field design and site-specific conditions through bridge simulations that account for combinations of extreme and dynamic metocean conditions, mechanical failures, or human error. The bridge simulations are worked through with multiple experts present until a consensus is reached that the field arrangement is acceptable in the design stage. The bridge simulation must also take into account the minimum safety margin, exclusion zone, or buffer area that is prudent around a nearby manned platform in accepting a consensus. Reaction time in a planned simulation is keen with forethought compared to an unpredictable real life upset event with critical personnel out of position. Also, communications and situational understanding pauses, and other human factor will add delays to the real-life event. “Work as done” is slower in reaction than “work as imagined.”

Oil majors have little specific guidance for SPM terminals maneuvering other than use of industry rules, terminal audits, and guidelines such as Class[3] rules (ABS), OCIMF, PIANC, and others. In the case of SPMs, ABS Class rules, OCIMF, and PIANC are dominant. Precedence, particularly from well established and well operated terminals plays a central role in helping an oil company determine if an SPM terminal is acceptable for its use. The LOOP Terminal is a well established reference for SPMs in exposed waters. Table 3: Maneuvering Areas for selected SPMs. Table 3 summarizes several SPMs and the associated MMA with Wandoo being the only one with less than a 1.0 nm MMA and even then it is restricted to smaller vessels.

Oil majors have established safety cultures and requirements for subcontractors and industry partners to have safety management systems, quality systems, and operations plans to address routine operations and emergency situations.

2.2 ABS SPM Rules (2023)

ABS defines the “maneuvering area” “…as the area through which a vessel is to maneuver in making an approach to, or a departure from, the SPM.” (ABS SPM Rules, 3-1-2/3.5)

The radius of the maneuvering area is to be at least [*3xL* + *hawser length* + *buoy offset*]. This can be modified to be smaller in certain site-specific applications or “increased substantially” for offshore exposed waters or

[3] Most IACS Class Societies have rules governing design, construction, and survey of SPMs. ABS is prominent in terms of having rules on maneuvering area.

other conditions that make vessel maneuvering more difficult. Fixed items, such as platforms or other SPMs are not to be within the maneuvering area.

There are no specific criteria on what amounts to “increased substantially.”

ABS indicated that the 2023 rule change to ABS SPM Rules, 3-1-2/3.5, Site and Environmental Conditions, is “To increase mooring distances for offshore buoys based on client experience at LOOP mooring tankers.” (ABS Notices and General Information, Table 3).

The emphasized wording shows the changes from the 2014 to the 2023 version changes:

> Where mooring maneuvers are to be made in extreme environments, the minimum radius is to be increased.” To “Where mooring maneuvers are to be made in extreme environments, *including offshore exposed waters where the prevailing environment (wind, waves, current, squalls, microbursts, rotary currents, and shallow water effect) unfavorably influences the mooring maneuver,* the minimum radius is to be increased *substantially to account for an additional safety allowance necessary for safe vessel maneuvering under those conditions.* (Ref: ABS SPM Rules, 3-1-2/3.5).

The rule change implies that offshore SPMs designers may use the LOOP arrangement as guidance and adjust the maneuvering area according to the site-specific conditions using a risk based approach.

2.3 PIANC

PIANC WG200 (March 2023) guidelines generally state 4xL for the minimum maneuvering area in protected waters should be “…significantly increased beyond the minimum recommendations due to the environmental conditions found in exposed waters.” (Ref. PIANC WG200, 5.1.2.1)

Exposed waters include locations *where the prevailing environment (wind, waves, current, squalls, microbursts, rotary currents, and shallow water effect) unfavorably influences the mooring manoeuvre*. (Ref. PIANC 5.1.2.1)

The 4xL formulation is unknown in terms of provenance, but is a well established starting point. The precise maneuvering area is generally taken with 4xL as the starting point and studies, such as maneuvering simulations, are made for the site-specific terminal with specific conditions and criteria. For an SPM servicing a VLCC in protected locations, the minimum maneuvering area would be 1,320 meters (0.71 nm). The emphasized language was adopted from the ABS SPM Rules.

2.4 OCIMF

The OCIMF SMOG (SMOG, 2.2.2) does not have a fixed rule for calculation of the maneuvering area. SMOG recommends that the maneuvering area be sized according to a “risk/consequence assessment” that addresses a number of factors including distances to obstacles, metocean conditions, vessel sizing, local conditions, use/non-use of tugs, etc.

SMOG does not put forward specific prescriptive or risk tolerance criteria other than “risk/consequence” assessment accounting for a number of factors. SMOG specifically uses the term “consequence” to describe the assessment; this implies that events can and do happen making the consequence analysis prominent as well as recovery from incidents such as breakaways. SMOG provides a drawing depicting the SPM manoeuvring area with a substantial increased “clearance” distance to a nearby platform (Figure 3), beyond the minimum manoeuvring area: The intent is clear that a significant distance between the SPM and the platform is intended. Maneuvering studies, such as desktop simulations or bridge simulations, that specifically address conditions where rough departures or breakaways occur are recommended.

OCIMF guidelines are a primary requirement for oil company use of vessels and terminals.

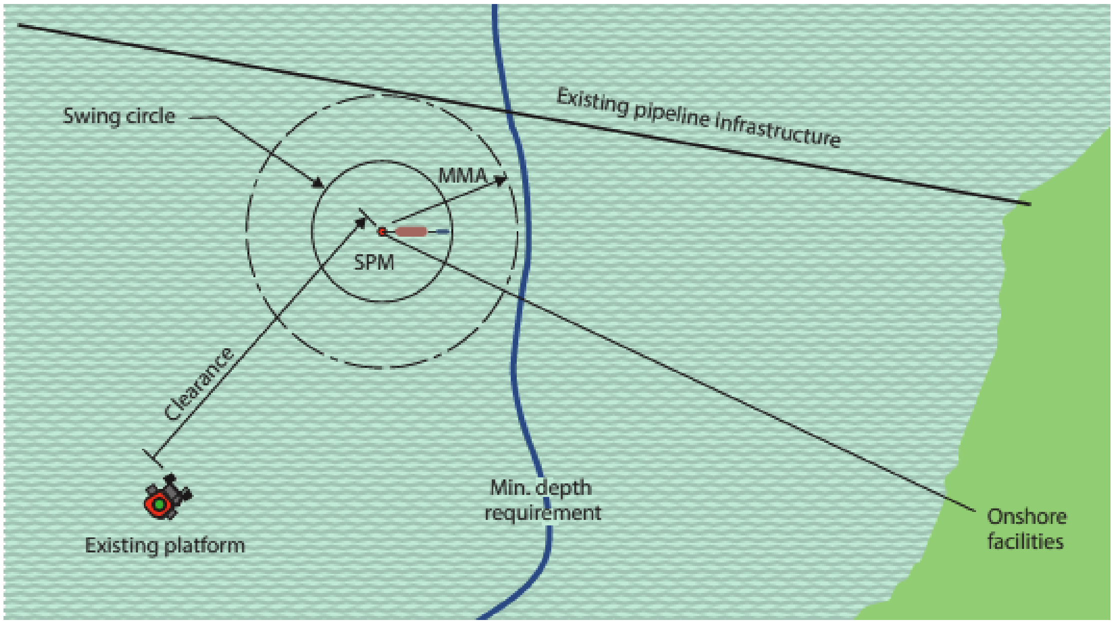

Figure 3: Additional Clearance for Platforms (Ref: OCIMF SMOG)

2.5 Summary Minimum Maneuvering Area Radius

The following are the summarized minima based on different requirement sets.

Table 2: Guidance on Minimum Maneuvering Area

Reference	Protected Waters	Exposed Waters	Notes
ABS SPM Rules (2023)	0.6 nm	1.1 nm	Exposed Waters based on LOOP Terminal
PIANC WG 200 (2023)	0.71 nm	0.98 nm	“substantial increase” is for a 500 meter exclusion zone around the platform
OCIMF SMOG	-	-	Risk/consequence assessment informed. Reference drawing provided

2.6 Comparison to Other Terminals for Maneuvering Area

Table 3: Maneuvering Areas for selected SPMs

Location	Type/Location	Distance	Notes
TGL DWP	CALM/Offshore US Gulf	1.25 nm	TGL DWP Proposal
LOOP Terminal	SALM/Offshore US Gulf	1.32 nm	Sized for ULCCs up to 700,000 DWT, which would be in excess of 450 meter length
NE Gateway	STL/Massachusetts Bay	1.0 nm	STL, LNG carriers. These are smaller vessels and the cargo connection is cleared once the buoy is cleared of the hull.
Exxon Hondo	Santa Barbara, California	1.50 nm	Decommissioned 12-year operation
Exxon West Africa	SPM/ West Africa	1.13 nm	Multiple locations, deepwater
Wandoo	Dampier, Australia	0.60 nm	Restricted to ships <100,000 DWT

2.6.1 LOOP (SALM SPMs, US Gulf)

The LOOP Terminal is the primary reference for TGL because of the similar arrangements, similar location, and proven history. The ABS Rules explicitly use LOOP Terminal as a primary reference for the maneuvering area.

The LOOP Terminal maneuvering area is 1.32 nm. Scaling for a VLCC vs. a ULCC would bring the maneuvering area to 1.13 nm.

Figure 4 shows a long term history of how the ships maneuver and transit in the LOOP Terminal maneuvering area.

The LOOP overlay illustrates the routine occurrence of the VLCC entering the 500-meter exclusion zone around the platform when working with a 0.65 nm maneuvering area (white dashed line) with an additional 365-meter (1200 ft) safety margin (black dashed line) for a total maneuvering area of about 0.85 nm. The AIS tracks of the station keeping and escort tugs are not included but will be much closer to the platform in many of these situations. Figure 4 demonstrates that if the SPMs were within the 0.65 nm or 0.85 nm distance, allisions or activation of emergency protocols would have occurred on many occasions..

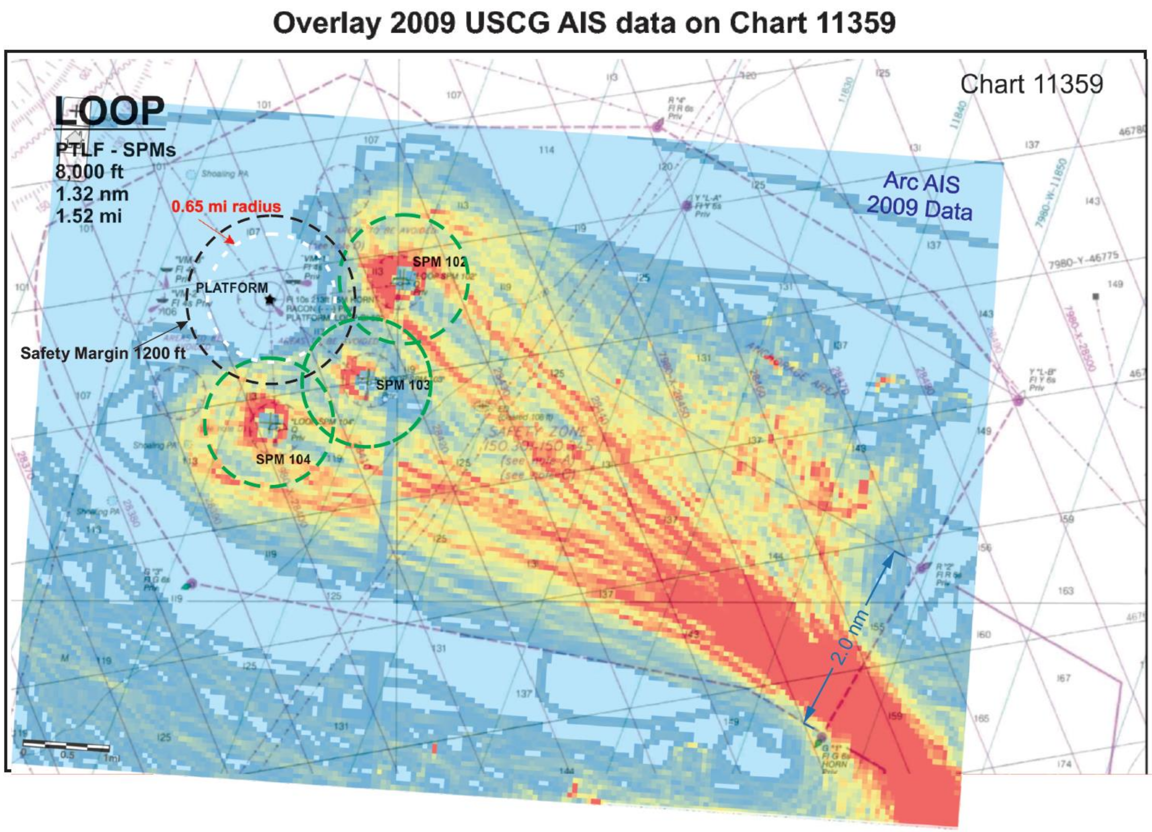

Figure 4: LOOP Terminal with AIS Overlay

2.6.2 NE Gateway (STL SPMs, Massachusetts Bay)

The Northeast Gateway is a submerged turret loading (STL) type of SPM located in Massachusetts Bay. It is used for transfer of LNG from LNG carriers to the shore terminals.

The NE Gateway uses a 1.0 nm maneuvering area, which is smaller than TGL. This is in line with the TGL proposal when considering the following differences between Northeast Gateway and TGL:

1. The LNG carriers are smaller than VLCCs. The LNG carriers are approximately ⅓ the displacement and ¾ the length of a VLCC.
2. LNG carriers have propulsion systems that can respond more quickly and with more effect than a conventional VLCC system.
3. There is no issue of hose entanglement once the LNG carrier is disconnected from the STL, meaning the LNG carrier can be shifted and turned at the buoy location instead of having to backdown almost 1 ship length to begin maneuvering.

3. Other Professional Reviews and Opinions

3.1 Summary

Sentinel Midstream has requested opinions or technical analyses from a variety of experts regarding the maneuvering area.

3.2 Glosten Associates

Glosten Associates, a naval architecture firm, ran several desktop maneuvering simulations of the TGL DWP. They found that in several simulations that the VLCC allided with the platform when using a 0.65 nm separation. Glosten indicated that the shallow water effects, which were not accounted for in the simulations, would make for worse results.

3.3 Locus/Maritime Pilots Institute

Locus, a firm that specializes in bridge and manned model simulations, summarized their findings as follows:

The further platform, located in the simulations at a location of 1.25nm distance from the SPM. was not in a risk hazard situation during any of the simulations. However, the alternate platform locations, located at 0.65nm from the SPM, was in a risk hazard during all simulations. (Ref: LOCUS/MPI Report, 4 August 2021).

3.4 Pilots

Several pilots and master mariners provided opinions on the 0.65 nm and 1.25 nm separation with consensus being 0.65 nm is too risky and 1.25 nm is a reasonable distance that a professional staff can maintain safe operations and recover from rough departures or breakaways.

Specific experts included:

- Sentinel Midstream, Captain Daniel Harris (retired LOOP Mooring Master)
- ExxonMobil (retired), Captain William Deppe
- Sandy Hook Pilot Association President, Captain Timothy Ferrie

3.5 Atlantic Technical Management

Atlantic Technical Management (ATM) reviewed the minimum maneuvering area obtained from ABS, PIANC, and OCIMF from a perspective of master mariners and arrived at a minimum maneuvering area of 1.0 nm for the TGL DWP. ATM had multiple in-house OCIMF SIRE certified Captains review the port design. The OCIMF certification is in indication that these individuals are acknowledged by the oil majors to fully understand and support safety cultures as practiced by the oil majors.

4. Shallow Water Effects

Shallow water effects have implications on the maneuvering performance of ships. The "Under Keel Clearance" (UKC) is a common measure of how "shallow" the water is and gives an indication of the general performance degradation of the vessel. The turning circle of the vessel—the most important maneuvering characteristic of the departing VLCC—increases as the water becomes shallower.

Effects of shallow water on maneuvering were measured with trials on *Esso Osaka* in 1977 and presented in a SNAME paper in 1979. Further study into this phenomenon has continued to more precisely determine the mechanisms for this degradation. The *Esso Osaka* trials are broadly confirmed by the work of the Vantorre, et al. paper.

Generally, it is difficult to assess the precise changes based on a general vessel class because the effects are non-linear and coupled with a variety of factors. The general, net effect, can be inferred from descriptive ranges such as “shallow water,” “medium depth,” or “deep water.” These descriptions, while hardly standardized, give a good description when matched to explicit UKC ratios.

The UKC ratio, defined as (h−T)/T where “h” is the water depth and “T” is the vessel draft, is about 40% for the fully laden VLCC at the TGL DWP. This is the conservative condition for consideration because the lighter draft conditions have tighter turning circles and higher UKC values. Figure 5 illustrates comparative turning circles for a vessel in various UKC ranges. For the VLCC at TGL DWP, these circles are at the following water depths for a 23 m draft VLCC: 25.3 m (10% UKC), 27.6 m (20% UKC), and 46 m (100% UKC). The degradation of the turning circle for waters shallower than 27.6 m is rapid while minimal by comparison for the 40-50% UKC for TGL DWP (32 meters).

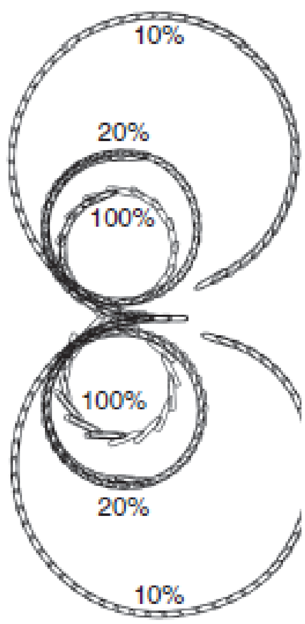

Figure 5: UKC Effect on Turning Circle (Ref: Vantorre, et al.)

Another aspect to consider is that many of the SPMs are in relatively shallow waters and the guidance that has developed over time inherently accounts for some degree of shallow water effect.

The minimum maneuvering area opinions considered the “medium” shallow water range of around 40%. The LOOP Terminal, the reference design, has a similar UKC limit for fully laden vessels. The TGL DWP specific studies by LOCUS/MPI studies were at UKC ~55%.

To reduce the maneuvering area based on having full deepwater performance characteristics would start to occur in about the 50-70 meter water depth, and even then the reduction on maneuvering area would be marginal.

The minimum maneuvering area would need to be increased if the UKC ratio started to approach 20% (Figure 5).

5. Metocean

The metocean characteristics of the site are important to gain an insight to the conditions and inform the development of operating plans for the terminal. In a probabilistic analysis, or quantitative risk assessment, the specific metocean conditions would be described in statistical forms that can be used to determine extreme conditions, rotating events, or other specifics. The statistical forms are the basis for developing simulation models.

The TGL DWP is located in an area with generally light winds and low seas well within operational limits of the SPM and ships with the exception of the winter months. There are occasional storms, such as hurricanes, with sufficient advance warning to secure operations and move vessels to safe areas until the storm passes. Sudden, often severe, thunderstorms and squall lines occasionally happen in the summer months. There are rare “microbursts” with accompanying strong winds and increasing seas that may or may not be detectable by radar. The April 2021 microburst off Louisiana is such an example. This is the type of escalating condition that leads to rough departures or breakaways.

Sentinel Midstream has indicated that the TGL DWP operational mooring limits are 30 knots wind and 2.75 meter seas (9 feet).

There is a steady current of less than 0.75 m/s (1.5 knots) with occasional loop current eddies passing through at a speed as high as 2 m/s.

5.1 Winds

The bulk of the winds come from onshore and are generally mild (<10 m/s). Stronger winds, upwards of 15 m/s, occur frequently from both onshore and offshore directions. The VLCC in ballast condition will be more affected by winds than the laden VLCC.

Table 4: Wind Speed

Wind Speed (m/s)	Occurrence
<5	33.9%
5-10	57.8%
10-15	8.0%
>15	0.2%

Source: Data from Copernicus.eu

5.2 Currents

The TGL DWP is located in an area where there is a consistent current running more or less parallel with shore at a speed of as high as 0.75 m/s. This speed does exert a noticeable load and effect on the VLCC but is well within operating ranges of typical SPMs using OCIMF guidelines for mooring and station keeping operations.

The current has more effect on the laden VLCC than one in ballast.

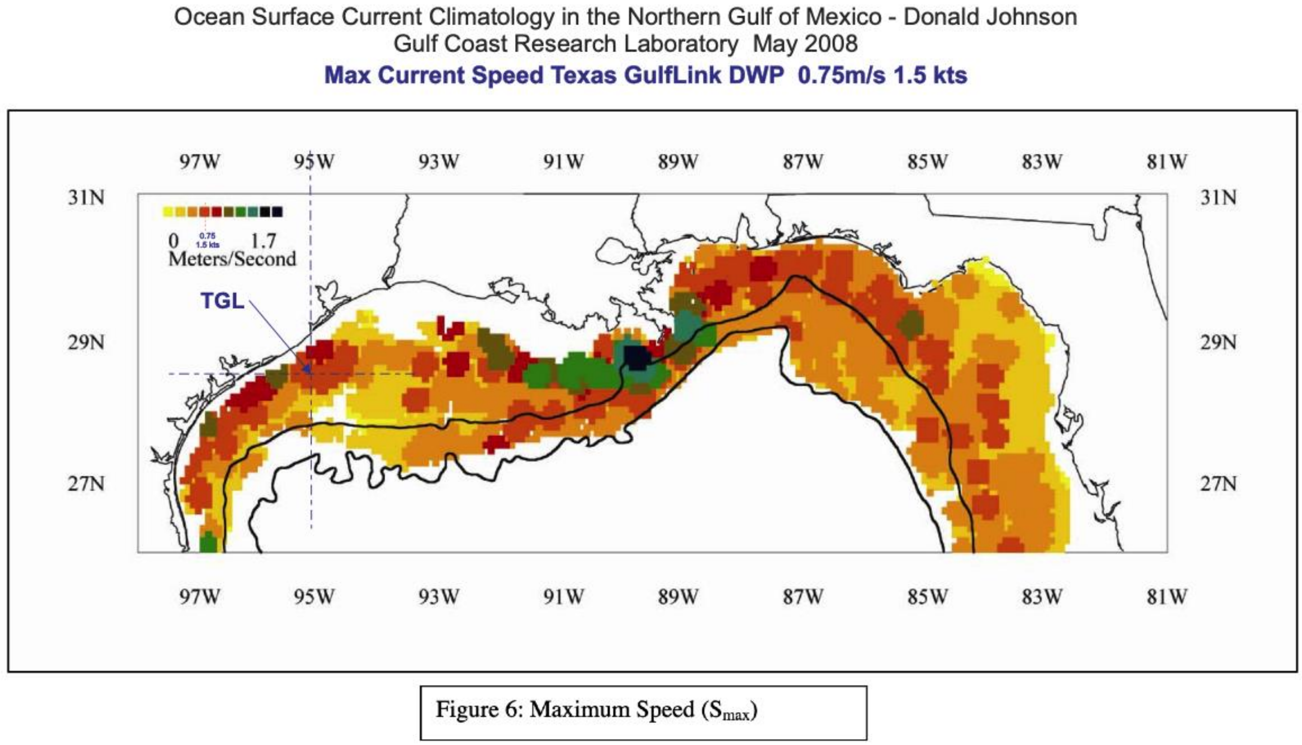

Figure 6: Currents at TGL DWP

5.2.1 Loop Current Eddies

The US Gulf loop current spawns occasional eddies that pass through the TGL DWP field. This results in currents as high as 2 m/s (4 knots) that gradually build, change direction, and fade. This scale of current has impacts on SPM operations but is not likely to cause rough departures or breakaways with the proper procedures and limits in place. This is because the currents, while fast moving at their peak speeds, are gradual in the build and fade.

The currents affect the laden VLCC more than the ballast VLCC.

Current Notes

A related feature is an area of warm water with an "eddy" or "Loop Current ring" that separates from the Loop Current, somewhat randomly every 3 to 17 months. Swirling at 1.8 to 2 meters/second, these rings drift to the west at speeds of 2 to 5 kilometers/day and have a lifespan of up to a year before they bump into the coast of Texas or Mexico. These eddies are composed of warm Caribbean waters and possess physical properties that isolate the masses from surrounding Gulf Common Waters. The rings can measure 200 to 400 kilometers in diameter and extend down to a depth of 1000 meters.

DIAGRAMATIC LOOP CURRENT MAP

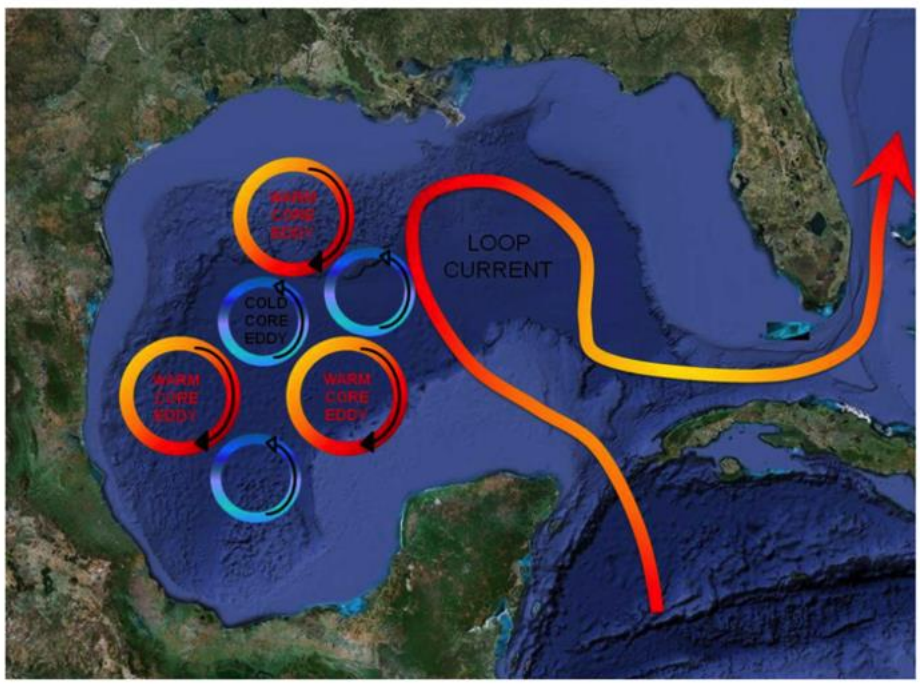

Figure 7: US Gulf Loop Current Eddies

5.3 Waves

The waves in the TGL DWP field are relatively mild. The SPMs are designed to accommodate VLCCs in conditions with waves in excess of 3 meters. The TGL DWP metocean has waves that exceed 3 meters about 7% of the year and waves that exceed 4.5 meters <0.2% of the year.

This is an indication that the greater wave heights are during storms when the VLCC should be off the SPM.

Table 5: Wave Heights at TGL DWP

Direction (Direction from which waves approach)	Percentage Occurrence
N	11.5
NE	13.1
E	17.1
SE	30.8
S	17.3
SW	3.1
W	2.0
NW	5.1

Source: Average Annual Occurrence Wave Direction Groups: Galveston Block 423: 105 Foot Mean Lower Water Depth: Offshore Texas
A.H. Glenn and Associates Services

5.4 Combined Metocean

The combined metocean shows that the wind, waves, and currents often come from different directions, otherwise known as "cross conditions" as opposed to "concurrent conditions." TGL DWP is designed to have both SPMs occupied by a VLCC simultaneously. These tankers are assumed to not necessarily have the same loading condition at the same time, meaning one VLCC can be in ballast while the other is nearly fully loaded.

The cross conditions for this scenario means the tankers will lie at different orientations to the SPM.

One scenario that does happen and must be evaluated and planned for is when there are condition changes—especially wind—that can rotate the vessels to different orientations that place them in different exposures to the platform or other SPM fairly rapidly.

6. Human Factors

Human factors are a central aspect to planned and unplanned departure events. Breakaways are unplanned departure events that test the human factors aspects of the true recovery capabilities of the "system" with respect to the VLCC crew, station-keeping vessel crew, mooring masters, and others. It also tests the engineering systems such as the communications, engine startup times, true physical capability of the vessels in what are likely to be stormy conditions. Events like breakaways happen on "dark and stormy nights" instead of sunny days in calm weather. They also happen in fast rising conditions (e.g. microbursts) that are hard to detect precluding normal time to prepare for a normal disconnection and departure.

7. Risk Management Format

The following sections follow a classical risk management program format of "tolerance," "identification," "evaluation," "assessment" and "management." Terms may differ in specific implementations with the end result being similar.

This form summarizes information in the preceding sections so it can be incorporated into existing risk management programs with suitable references to supporting materials.

This format can be readily adopted into a risk management program that is ISO 31000 compliant.

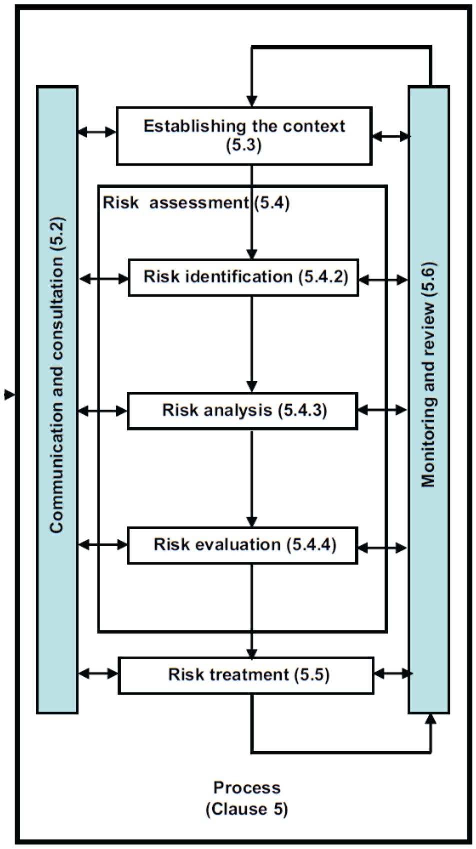

Figure 8: Risk Management Process (Ref: ISO 31000)

7.1 Risk Tolerance

The risk tolerance, or "acceptance criteria," are the criteria established by the participants for what are acceptable or unacceptable exposures in certain risk dimensions or vectors. Within the ISO 31000 terminology, this is "establishing the context."

Sentinel Midstream has requested the risk tolerance that meets regulatory requirements, industry guidance, and compatibility with expectations that result from design and operations practices of oil majors.

For this assessment, the criteria are associated with safety, environment, and asset damage which are the same as generally applied in industry and regulatory applications for technical and operational considerations. Other criteria, such as reputation or business interruption are not considered for this assessment because these criteria are not universally nor uniformly applied across the industry.

Oil majors have been moving towards basing their requirements more fully on established codes and guidelines rather than using internal standards.

Industry guidance for the maneuvering area is found in OCIMF, PIANC, and Class Rules.

The regulatory requirements for minimum maneuvering area are not firmly established, but it is generally accepted that the ABS SPM Rules for maneuvering area would apply.

The US 46 CFR 170.050 clearly establishes that the TGL DWP would be in "exposed waters."

Summarizing, the risk tolerance is based on the requirements of OCIMF, PIANC, ABS SPM Rules, and certain industry experience for safety, environment, and asset damage.

The OCIMF SMOG requirement for a "risk/consequence analysis" establishes the basis that a consequence based risk assessment is to be considered instead of a frequency x consequence risk matrix, QRA, or other approaches that measure risk by a combination of failure potential combined with the consequences of a failure.

The complexity of rough departure or breakaway situations is difficult to model in a pure numerical form, especially with the human factors aspects, thus a qualitative approach supported by analytic studies offers a conservative and practical approach that has been well proven in the offshore industry.

During a breakaway or rough departure, any vessel that encroaches the platform exclusion zone of 500 meters without impact is considered a high potential event.

An allision with the platform is considered a high consequence event on one or more of the dimensions.

The risk tolerance criteria simplifies to accepting that rough departures or breakaways will occur and the field arrangements, systems, and equipment are capable of reliably preventing an allision with the platform and bringing the event to a safe state.

The MMA is to account for extreme conditions, such as microbursts, that may suddenly arise.

The barriers to prevention have failed and recovery is the focus of the system design and concept of operations.

Key Elements:

- Industry guidance of OCIMF, PIANC, and ABS are to be used.
- A breakaway is assumed to occur and the efforts are to bring to a safe state.
- Consequence based approach considering that an allision with the fixed platform is to be considered a high consequence event.
- TGL DWP is to be considered as "exposed" waters.

7.2 Risk Identification

The operations of interest and battery limits are clear that the primary consideration are departures of both a planned and unplanned nature. Other events, such as mooring approach or passing vessels are not considered explicitly because those are considered in other work streams.

The identification of risk by the operator, general industry, and known history of other similar terminals shows that breakaways can and do happen, so they cannot be discounted as "rare" or "improbable." The LOOP Terminal has had 4 breakaways during its 40+ year operating history, the most recent resulting from a microburst event in 2021.

These events have shown that singular administrative or operational controls should not be relied upon. When possible, use of engineering controls and definitive signals (e.g. loss of tension on the mooring hawser) that trigger response actions are the primary defense against safety, environmental, or asset damage.

Multiple failures, both hidden and known including human error can and do happen in these types of events. Hence a consequence based approach that evaluates the overall effectiveness of responses to prevent an allision.

Event specific failures can include, but are not limited to, late detection of mooring hawser failure, failure of VLCC engine to start, lack of situational awareness on part of members of the operations team[4], poor coordination among the operations teams, or ineffective use of the station-keeping tug.

There can be systematic failures that set the conditions for a breakaway or rough departure to lead to an allision. These failures are anticipated to potentially include, among others, be weak safety management systems (SMS), weak integrations into quality systems, or “work as done” that is at a distinctly lower quality compared to “work as imagined.”

As it is structured, there is the TGL DWP operators that include the Port Superintendent, Mooring Master, and Vessel Traffic Controller among others. These staff are stationed on the platform and the VLCC. All of the in-field vessels are staffed by an external contractor working on a long-term contract (>5 years), which presumably presents a stable environment with the contractor staff and TGL DWP staff routinely working together. The VLCCs are from the open market, meaning each VLCC is an infrequent visitor and the crew will probably not be familiar with the TGL DWP. However, VLCCs do frequently call on SPMs throughout the world, so the VLCC crews are familiar with SPMs that are compliant with OCIMF guidelines.

The smaller the maneuvering area, the more critical a good safety culture and good operations are to preventing an allision or high potential event during a breakaway or rough departure.

7.3 Risk Evaluation

The desktop maneuvering analyses, the bridge simulations, and expert opinions from a range of professionals indicates that the maneuvering area of 1.25 nm is sufficient provided the operations are sturdy. The simulations show that there is enough room to avoid the platform with well prepared and a coordinated operations team in place.

LR has identified that a breakaway or rough departure in a fast-rising storm or dynamic conditions where there is little control or too little maneuvering room can lead to a “brutal audit.”[5]

LR has identified the human element and the “system” interactions between the vessels and the different members of the operations team have a large role in determining the outcome.

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[4] The operations team, in this instance, is the combined TGL DWP operations team, tug operator team, and VLCC team. The Port Superintendent and Mooring Master are the leadership of the TGL DWP team, the VLCC master and watch officer are the leadership of the VLCC team, and the tug crews are the leadership team of the individual tugs.

[5] “Our ability to deal with chaos depends on structures that have been developed before the chaos arrives. When the chaos arrives, it serves as ‘an abrupt and brutal audit: at a moment's notice, everything that was left unprepared becomes a complex problem and every weakness comes rushing to the forefront. The breech in the defences opened by crisis creates a sort of vacuum’ (Pat Lagadec).

The assessment considers this a simultaneous operations (SIMOPS) type of case. LR reviewed the materials provided by Sentinel Midstream and general industry materials both widely available and internal to LR to prepare for an interview of Sentinel Midstream's marine operations leadership in charge of developing, implementing, and preparing for the "first day" of operations along with Sentinel Midstream's trusted advisors.

The interview surfaced the experience of SPM operations as being routine, exceptionally safe, and practical where there are many "exit cards" or options available to a well-prepared team to get the ships to safety even in extreme events.

The interview equally showed that weaknesses in ensuring the safety systems of the SPM, tug contractor, and VLCC may not reveal themselves until a breakaway or rough departure. The level of trust and in-practice coordination have central roles in how an event is managed by the operations team.

Human element and human/system interaction is prominent.

7.4 Recommendations

The "recommendations" fall under the "risk treatment" aspect of ISO 31000. The recommendations for risk management in the design of the TGL DWP, its concept of operations, and actual operations.

The following recommendations are areas that LR sees as critical to ensure a safe operation for the TGL DWP with respect to the maneuvering area and field layout of TGL DWP. There is no such thing as a list of "all" for dynamic, complex systems or events such as the breakaway or rough departure events at the SPM.

7.4.1 Minimum Maneuvering Area

The minimum maneuvering area, to meet the general risk tolerance criteria is a minimum of 1.1 nautical miles. This is based on established assumptions, but may increase based on the results of certain studies, analyses, or discussions that may occur during the design of the field arrangement or operating envelopes in terms of ship size or other in-field support vessels.

7.4.2 Hawser Tension Monitoring

Hawser tension monitoring systems have become reasonably reliable in the past decade. The hawser tensions should be monitored and measured for three purposes:

1. A low tension value can indicate that the vessel has broken free of the SPM before other means of detection are triggered.
2. Use of the hawser tension monitoring system can provide the Mooring Master an indication of when the loads are near or exceeding the established operating limits in order to initiate an orderly departure.
3. The hawser tension history can be used to estimate the remaining fatigue life of the hawser and give an estimate of current breaking strength of the hawsers. The hawsers are assumed to be synthetic ropes that are specified in accordance with the OCIMF MEG4; these specifications provide the material information on the fatigue life characteristics of the hawsers.

7.4.3 Simulations

7.4.3.1 Sentinel Midstream and In-Field Support Operator Simulations

Simulations are a critical element for planning, practice, and improving the operating plans and procedures (SMS, Quality, Port Booklet, etc.) of the TGL DWP. The simulations should include a range of metocean conditions, including cross and variable—including "rotating"--conditions as well as concurrent, steady state conditions. These situations are useful in the design and implementation stages prior to "first day" in order to establish operating envelopes. This should also apply to the VLCC and in-field support vessels in terms of maneuvering performance degradation due to shallow water and ship motions that reduce the effective thrust of the propulsors. These simulations should consider both VLCCs in varying loading conditions because the wind, waves, and currents affect the VLCC differently based on loading condition of the vessel.

The simulations should address periods when loop current eddies are in-field simultaneously with a range of metocean conditions. Results from this work may affect operating envelopes when the loop current eddies are present.

Simulations should be conducted considered VLCCs connected to both SPMs with one in a breakout and the other entering conditions into what could become a rough departure event. This will likely aid in establishing operating envelopes and response plans to consider this type of scenario.

Microburst types of events should be included in the simulations.

7.4.3.2 Charterer and Tanker Operator Simulations

Certain charterers or tanker operators with routine visits to the TGL DWP may be open to jointly conducting simulations with Sentinel Midstream and the tug operator. This would be a valuable period to test and improve the SIMOPS aspects of having three organizations and a large number of vessels in close proximity working together to prevent allisions, collisions, or high potential events.

7.4.4 Terminal Clearance

TGL DWP indicated that it grants terminal clearance to each ship prior to arrival. TGL DWP uses established routines such as reviewing standard vetting reports such as Q88, SIRE, and perhaps TMSA reports.

The terminal clearance process should be well established with clear criteria for vessel acceptance in terms of technical requirements (e.g. OCIMF fittings for SPMs) and operational quality requirements such as ensuring a certain number of the VLCC senior staff have SPM experience.

7.4.5 Human Factors Recommendations

In order to successfully manage the operation of the TGL Single Point Moorings, platform and associated facilities, consideration should be given to reducing the potential for human error. The following topics suggest factors for Sentinel to consider as a part of the overall risk management approach.

7.4.5.1 Human Factors Interface–Computerized system

To aid situational awareness, determine if there could be an overview computer screen with a small number of key parameters (10 -12) to provide early alert of worsening conditions. Each parameter would be displayed as a numerical value as well as a color-coded indicator, such as a traffic light scheme, to signal normal or off normal conditions. This concept could be expanded to create such separate overviews for the various sequences of mooring / loading operations while maintaining one screen with primary indicators.

7.4.5.2 SIMOPS Type of Chart with Overall Safety Criteria and Interfaces

Ensure safety criteria for each sequence of operations (pre-arrival though departure including easy exit / planned departure versus quick or emergency departure) are well documented and shared with various stakeholders including the vessel. The idea is to create a one-page chart or matrix with criteria related to wave, wind, currents, weather, etc to indicate where acceptable windows of operation exist, where factors interact, where operations must be stopped temporarily or where departure is recommended. The formalizing of safety criteria and risk factors can serve as a reference to guard against unconscious bias that can lead to wrong decisions and impact safety performance.

7.4.5.3 Port Manual

Ensure that Texas Gulf Link Deepwater Port Operations Manual conveys overall Sentinel safety margins, allowances, and restrictions, while taking into account that vessel using SPM will be different for each loading. As a result, the safety information will be generic and may define a range rather than a single criterion. Providing written information, in simplified English, to vessels would outline potential hazards and sanctioned risk management approaches. Providing clear and concise information could address potential language challenges from crews from whom English is a second language.

The use of simplified English is particularly important for the international nature of the VLCC crew members. Addressing potential language challenges with the vessel will build upon the strength of the interrelationships and understandings held between Sentinel and the tug / boat operator who work together regularly. The vessel crew will not have the benefit of frequent interactions, or the level of trust shared by Sentinel and the tug / boat operator thus clear, simple, readable instructions / criteria, that can be reviewed before arrival at the SPM or the beginning of a sequence of operation, could aid understanding.

Since TGL Deepwater Port will be in exposed shallow waters, provide information on potential risk / safety factors associated with this location to vessels that will be using the SPM. This would be aimed at highlighting any factors that might be of interest to vessels that primarily have experience with SPMs in protected waters. This information could be related to sea, wind, current, depth or other conditions that are unique.

Provide overall information related to proposed roles and responsibilities during emergencies including breakaways for Sentinel, tug / boat operator as well as for the vessel. This should be presented at a high level (not detailed) due to the differences between vessels, changing nature of events during emergencies and since the Master of the vessel at the SPM will retain his command of the vessel under all circumstances.

7.4.5.4 Training

Ensure that unique competencies related to SPM operations including emergencies have been identified and that the Company training program incorporates training above and beyond regulatory requirements to ensure personnel understand unique SPM operations related risks, including hazards, potential consequences and the safeguards to prevent or mitigate them. Competences directly related to emergency response including those related to communication, leadership, decision making, work force (Sentinel, contractor, vessel) management / coordination should be defined. These would be in addition to identified competencies related to unique aspects of SPM operations related to environmental factors (water depth, sea conditions, weather) and potential mechanical failures. The identification of these unique competencies would apply to Sentinel personnel but also to the tug / boat operators.

Ensure that simulator training / exercises include scenarios are based on historical incidents such as at the LOOP or experienced at TGL as well as those related to equipment failures, heavy weather, changing sea conditions, and various emergencies including breakaways. Potential human errors that could create or exacerbate worsening conditions should also be folded into simulator training exercises. This could be circumstances where:

- the wrong action is taken or there is inaction;
- a poor decision is made;
- leadership roles are unclear;
- personnel change or are unavailable during the evolution of the emergency;
- there are communication failures;
- extreme time pressures surface;
- misinterpretation or misunderstanding of existing conditions occurs.

The training scenarios would also need to take into account the means for maintaining minimum safety margins, exclusion zones and buffer areas around the nearby platform and SPM with worsening conditions. Scenarios can also be built around any tug / boat near misses. incidents as the relate to the SPM. As planned, the training would include Sentinel personnel (Port Superintendent, Mooring Master, TS Controller) as well as personnel from the tug / boat operator.

7.4.5.5 Management of Change Process

Ensure a robust Management of Change (MOC) process is defined. This process should outline the steps required to implement both temporary and permanent changes related to the platform, SPM, associated equipment/facilities or operations. Records of implemented MOC process should be retained for audits/inspections. Candidates for MOC include those related to physical safeguards such as equipment or components; operating procedures; maintenance routines or critical spares. Records of implemented MOC process should be retained for audits/inspections. This process can also be used for temporary or regular crew changes.

7.4.5.6 Sharing of Safety Related Information

If not already occurring, share safety related information from near misses and incidents with tug / boat operator and obtain their reports as well. In addition, during Sentinel management/audit visits to platform/SPM and contractor's tugs / boats, conduct safety observations to be share amongst all parties. Such information could be shared during periodic reviews or meetings. The content would also include outlining the resolutions to any issues. The information could be shared through safety alerts/moments, suggested toolbox talks, newly prepared job safety analyses (JSA) or modified processes or procedures. This will promote a learning culture.

Based on reports created after each vessel visit to the SPM, share any Lessons Learned from visits within Sentinel and with tug / boat operators. This can be shared through to same mechanisms as near miss / incident information.

It is recommended that review be periodically undertaken where Sentinel works together with the tug / boat operator to ensure that related processes / procedures in each Companies' respective Safety Management Systems (SMS) harmonize and complement each other. Such a review would assist with similar approaches being undertaken to manage risks, especially those which are common or shared. This could be completed by shoreside personnel.

7.4.5.7 Audits of Subcontractors

Periodic audits of the tug operator's policies, procedures and recordkeeping should be undertaken. This could include review of the Safety Management System and portions of this related to tug /boat personnel's selection / hiring criteria, licenses / certification, work / rest hours, training. The audit could also review safety / emergency procedures and reporting, operations procedures, maintenance and non-conformity / issue resolution.

7.4.5.8 Information to Request from Vessel Prior to Visit

Consider requesting vessel to provide it's OCIMF Tanker Breakout and Emergency Departure Procedures to Sentinel prior to operations at SPM. This would provide an opportunity to review the vessel's strategy and risk management approach to upset conditions. This request could be made during the contracting phase.

8. Assumptions

The following assumptions were made during the course of this risk assessment.

Oil Major acceptability: The oil major acceptability are estimates based on established safety cultures and the practice of relying on Class, and Industry codes and standards.

Mooring Makeup: The mooring makeup is a two hawser arrangement for the VLCC according to OCIMF MEG4 guidance.

Support Vessel Operations: Support vessel operations are in accordance with OCIMF recommendations in terms of sizing and handling.

Vapor Recovery Vessel: The vapor recovery vessel stands off the VLCC and can immediately exit the area if required. The vapor recovery hose is a low pressure hose with an MBC. The hose is short enough that it won't get entangled in the VLCC's propeller or rudder.

9. Abbreviations

9.1 Abbreviations

ABS: American Bureau of Shipping

Aframax: Large crude oil tanker size of around 100,000 DWT

AIS: Automatic Identification System

ATBA: Area to Be Avoided

CALM: Catenary Anchor Leg Mooring system

CFR: United States Code of Federal Regulations

DP2: Dynamic Positioning, Class 2 which allows for a single fault or failure of an active component in the system and retain automatic stationkeeping capability.

DWT: Deadweight Tonnes, a measure of the cargo capacity of the ship and a general proxy for tanker size.

IOC: Independent Oil Company

JSA: Job Safety Analysis

LNG: Liquified Natural Gas

LOOP Terminal: Louisiana Offshore Oil Port

LR: Lloyd's Register

MBC: Marine Breakaway Coupling

MMA: Minimum Maneuvering Area

MOC: Management of Change

nm: nautical mile (1,852 meters)

OCIMF: Oil Companies International Marine Forum

OSV: Offshore Support Vessel

PIANC: The World Association for Waterborne Transport Infrastructure

QRA: Quantitative Risk Assessment

SALM: Single Anchor Leg Mooring

SIMOPS: Simultaneous Operations

SIRE: OCIMF Ship Inspection Report Program

SMS: Safety Management System

SNAME: Society of Naval Architects and Marine Engineers

SPM: Single Point Mooring

STL: Submerged Turret Loading

Suezmax: A large crude oil tanker of about 150,000 DWT

TGL DWP: Texas GulfLink Deepwater Port

TMSA: Tanker Management and Self Assessment program

UKC: Under Keel Clearance

ULCC: Ultra Large Crude Carrier, a large crude oil tanker of greater than 350,000 DWT.

VLCC: Very Large Crude Carrier, a large crude oil tanker ranging from 270,000-350,000 DWT.

10. References

ABS SPM Rules, *Rules for Building and Classing Single Point Moorings*, January 2023

Glosten Associates: "Texas GulfLink Deepwater Port—Shallow Water Ship Simulations," October 2021

ISO 31000: *Risk Management—Principles and Guidelines*

LOCUS/MPI: "Maritime Simulation Evaluations for Sentinel Midstream Single Point Mooring Operations," August 2021

OCIMF GOTO: OCIMF *Guidelines for Offshore Tanker Operations* (2018)

OCIMF MEG4: OCIMF *Marine Equipment Guidelines*, 4th Edition (2018)

OCIMF SMOG: OCIMF *Single Point Mooring and Operations Guide* (2015)

PIANC WG200: *Recommendations for the Design and Assessment of Single Point (SPM) And Multi Point Mooring (MPM) Facilities* (2023)

Vantoore, Eloot, Delefortrie, Lataire, Candries, and Verwilligen: "Maneuvering in Shallow and Confined Water," Encyclopedia of Maritime and Offshore Engineering, 2017

Appendix A References

A.1 Appendix 1: Annotated References

Title	Source	Notes
Guidelines for Offshore Tanker Operations—Overview Presentation (2018)	OCIMF	Slide Deck providing an overview of the substantially revised GOTO (2018). Consolidated and reconciled many OCIMF guidelines including MEG4 and others. SMOG, ISGOTT, and STS Transfer Guide are still separate and complementary. Addresses offshore terminal operations including with SPMs.
Port Layout 065, 9 May 2020	Sentinel Midstream	Mooring string layout comparing ABS minimum (<2023) (0.65 nm). Indicates VLCC must be turning before clearing the hoses in order to clear the platform following a disconnect.
Texas GulfLink Presentation on ABS and PIANC Guidelines on Maneuvering Distance (March 2023)	Sentinel Midstream	Describes TGL Safe-Port-Design concept with respect to ABS and PIANC guidelines. General overview that coordinates across many guidelines, studies, and industry experience.
General Arrangement, Damen ASD 5016 Tug	Damen	General Arrangement of Damen ASD Tug 5016.
ABS and PIANC Maneuvering Area Diagram (9 March 2023)	Sentinel Midstream	Diagram comparing the ABS (2023), PIANC WG 200, and proposed TGL maneuvering area.

Title	Source	Notes
Evacuation Limits DWP2, 4000 ft (5 Oct 2022)	Sentinel Midstream	Diagram showing 4000 ft (0.6 nm) distance is insufficient for unmooring in rough seas. Conclusion is 4,000 ft is insufficient.
Evacuation Limits, 4000 ft compared to LOOP Platform Evacuation Limits (3 Feb 2023)	Sentinel Midstream	Diagram showing 4000 ft (0.6 nm) radius compared to LOOP Terminal platform evacuation policy. Conclusion is 4,000 ft is insufficient.
Port Evaluation list	Sentinel Midstream	Abbreviated list of references and notes for checking port design requirements.
Deepwater Port Maneuvering Area Comparison	Sentinel Midstream	Simplified comparison of SPOT, TGL, LOOP, Exxon Hondo, and Exxon West Africa characteristics. Useful summary information
Review of PIANC WG 200 Report (17 March 2023?)	Atlantic Technical Management	ATM reviewed the updated ABS rules, PIANC WG 200 report and concurred with the minimum of 4 x L minimum maneuvering area for exposed waters. This generally corresponds with OCIMF guidance.
Correspondence from Bill Deppe to Dan Harris (22 July 2021)	Sentinel Midstream	Message from Bill Deppe to Dan Harris (Sentinel Midstream) that the 0.65 nautical mile maneuvering distance is too small with the general operating parameters provided. The message went on to indicate that a risk assessment would be highly recommended.
News Item, Anchorage Daily News (29 June 2016)		Indication of the value of Bill Deppe to Exxon in the aftermath of the *Exxon Valdez* grounding and spill (1989).

Title	Source	Notes
Current Speed at TGL DWP based on Ocean Surface Current Climatology in the Northern Gulf of Mexico	Gulf Coast Research Laboratory (May 2008)	Graphic image showing the maximum current at the TGL DWP is 0.75 m/s (1.5 knots).
ATBA Dimension, 1276 m (22 June 2020)	Sentinel Midstream	Diagram showing SPM and platform placement with 1276 m ATBA.
"Maneuvering Trials of a 278,000 DWT Tanker in Shallow and Deep Waters"	*SNAME Transactions*, Vol. 87, 1979	Trials with *Esso Osaka* to demonstrate the general degradation of maneuvering in shallow water vs. deep waters. Trials were conducted at 1.2, 1.5, and 4.2 Depth/Draft ratios. The TGL Port is in the range of 1.3 depth/draft ratio, indicating that maneuvering is subjected to shallow water effects.
Ref. 46 CFR 170.050	CFR Definition of Exposed Water	Exposed waters are >20 nautical miles offshore. The TGL port is considered "exposed waters."
ExxonMobil West Africa CALM Buoy depiction	ExxonMobil	Depiction of CALM type SPM with longer submerged loading lines between the FPSO and the SPM. Distance between SPM and SPM is shown as 2100 meters.
Texas GulfLink Deepwater Port--Ship Simulations (14 June 2021)	Glosten and Associates	Ship maneuvering simulations as 0.65 nm separation for the VLCC and 90 tonne ASD tug. Engine failure and breakaway with metocean at 40 knot wind, 9.7 ft wave, and 1.5 knot current. Results indicated 0.65 nautical miles resulted in insufficient maneuvering area.

Title	Source	Notes
Texas GulfLink Deepwater Port—Shallow Water Simulation (4 October 2021)	Glosten and Associates	Ship maneuvering simulations for VLCC. Separation of 0.65 nm was insufficient. Separation of 1.25 nm provided enough sea room to avoid the platform.
Hondo Platform/Field Arrangement	Exxon	Older image showing the depiction of the field arrangement of the four platforms, export SALM, and tiebacks to shore.
KR Guidances for Single Point Mooring (2017)	KR	KR requirements for SPMs. Ch. 3, Sect. 1, Site and Environmental Conditions apply to maneuvering area. Maneuvering area is minimum of 3xL+(hawser length + bouy offset). Maneuvering area may be modified based on site specific and operating conditions.
Maritime Simulation Evaluation for Sentinel Midstream Single Point Mooring Operations (4 August 2021)	Locus LLC/Maritime Pilots Institute	Bridge simulations were made for various conditions for a VLCC departure with either a 90 tonne tug at full capability or derated according to simulation practice as a hold back/assist tug. The 0.65 nm separation resulted in either allision or near misses with about ½ ship length as the maximum distance between the ship and the platform. The 1.25 nm separation was reviewed and safe distances (buffers) were able to be maintained.

Title	Source	Notes
LOOP Port Booklet (Aug 2013)	LOOP LLC	Port operation handbook for LOOP Terminal.
LOOP AIS with 0.65 nm Overlay	Sentinel Midstream	Overlay of ship positions at LOOP with a 0.65 nm manuevering area circle to illustrate the frequency of incursion into the platform exclusion zone
LOOP AIS with 1200 ft safety margin overlay	Sentinel Midstream	Overlay of ship positions at LOOP with a 0.65 nm manuevering area circle with additional 1200 ft safety margin (366 meters) to illustrate the frequency of incursion into the platform exclusion zone
Loop Current Notes	Unknown source	Image of US Gulf Loop current and eddies. A brief description is included that describes the current and eddy characteristics including time frames, current speed, general sizes, and water depth of the currents. The TGL DWP may experience occasional currents of up to 1.8-2.0 m/s as the eddy passes through the area. The system moves at a rate of about 2-5 km/day.
"Maneuvering in Shallow and Confined Water," April 2017 found in *Encyclopedia of Offshore Engineering*	Vantorre, Eloot, Delfortirie, Lataire, Candries, and Verwilligen (Ghent University and Flanders Hydraulics Research)	Paper confirming that maneuvering characteristics are downgraded when moving from deep water to shallow water. References SNAME paper on *Esso Osaka* trials. The paper includes more extensive engineering details on shallow water, bank effect, ship-to-ship interaction, etc.

Title	Source	Notes
PIANC MarCom Working Group Report No. 200-2023: Recommendations for the Design and Assessment of Single Point (SPM) and Multi Point Mooring (MPM) Facilities, March 2023	PIANC	A primary industry reference for SPMs. SPM specific guidance is in Chapter 5. Section 5.1.2.1 is specific to maneuvering area sizing.
Microburst (US Gulf, 13 April 2021)		The liftboat *Seacor Power* capsized in the US Gulf during a microburst that was not detected by radar. The accident is documentation that intensive atmospheric storms can rise with little or no warning exposing facilities or vessels to extreme conditions.
GOTO (2018) Sections 6.2.2 and 6.2.5	OCIMF Guidelines for Offshore Tanker Operations (GOTO), 2018	Guidance on hold back (or "pull-back") tugs in terms of bollard pull, towing arrangement, and length of towing hawser. Generally: 40-80 tonnes for SPM terminals, ASD type recommended, towline over-the-bow arrangement with a full towline length of around 300 meters.
PIANC Information	Unknown	Description of PIANC and specifically its more recent work on SPMs. MARAD has referenced PIANC in ROD.
PIANC WG 153B, Recommendations for the Design and Assessment of Marine Oil, Gas and Petrochemical Terminals (2022)	PIANC	
PIANC WG 153B, Notes	PIANC	Notes for sections 5.3.4, 5.4.3, 5.5, 5.5.3, and 5.8.3.1 on maneuvering areas and metocean conditions

Title	Source	Notes
PLEM Arrangement (2019)	SOFEC	Drawing showing general arrangement of CALM buoy, anchor legs, risers ("lantern" arrangement), PLEM on the seabed, and tanker in position with two mooring lines. Mudline at 32.5 meters.
Safe Port Design Concept, Texas GulfLink Deepwater Port Project (Feb 2023)	Texas GulfLink	General design philosophy of the Safe Port Design including philosophy on minimum maneuvering area/distances. References ABS, OCIMF and others. Considers metocean conditions, shallow water effects, experience of similar facilities.
TGL DPW Safety Zone, Rev 5 (17 March 2020)	Sentinel Midstream	Diagram showing 1276 m ATBA and 500 m safety zones for entire TGL DWP spread.
Microburst, 12 Apr 2021	Compiled from NTSB and LOOP Terminal	Liftboat *Seacor Power* capsize in a microburst. Same microburst caused a VLCC breakaway from the LOOP Terminal. Conditions included heavy rain, winds in excess of 80 knots, and seas that quickly built from ~1 meter to 3.5-4.0 meters. The microburst was not detected by radar—indicating how quickly they can develop.
Notes from OCIMF *Single-Point Mooring Maintenance and Operations Guide* (2015)	OCIMF	The notes from the SMOG from section 2.2 discusses maneuvering area and operations related to ship handling.

Title	Source	Notes
General Specifications, 320 kDWT VLCC	Ship Specifications	A general set of specifications indication principal dimensions, cargo capacities, and certain standards to be met. This ship is an example of a VLCC that would call at TGL DWP. The specifications include typical requirements for mooring at SPMs and towing outfit.
TGL NAA (23 June 2020)	Sentinel Midstream	Drawing showing location and arrangement of TGL DPW spread with respect to adjacent fairway. Pipelines, cables and other items are shown as well.
Average Annual Occurrence of Wave Direction Groups, Galveston Block 423.	Provided by A.H. Glenn and Associates.	Wave directions by summary percentage occurrence. Wave heights not included.
Distance of SPOT facility in relation to TGL	T. Baker Smith	Diagram showing locations of SPOT and TGL facilities in relation to each other.
SPOT Metocean Mooring Criteria	Unknown source	Metocean limits for mooring.
TGL Support Boats	Texas GulfLink	Slide showing the in-field support vessels: 90/95 tonne ASD tug Hose Tug (2800 hp, twin shaft) Line Boat
TGL Safe Port Design 2023 (8 February 2023)	Sentinel Midstream	TGL DWP arrangement showing NAA=1,000 m, ATBA=1276 m, 1.25 nm separation between SPM and Platform. ATBA=total mooring string + 500 m

Title	Source	Notes
Sandy Hook Pilot comment	Sandy Hook Pilot correspondence (8 June 2021)	Message indicates that ABS rules (prior to 2023) might be sufficient for protected waters, but certainly insufficient for exposed waters. Shallow water effects are crucial to understand for piloting in shallow or restricted waters.
PIANC WG 200, Terms of Reference	PIANC	Terms of Reference for the MarCom WG 200 to produce substantial recommendations on the design and assessment of Single Point Moorings and Multi-Point Moorings.
ATM Review of GulfLink Deep Water Safe Port Design (20 May 2021)	Atlantic Technical Management (ATM)	Summary independent review of the TGL DWP arrangement from a maneuvering perspective. ATM indicates industry practice for exposed waters would have separation at 1.1-1.5 nm; TGL is at 1.25 nm.
USCG Correspondence on Safety Zone, No Anchoring Area, and ATBA (23 June 2020)	USCG	USCG indicated that the 500 meter safety zone and 1,000 meter NAA appear reasonable. The ATBA may need to be revised to ensure the complete NAA zones around the SPMs and Platform are considered.

Appendix B CVs of Selected Mariners

B.1 Captain Daniel Harris

Objective

Provide Consulting Services to the Offshore Oil & Gas Industry with focus on Deepwater Port Operations in the Gulf and East Coast. Develop Safe-Port-Design systems including Safety Zones, NAA, ATBA and approach/departure routing, mooring systems, navigational issues, feasibility study, port location selection criteria, analyze AIS and PARS information studies, and provide HazID and HazOp support. Provide marine subject matter expert support to MARAD application development, ROD and license.

Experience

1978-1983

Product Tankers carrying multiple clean products throughout the world as Third & Second Mate.

1984-1990

US Flag VLCC Brooks Range & Thompson Pass (165,000 DWT) chartered to BP on the TAPS Alaska West Coast Trade Route as Chief Mate. Extensive shipyard periods, including bracket enhancement project, critical area inspections, tank coatings, and deck side repairs. Prince William Sound disable tanker study involvement with towing trials.

1990-1997

US Flag VLCC Brooks Range as Master. First Class Pilot Prince William Sound. Lightering operations Long Beach CA, and Anacortes WA. Multiple Point Mooring (MPM) El Segundo, CA operations. BP US annual technical conference contributor.

USNS Gordon and USNS Gilliand LMSR 950 ft Ro-Ro vessels: builders trails, dock trials and sea trials for Newport News on behalf of MSC.

SS Gopher State MSC Operations in COMPSRON THREE as Master.

Multiple MARAD activations of breakout reserve fleet vessels as Master.

MV Cape Hudson as Master, multiple voyages to Persian Gulf in support of Desert Storm.

1999-2000

BP OIL US. Southeast and US Gulf Coast Port Captain. Technical support for the BP Alliance Oil Refinery. Conducted Barge Company Audits, Terminal Audits, Tanker and Barge Inspections. Participant in BP Group Development Program. Involved in STS Operations, Risk Management audits, Spill Response and Shipyard Activities. Alaska SONS oil Spill drill participant. BP's representative for high-risk cargo operations in S. America.

1999-2000

OCIMF Accredited SIRE Vetting Inspector Certified for GAS, OIL and CHEMICAL Vessels conducting over 300 inspections on behalf of BP, Shell and Exxon/Mobil in the US, Caribbean Islands and South America.

2000-2019

Mooring Master at LOOP Deepwater Port with 2000 Moorings/Unmooring. ULCC and VLCC Tanker experience. Participant 2005 LOOP Expansion Committee. Assist development Mooring Master training and qualification matrix. PIC on VLCC SPM loading operations.

2019-2023

Consultant to Sentinel Midstream LLC, Texas Gulf Link Deepwater Port. Director of Marine Operations. Offshore subject matter expert on SPMs and Tanker Operations. Project lead on development of OSV prototype vapor recovery vessel. Safe Port Design application and development. MARAD application support including permit submittal, EIS, Spill Response, HAZID, Facility Security, and EPA Air permits. Selection and design of support vessel fleet.

Education

1974-1978

Sate University of New York Maritime College

Bachelor of Science, Marine Transportation

Endorsements

USCG Unlimited Masters, Oceans (current)

First Class Pilot Prince William Sound

OCIMF SIRE Accredited Vetting Inspector (1999-2003)

LOOP designated Mooring Master

B.2 Captain William J. Deppe

Objective

Provide quality support for ExxonMobil Function and Project activities

Supply accurate, fit for purpose, and useable deliverables for end users

Contribute to success of teams and individuals

Provide technical advice and mentoring

Work Summary

2006- 2014 Marine Advisor ExxonMobil Development Company (EMDC)

2006 Retired from ExxonMobil with 33 years service

2003-2006 Marine Advisor Upstream Projects, Exxon Mobil Upstream, Houston, TX

2002-2003 Area Marine Manager/Port Operations Manager, SeaRiver Maritime, Valdez, Alaska

2000-2002 Marine Advisor Exxon Mobil Production Company (EMPC), New Operations, Houston, TX

1998-2000 Area Marine Manager, SeaRiver Maritime, Benicia, CA

1993-1998 Port Operations Coordinator, SeaRiver Maritime (formerly Exxon Shipping), Valdez, Alaska

1990-1993 Master (Captain) SEA RIVER LONG BEACH

1986-1990 Port Captain and Ship Group Coordinator, Exxon Shipping, Benicia, CA

1980-1986 Chief Officer and Master (Captain) various tankers Exxon Shipping

1979-1980 Marine Analyst, Exxon Shipping, Concord, CA

1972-1979 3rd Officer, 2nd Officer, Chief Officer, various tankers Exxon Shipping

1972 Hired as 3rd Officer by Exxon Shipping, seagoing position

Education

1972 Bachelor of Science from SUNY Maritime College- Marine Transportation

1972 USCG License as 3rd Mate US Merchant Marine

1974 Study toward M.Sc. Marine Environmental Studies (15 credits)

1981 USCG License as Master US Merchant Marine

Experience

ERHA-Nigeria

Kizomba-Angola

YOHO -Nigeria

Banyu Urip-Indonesia

KK1-Cameroon

YOHO Root Cause Failure Analysis (RCFA)

Kizomba Hose RCFA

Scarborough LNG tandem Offloading-NW Australia

Operability of Natuna gas project Indonesia

ERHA tandem loading preparations

QIT Berth Operating Platform study-Nigeria

Direct Offloading Technology Qualification Lead- Newfoundland

Hose for Offshore Loading System Technology Qualification Lead- Newfoundland

Double Carcass hose and tandem hawser decision coordinator

Floating Storage Regasification Unit tug design-New York

Floating Storage Regasification Unit side by side mooring facility -New York

Hibernia and Hebron Offshore Loading System design and operation- Newfoundland

Developed tandem mooring program for Kizomba Floating Production Storage Offloading facility

Coordinator for mooring master training & qualification for Kizomba FPSO

Pre-start up Independent Project Reviews (IPRs) for Kizomba and Erha

Command position on tankers in world-wide trade

EMPC Mooring Rapid Response Plan (MRRP) participant

CALM Buoy Operability assessments

Kara Sea Drilling Program – Marine Advisor for ice defense coordination and operations Conceptual design of offloading systems in ice

Unique Activities

Salvage and lightering of Exxon Houston off Oahu, Hawaii

Company Representative at Exxon Houston trial, Oahu Hawaii

Person-in-Charge Lightering of Exxon Valdez at Bligh Reef, Valdez, AK

Relief Master Exxon Valdez at Bligh Reef

Company Representative National Transportation Safety Board investigation of Exxon Valdez grounding, Washington D.C. & Alaska

Master of new ships EXXON BAYTOWN, EXXON LONG BEACH

Chief Officer on first vessel EXXON LEXINGTON at first U.S. Floating Production Storage Offloading facility - Exxon Santa Ynez, Santa Barbara, CA

Project and Operational Experience with Tandem mooring, Catenary Anchor Leg Mooring, and Multi Buoy Mooring

Visits to multiple Floating Storage Offloading facilities and FSPO facilities

Company representative in Valdez during Exxon Valdez trial

Company representative in Alaska with industry, regulatory and community affairs

B.3 Appendix 3: LOOP Terminal details for SALM SPM

Details retrieved from SOFEC website (8 June 2023)

Scope of Work

SOFEC designed, constructed, and supervised installation of the SPM #102, SPM #103 and SPM #104 SALMs for unloading tankers up to the ULCC for the first domestic deep-water “superport”.

The Louisiana Offshore Oil Port (LOOP) was the first deepwater 35m import facility in the United States and the first application of SPM technology for crude oil import in the United States.

The three SOFEC SALM terminals were designed and fabricated to safely moor and unload up to 700,000 dwt tankers. The LOOP facility allows fully loaded tankers to unload crude oil directly into underground storage then connected to a major pipeline system supplying over 25% of the total U.S. refining capacity. Tanker offloading rates are 110,000 BPH. The LOOP SALMs are designed to withstand a hurricane survival wave of 21.3m in conjunction with winds of 143.3 knots. Numerous hurricanes have swept across the LOOP facility with no damage to the facilities.

Project Specifications

Water Depth:	35m (114ft)
Tanker Size:	700,000 dwt
Dimension:	14m x 6.4mØ
Floating Hose System:	2 x 24-in.
Hawser System:	15-in. Dual grommet
Anchor Leg System:	6.5-in. U3 Grade with Chain swivel
Anchor System:	4 x 60-in. Ø Piles with mooring base

Comments

Ashland Oil, Marathon Pipeline Co., Murphy Oil Corporation, Shell Oil Company and Texaco established LOOP in 1978 and 1979 to import crude oil into the USA via ULCC's due to the lack of deepwater ports.

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