UNIVERSITY OF CALIFORNIA
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EVALUATION OF LIQUEFIED NATURAL GAS RECEIVING TERMINALS FOR SOUTHERN CALIFORNIA

A Group Project submitted in partial satisfaction of the requirements for the degree of
Master's in Environmental Science and Management
for the
Donald Bren School of Environmental Science and Management

by

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Evaluation of Liquefied Natural Gas Receiving Terminals for Southern California

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The Group Project is required of all students in the Master's of Environmental Science and Management (MESM) Program. It is a three-quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Final Group Project report is authored by MESM students and has been reviewed and approved by:

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ABSTRACT

This Project comparatively analyzed three liquefied natural gas (LNG) receiving terminals for Southern California. Currently, three LNG terminal types are under consideration: onshore, platform conversion, and floating storage and regasification unit. Using site-specific information from the three proposed terminals, possible impacts to the categories of community safety, environment, and socioeconomic aspects were analyzed for each terminal type. Impacts were considered throughout the life cycle of the facility (construction, operations and maintenance, and decommissioning)

Community Safety impacts included an analysis of minor, moderate and major accidents within four scenarios. Operational failure, maritime accidents, natural phenomena, and terrorism/sabotage were all evaluated on a minor, moderate and major scale. Analysis of environmental effects included marine communities (benthic and pelagic), air quality, and terrestrial and freshwater biology. Socioeconomic aspects of analysis included population effected, economy and employment, property value, housing, public services, and traffic. Effects were evaluated based on the expected magnitude of impact and likelihood of occurrence. A ranking matrix was established for visual comparison of the terminals' strengths and weaknesses.

Although this analysis focused on the three specific proposals, we believe that the methodology and most of the results are valid in a more general case. Based on our analysis, general recommendations for future siting of terminals were derived. They include: remote siting to lower safety risks, consideration of ecologically sensitive areas when determining siting location, and consideration of impacts to local housing and traffic prior to siting.

EXECUTIVE SUMMARY

Evaluation of Liquefied Natural Gas Receiving Terminals for Southern California

California currently imports approximately 85% of its natural gas from domestic sources. The gas is received from five major production basins, located in Canada and the Mid-Western United States. According to the U.S. Department of Energy, U.S. natural gas demand is projected to rise 50 percent over the next 25 years. As demand increases in other states, California's domestic imports may be in jeopardy. Therefore, alternative natural gas supplies are being considered for the state. One alternative supply option would be the construction of a liquefied natural gas receiving terminal on the California coast.

At the time of this publication, applications for three different liquefied natural gas (LNG) receiving terminals proposed for Southern California are in the hands of federal, state and local regulators. LNG would be imported from overseas or brought to California from other US sources. The current proposals are:

- **Long Beach Import Project, proposed by Sound Energy Solutions** is an onshore facility proposed for Pier T in the Port of Long Beach. There are currently four LNG receiving terminals in the United States (three on the East coast and one on the Gulf of Mexico). All four existing terminals are onshore facilities.
- **Crystal Clearwater Port Project, proposed by Crystal Energy, LLC,** is an offshore oil platform converted to regasify imported LNG. This type of facility represents a new approach to LNG importation, and is the first terminal of this type to be proposed. The oil platform chosen for this project is Platform Grace, located 18 km (11 miles) off the coast of Oxnard. Platform Grace ceased oil production in 1995, and would need to be retrofitted for this purpose.
- **Cabrillo Port Project, proposed by BHP Billiton LNG International Inc,** is a floating storage and regasification unit (FSRU). This is also a new type of LNG import facility. The proposed receiving terminal (similar in appearance to an LNG tanker) performs storage and regasification onboard, and would be moored to the sea floor 22.4 km (13.9 miles) off the California coast.

This report comparatively analyzes the three LNG receiving terminal types – onshore, platform, and FSRU – using site-specific information from the three currently proposed projects. The ultimate goal of this project is to compare information from the three specific proposals to outline general issues of concern for each of the three terminal types. This document is intended to be useful for community members who may seek an independent and factual account of the important issues regarding LNG receiving terminals. It may also serve regulators, by providing an unbiased comparison of the projects.

In this analysis, three categories of possible impacts were assessed for each LNG receiving terminal type: community safety, environmental, and socioeconomic. Impacts were evaluated based on their expected magnitude and likelihood of occurrence. A ranking matrix was established for visual comparison of the terminals' strengths and weaknesses.

This document does not intend to determine the "best" LNG receiving terminal type. This analysis is strictly informational and educational in its scope. Its focus is on understanding and analyzing important aspects of each terminal so that communities and agencies may make more informed decisions regarding LNG receiving facilities. Although the analysis focused on the three specific proposals, we believe that the methodology and most of the results are valid in a more general case.

Background

The process of cooling natural gas to a liquid form is known as liquefaction. At -126°C (-260°F), natural gas undergoes a phase change, forming an odorless, colorless cryogenic liquid, called Liquefied Natural Gas. In liquid form, natural gas takes up 1/600th the volume of its gaseous form, allowing for much more efficient transport.

LNG imports to the US come primarily from areas such as Algeria, Indonesia, Trinidad, Nigeria, and Australia, where large reserves are presently being exploited. These locations do not typically have high natural gas demand; therefore surplus gas exportation is a viable enterprise. LNG import terminals are found throughout Europe and the Pacific Rim. There are several steps in the LNG supply chain:

- Exploration and production of natural gas at the source
- Processing and liquefaction at an export terminal
- Oceanic transport of LNG by tanker
- Regasification and distribution at the receiving terminal

Conclusions and Recommendations

Community Safety

To compare community safety impacts, four accident scenarios and their potential effects were analyzed for each terminal type: operational failure, maritime accidents, natural phenomena, and terrorism/sabotage. Within each scenario, minor, moderate and major accidents were evaluated. This list is not inclusive comprehensive of all possible accident types, but instead represents the main safety issues faced by facilities.

The main difference between the terminal types evaluated is the impact magnitudes under moderate and major accident scenarios. The proposed onshore facility would be the closest to a dense population, and it is assumed this will be the case for all onshore facilities in Southern California. Therefore, in terms of community safety, the highest impact magnitude would be for the onshore terminal, followed by the Platform and then the FSRU, although the impacts are similar for the two offshore terminals. However, if an onshore location can be found that is suitable for vessel traffic and is in a remote location, the potential impact of the facility may decrease substantially.

The platform facility is expected to be more vulnerable to operational disturbances due to the longer unloading time and the lack of redundancy in the LNG unloading system. The relatively smaller footprint of the facility limits its capacity. The absence of storage tanks may decrease the likelihood of large releases of LNG into the water. However, the possible presence of active oil pipelines in the vicinity of the platform may complicate emergency response and cleanup efforts. Expanding the unloading system or adding storage capabilities to the platform could improve the reliability of the facility. The addition of storage to a platform facility would require an additional review of the platform's structural integrity as well as a new evaluation of LNG spill impacts.

Emergency response capabilities differ between onshore and offshore facilities. While offshore facilities are farther from emergency response teams, studies predict short burn times for LNG fires. Once an LNG fire begins, there is limited action that can be taken by the emergency response team. Onshore facilities are closer to emergency services, but this may not translate into a quicker response time due to differences in transportation and traffic. It is recommended that each facility have its own emergency response protocol, and not rely solely on outside response. Since the off-shore terminals are planned to be at least 18 km (11 miles) from the shoreline, the potential impact of an LNG fire is significantly reduced compared to the proposed Long Beach onshore project, even if the response is slower.

Environmental

Possible impacts to marine communities (benthic and pelagic), air quality, and terrestrial and freshwater biology were evaluated for each terminal type. These environmental areas were chosen for analysis based on general NEPA guidelines.

When considering environmental impacts of the three terminal types, the most important factor is not the terminal type; it is the siting location. Environmental impacts of any project are dependent on the biological resources in the area as well as the potential to impact those resources.

The most noticeable difference between terminal types was seen when analyzing air quality impacts. We used a simple Gaussian-plume model to model air quality, which corroborates the information presented in the three project proposals. Based on this model, it appears that there are significant air quality concerns with the onshore project. Additional technology may be required to significantly reduce emissions of NO_2, PM_{10}, and SO_2, due to the terminal's close proximity to the population. The offshore projects allow for dissipation of emissions before reaching the shore, thus the air quality impact to potential human receptors is minimal under all circumstances.

The construction phase of all projects may cause several impacts to the surrounding environment, such as destruction of habitat or disruptions in feeding, breeding, or migration areas. If important biological resources are present at a proposed site, construction and operation of a terminal will have more significant impacts to the environment.

For offshore terminal types, noise due to construction, operation and decommissioning can have a significant impact to marine mammals. Timing of construction should be considered, so as not to disturb migration.

All proposed projects would increase marine traffic. Vessels may strike marine mammals or reptiles, significantly impacting pelagic communities. In addition, increased vessel traffic is likely to increase petroleum hydrocarbons discharged into the water. Petroleum products can cause skin and eye irritation in marine mammals, and the products are toxic if ingested. Sea turtles may experience skin irritation, decrease of blood glucose levels, changes in respiration, and total shutdown of salt gland function if exposed to a petroleum spill.

Socioeconomic

Socioeconomic analysis categories included: population affected, economy and employment, property value, housing, public services, and traffic effects. The magnitudes of impact vary throughout the project life cycle. The greatest impacts on society appear to occur during the construction and decommissioning phase of all projects.

When comparing the three terminal types, the onshore project appears to have the widest range of socioeconomic effects. It received the best ranking in terms of economic and employment indicators. However, negative impacts on population and traffic appear to be much more significant when compared to the offshore projects.

Not one of the socioeconomic impacts associated with the FSRU project stood out as either significantly beneficial or detrimental in our analysis. Local economy and employment benefits are likely as a result of the proposed project; however, relative to general population size, these benefits are expected to be minimal.

The FSRU and platform projects show only minor differences with respect to socioeconomic effects. It is expected that the platform terminal will have a greater traffic impact during construction and decommissioning due to the location of project activities. The platform will be built and decommissioned locally. In comparison, most of the FSRU project will be built and decommissioned outside of the local area.

Recommendations

Our analysis of key issues and impacts for each proposed terminal type leads to general recommendations that may be applied to other LNG terminals:

- Remote siting lowers safety risks, therefore siting a facility away from densely populated areas is recommended.
- Care should be taken to avoid sensitive ecological areas when siting a facility.
- Additional technology may be required to reduce emissions of criteria pollutants, especially for facilities close to the general population.
- Prior to siting a facility, local communities should consider housing availability and potential increases to traffic flow due to construction, operation or decommissioning of a facility.

Further Study

The three proposed Southern California terminals are currently undergoing extensive reviews at the federal, state and local level. Much of the terminal information used for this analysis has not yet been peer reviewed, and some project details are still considered proprietary information. Additional information will become available as the applications progress, and should be integrated into any analysis regarding the receiving terminals. Since it is possible to mitigate some of the impacts, our analysis considers only the current projects and seeks to present the most significant concerns to date.

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ACRONYMS

AHTS – Anchor Handling/Tug Supply Vessel
BCDC – (San Francisco) Bay Conservation and Development Commission
BCF – Billion Cubic Feet
BGS – Below Ground Surface
BSCFD – Billion Standard Cubic Feet per Day
CALTRANS – California Department of Transportation
CCA – California Coastal Act
CCC – California Coastal Commission
CDFG – California Department of Fish and Game
CEQA – California Environmental Quality Act
CFR – Code of Federal Regulations
CINMS – Channel Islands National Marine Sanctuary
COE – Army Corps of Engineers
CPUC – California Public Utilities Commission
CSLC – California State Lands Commission
CZMA - Coastal Zone Management Act
dBA – Decibel (A Scale)
DXV – Direct Exchange Vaporizer
EA – Environmental Assessment
EFH – Essential Fish Habitat
EIR – Environmental Impact Report
EIS – Environmental Impact Statement
FMP – Fish Management Plan
FSRU – Floating Storage and Regasification Unit
HDD – Horizontal Directional Drilling
HDPE – High Density Polyethylene
IFV – Intermediate Fluid-Type Vaporizer
LARWQCB – Los Angeles Regional Water Quality Control Board
LAX – Los Angeles International Airport
LFL – Lower Flammability Limit
LOS – Level of Service
MMCF – Million Cubic Feet
MMSCFD – Million Standard Cubic Feet per Day
NAAQS – National Ambient Air Quality Standards
NEPA – National Environmental Policy Act
NFPA – National Fire Protection Association
NOAA – National Oceanic and Atmospheric Administration
NPDES – National Pollutant Discharge Elimination System
OCS – Outer Continental Shelf
PMP – Port Management Plan
POLB – Port of Long Beach
SCB – Southern California Bight
SCV – Submerged Combustion Vaporization
SWRCB – State Water Resources Control Board

TCF – Trillion Cubic Feet
USFWS – United States Fish and Wildlife Service
VOC – Volatile Organic Compounds
WLNG – Western Liquefied Natural Gas Terminal Associates

1 INTRODUCTION

1.1 Project Significance

There are currently three LNG receiving terminal types proposed for the Southern California coast. The completion of one or more of the currently proposed LNG facilities could supply in excess of 700 million cubic feet per day (mmcfd) of additional natural gas to the state grid (CEC, 2003). In order for communities and agencies to decide which of the proposed terminal types would be appropriate, benefits and drawbacks associated with each facility type must be understood. By comparatively analyzing the three proposed import terminal types in one study, decision makers can determine which type is suitable for their needs.

1.1.1 Three Receiving Terminal Types

In Southern California, there are currently three receiving terminal types under consideration. All terminal types receive LNG transported by carrier and regasify the LNG for distribution. Primary differences are location of terminal, design and storage capacity.

Onshore LNG Facility

An onshore LNG facility consists of a land based terminal which receives LNG for storage and regasification. A typical onshore terminal consists of a terminal to receive liquefied natural gas tankers, LNG storage tanks, regasification equipment (vaporizers) and other equipment (pipelines) to aid in natural gas delivery to industrial and residential consumers. The four existing LNG import terminals in the U.S. are onshore facilities. This analysis uses the proposed onshore facility for the Port of Long Beach as a case study to examine specific issues to be considered when siting a new terminal of this type in Southern California.

Figure 1 - Onshore Facility. *Source: Spec Engineering*

Platform LNG Facility

The platform LNG facility converts an existing offshore oil platform to accommodate liquefied natural gas. As with the onshore facility, the LNG is delivered to the platform via liquefied natural gas tankers. The platform LNG facility has no LNG storage capacity: after regasification the natural gas is immediately delivered to shore through a subsea pipeline. This pipeline will be constructed using existing pipeline corridors. Although a terminal of this type does not yet exist, the conversion of Platform Grace, off the coast of Oxnard, California, has been proposed as a LNG regasification facility. This proposal, the Clearwater Port, will be used as a case study to evaluate possible strengths or weaknesses of a platform LNG receiving terminal.

Figure 2 - Platform Facility. *Source: Minerals Management Service*

Floating Storage and Regasification Unit (FSRU)

Figure 3 - FSRU Facility. *Source: Cabrillo Port EA*

The FSRU is a new type of terminal currently in development. Located offshore, the terminal will be permanently moored with capacity for storage and regasification on board. The LNG carriers offload LNG directly to the FSRU storage units. After regasification, the natural gas will be transported to shore via subsea pipeline. Construction of such a terminal, the Cabrillo Port FSRU, is proposed off the coast of Oxnard, California. To study specific aspects of an FSRU, the Cabrillo Port FSRU proposal will be used as a case study.

1.2 Objective

The objective of this study is to comparatively analyze strengths and weaknesses of the three LNG terminal types. Although the evaluation will highlight general aspects of each terminal type, the case studies of proposed Southern California terminals will be used for more specific analyses. This study is not intended to determine the "best" LNG receiving terminal, but merely to understand and analyze aspects of each terminal type so that communities and agencies may make more informed decisions about LNG import facilities.

2 BACKGROUND

2.1 Introduction

National energy and economic experts have raised concerns about the available supply of natural gas throughout the United States. According to the United States Energy Secretary, total U.S. natural gas demand is projected to grow 50 percent over the next 25 years (Abraham, 2003). Annual estimates range from 0.8 to 2.8 percent growth in the coming decade. The U.S. Department of Energy projects natural gas consumption to increase from its annual 2001 level of 21.6 trillion cubic feet to between 31.8 and 37.5 trillion cubic feet by the year 2025. More than 57 percent of the increase will be used to power new gas-fired power generation facilities. The remaining will be used to meet the increasing demand expected in the residential, commercial, industrial, and transportation sectors (EIA, 2003).

Approximately 14 percent of total U.S. natural gas consumption is used to generate electricity, a figure that will go up dramatically over the next decade (EIA, 2002). California currently leads the nation in natural gas-fired power plants, with more than 35 percent of the state's natural gas consumed by electricity generation (Figure 4). In the aftermath of the 2000-2001 California energy crisis, which was accelerated by natural gas shortages, California politicians are becoming increasingly concerned about securing a reliable source of natural gas. According to David Maul of the California Energy Commission, more than 5,150 Megawatts of additional gas-fired power plant capacity has been added since the energy crisis, and an additional 9,526 Megawatts are proposed in the near future (Zeus Development Corporation, 2003).

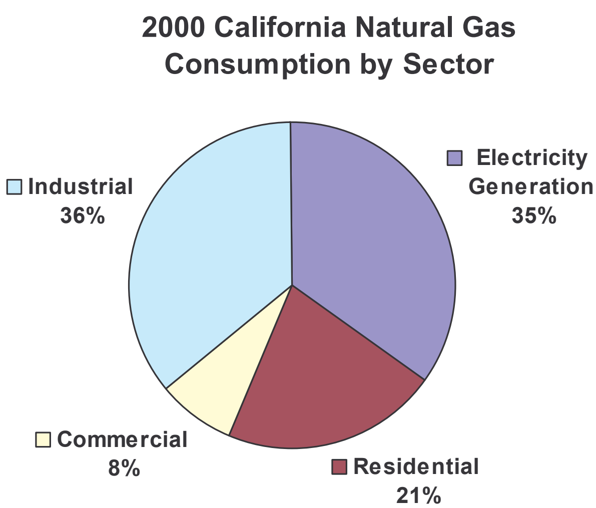

Figure 4 - California Natural Gas Consumption by Sector, 2000. *Source:* http://www.energy.ca.gov/naturalgas/natural_gas_facts.html

2.2 Natural Gas Market

2.2.1 North American Natural Gas Infrastructure

Natural gas is unevenly distributed around the globe. Worldwide natural gas supplies are abundant. However, the United States holds less than 4 percent of the total global reserves (DOE/EIA, 2002). Most of the natural gas in North America flows from Southern states and Canada to the Northeastern, Midwestern and Western Markets. The relative capacities and associated directions of natural gas flow throughout the U.S. are illustrated in Figure 5. Transmission corridors carrying the largest volumes of gas are shown as wider bands.

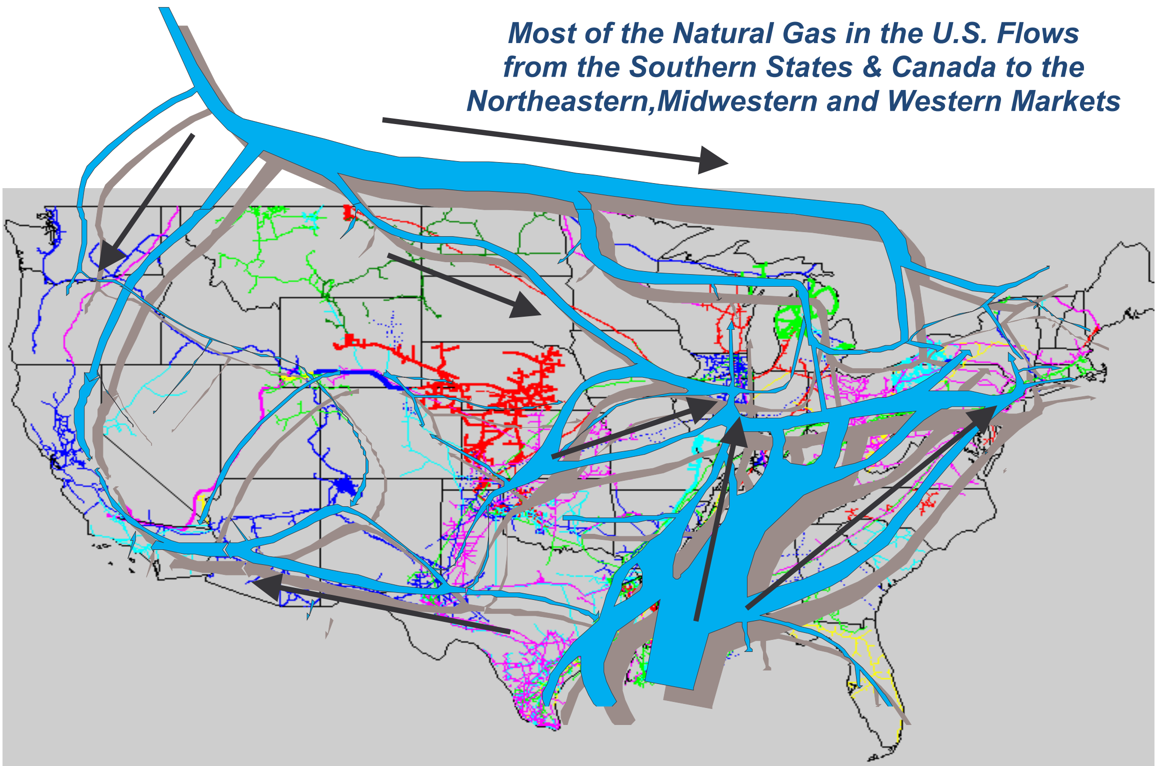

Figure 5 - Natural Gas Flow in the United States. *Source: Energy Information Administration, Natural Gas Pipeline State Border Capacity Database, as of December 2000.*

2.2.2 California's Natural Gas Infrastructure

Natural gas for the West Coast is received primarily from five major production basins located in Canada, the Rocky Mountains, and South of New Mexico (Figure 6). California receives approximately 15 percent of its natural gas from in state production, while the remaining 85 percent is imported from these regions.

With the exception of the Southern basins, all major out of state regions that provide gas to California have flat or declining production (CEC, 2002). Large interstate pipelines transport natural gas hundreds of miles and across several states to supply California. These pipelines must be large enough not only to meet California's needs, but also the needs of the states along the delivery paths. Most of California's imported gas (60 percent) comes from the South West (Zeus Development Corporation, 2003). Figure 6 shows the locations of the natural gas supply basins and major pipelines serving the western states. The map also shows that California is at the end of the interstate pipelines, making the state more vulnerable to supply shortages.

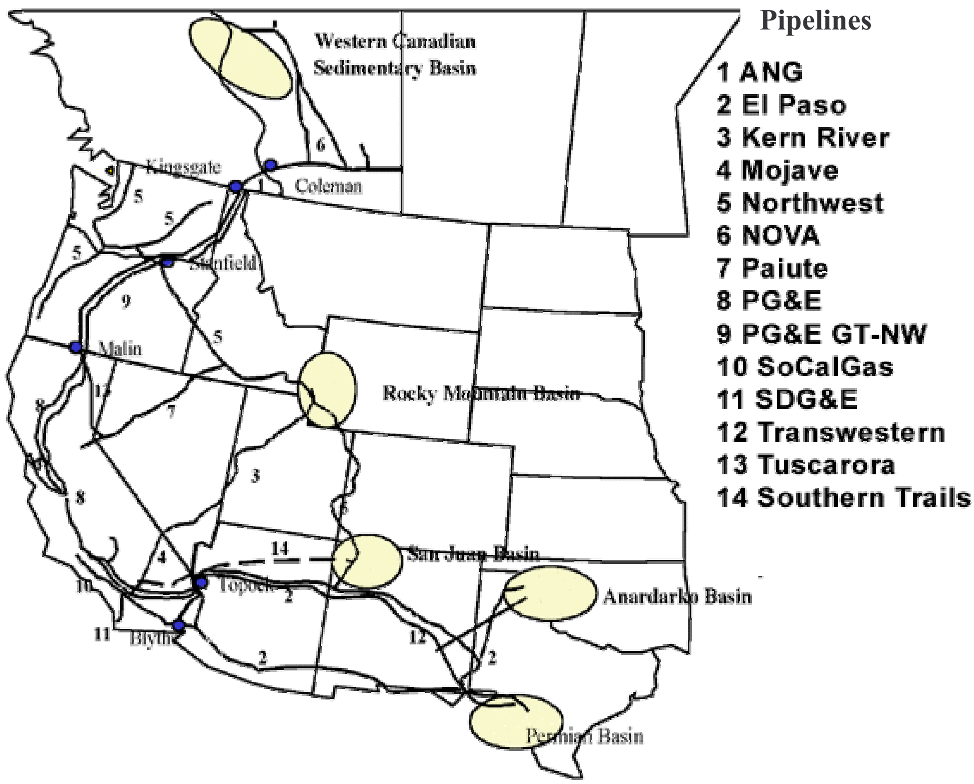

Figure 6 - Interstate Pipelines. *Source: California Energy Commission, www.energy.ca.gov*

California receives an estimated 85 percent of its natural gas from three transmission and distribution companies: Pacific Gas and Electric (PG&E), San Diego Gas and Electric (SDGE) and Southern California Gas Company (SoCal Gas). Two of them are subsidiaries of Sempra Energy (SDGE and SoCal Gas). The remaining 15 percent is supplied by local production, sold to these same firms, and delivered to consumers.

There are four major interstate pipelines entering California (PG&E, El Paso, Transwestern and Kern River) with an estimated delivery capacity of 6,630 million cubic feet of gas per day (mmcfd) (Table 1). All four are planning to expand capacity to meet contractual agreements and address the expected rise in California gas prices. An additional interstate pipeline (Southern Trails) is under construction and will add an estimated 80 mmcfd to the state grid. PG&E Transmission delivery capacity to California is impacted by its deliveries to Tuscarora Pipeline, which has a rated capacity of 125 mmcfd. Tuscarora Pipeline has plans to expand capacity to meet the growing needs of natural gas customers in northern Nevada. This expansion will place further stress on PG&E deliveries to California. Cold weather in the Pacific Northwest can also reduce deliveries to California, by as much as 350 mmcfd. Currently, in-state storage facilities can hold 172,000 million cubic feet (mmcf) to help meet demand peaks (CEC, 2002)

Table 1 - Interstate Pipeline Capacity. *Source: California Energy Commission, Natural Gas and Special Projects Office http://www.energy.ca.gov/naturalgas/natural_gas_pipelines.html*

Pipeline (mmcfd)	2001 Capacity	Capacity Additions	2003 Total Capacity
PG&E Transmission	1,950	200	2,150
El Paso	2,890	230	3,120
Transwestern	1,090	120	1,210
Kern River	700	1,050	1,750
Southern Trails	--	80	80
Total	**8,631**	**1,680**	**10,313**

Unlike interstate pipelines, which divert natural gas to the best market during peak demand periods, an LNG receiving terminal, once in place, would create a one-way market; Southern California will always be the recipient of the imported gas.

2.2.3 Unique factors influencing the California Market

Four primary factors contribute to California's volatile natural gas market:

1) demand swings due to seasonality,
2) drought conditions,
3) changes in economic parameters, and
4) gas storage availability.

Seasonal weather patterns increase our reliance on gas during temperature spikes in the winter and summer months. Although the greatest demand occurs during the summer months, energy demand increases during cold winter months as well. Cold winters require more gas to heat homes and hot summers require more electricity (which is primarily gas-fired) for air conditioning. Drought conditions, or lack of adequate rainfall, decrease the availability of hydro-electric power, thereby increasing demand for power generated from natural gas-fired power plants.

To account for these market fluctuations, excess gas is stored during off peak months in aquifers, depleted reservoirs, salt caverns, and/or in strategically located LNG storage facilities. These facilities are called peak shaving facilities because the gas can be drawn upon during peak seasons. There are currently over 113 storage, or peak shaving, facilities located throughout the U.S. (Figure 7).

The demand for natural gas can experience considerable decreases, throughout the nation, during an economic recession (CEC, 2002). This was evident throughout 2002. The 2000-2001 California energy crisis occurred during a time of low storage levels, drought conditions and an increased demand for gas caused by a cold winter.

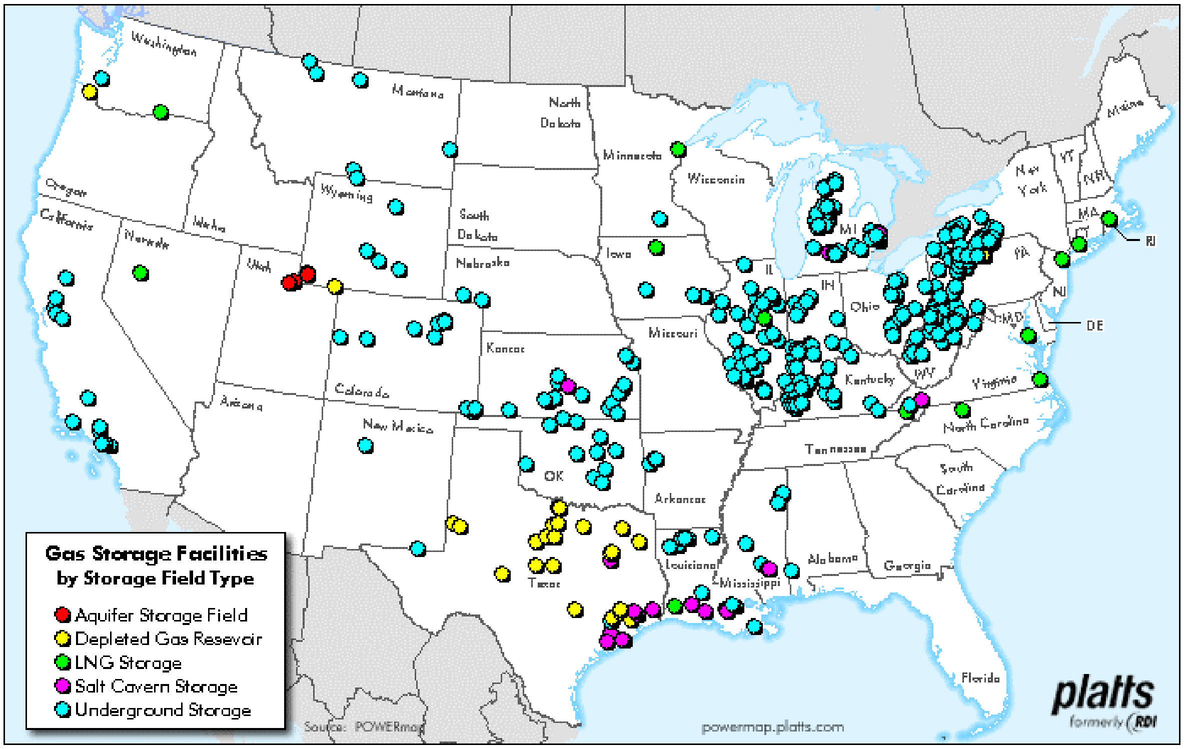

Figure 7 - U.S. Natural Gas Storage Facilities. *Source: http://www.platts.com/features/usgasguide/storagefacilities.shtml*

An LNG terminal located in California would improve access to diverse supply alternatives in the region, supplement storage capacity, and place downward pressure on the price of natural gas throughout the state. Additional storage capacity could also help stabilize price spikes during peak demand.

2.3 Overview of Liquefied Natural Gas

2.3.1 Raw Natural Gas

Natural gas is usually found as a mixture of hydrocarbon and non-hydrocarbon gases in porous geological formations (reservoirs) beneath the earth's surface. The actual chemical composition and heating value (Btu content) of natural gas varies with the production field from which it is extracted. Natural gas is extracted from these formations either from gas wells (non-associated) or in conjunction with crude oil (associated) production. Nearly three-quarters of the natural gas produced in California is associated production (CEC, 1998). Regardless of the production method, composition of natural gas received at the wellhead is never constant.

In its raw form, natural gas is primarily methane (CH_4), typically containing smaller amounts of ethane, propane, and heavier hydrocarbons. Raw gas contains varying quantities of non-hydrocarbon components, or impurities, such as carbon dioxide, oxygen, nitrogen, hydrogen sulfide, and rare gases. Physical properties of natural gas measured directly from the wellhead can also vary greatly.

Much of the associated natural gas produced in California is of poor quality. Many local fields produce a high percent of carbon dioxide (a corrosive gas) and hydrogen sulfide (a corrosive and deadly gas), which require additional processing to meet safety and/or pipeline quality specifications. Typical properties of raw natural gas are outlined in Figure 8.

Chemical Properties listed in order of abundance.

Methane (CH_4)	70-90%
Ethane (C_2H_6)	
Propane (C_3H_8)	0-20%
Butane (C_4H_{10})	
Carbon Dioxide (CO_2)	0-8%
Oxygen (O_2)	0-0.2%
Nitrogen (N_2)	0-0.5%
Hydrogen Sulfide (H_2S)	0-0.5%
Rare Gases Ar, He, Ne, Xe	trace

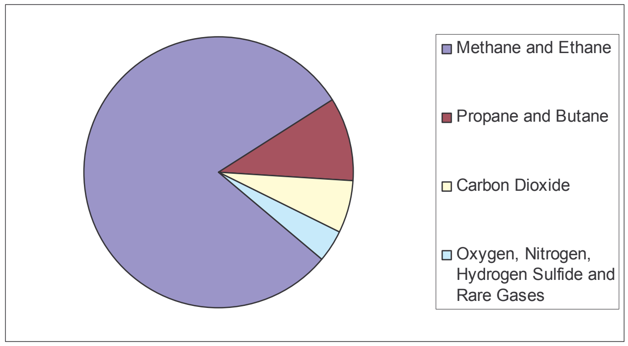

Figure 8 - Components of Raw Natural Gas. *Source:* **www.naturalgas.org**

2.3.2 Processed Natural Gas

Processed "merchantable" natural gas is achieved by removing much of the higher-level hydrocarbons (such as ethane, propane, and butane) and impure non-hydrocarbon components (such as carbon dioxide, oxygen, nitrogen, and hydrogen sulfide). Chemical composition depends mainly on the pipeline requirements set by regulators, wholesale marketers, and the needs of industrial and domestic consumers. In general, most processed natural gas is greater than 90 percent methane. Because of methane's simple chemical make-up, natural gas burns much cleaner than complex fossil fuels such as oil and coal (which contain high proportions of carbon, sulfur and nitrogen).

Processed (pipeline quality) natural gas is the same gas used in many of our homes. After processing, natural gas is colorless and odorless. As a safety precaution, an odorant with a distinctive "rotten egg" smell (mercaptan) must be added to assist in detecting leaks. Natural gas is also nontoxic, which means inhaling it will not cause ill effects. It is however an asphyxiant, meaning in very large quantities natural gas can displace most of the oxygen in the air, at which point breathing becomes difficult. However, before this happens, the odorant will alert you to the presence of gas.

Natural gas has a very limited range of flammability. It will only burn in a 5 to 15 percent gas-to-air mixture, and it has a very high ignition temperature relative to other hydrocarbon mixtures. Unlike many other hydrocarbon forms, natural gas is lighter than air; so when it is released it will rise into the atmosphere. Refer to Table 2 for a comparison of hydrocarbon physical properties.

Table 2 - Physical Properties of Various Hydrocarbons. *Source: Modified from Fire Protection Handbook*

	Specific Gravity H_2O =1	Vapor Density Air = 1	Boiling Point (C°)	Btu Per cu ft	Auto Ignition Temp.(C°)	Flame Speed	Flammability Limits
Natural Gas	0.31	0.75	-162	1008-1071	557	40 cm/sec	5-15%
Propane	0.509	1.50	-42	2516	549	46 cm/sec	2.1-9.5%
Acetylene	0.91	0.91	-75	1499	305	7.62m/sec	2.5-81%

2.3.3 Liquefied Natural Gas

The main incentive for liquefying natural gas is a greatly reduced volume that allows for economical transport. The process of cooling natural gas to a liquid state is referred to as liquefaction and results in a composition that is almost pure methane. In liquid form, the same volume of natural gas occupies 625 times less space, making vessel transport practical (LNG in Vallejo, 2003).

Before the gas can be liquefied, water, sulfur, and any other chemicals that would form solids during the process are removed. Other gases such as ethane, propane, and butane may be drawn off for separate markets. Typical LNG composition is listed in Figure 9.

Chemical Properties listed in order of abundance.

Methane (CH_4)	83-99%
Ethane (C_2H_6)	1-13%
Propane (C_3H_8)	0.1-3%
Butane (C_4H_{10})	0.2-1.0%

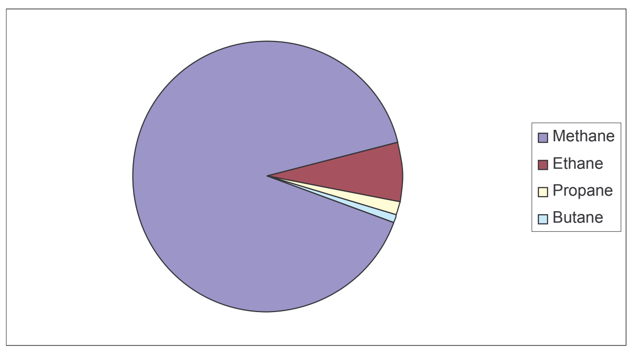

Figure 9 - Typical LNG Composition. *Source: Fire Protection Handbook*

Physical Characteristics

At minus 162°C (-259° F), natural gas undergoes a phase transition and condenses into a liquid. Cooling natural gas to this temperature results in a cryogenic, clear, colorless and odorless liquid (Marks, 2003). LNG has a density of approximately 1.77 kg (3.9 pounds) per gallon (University of Houston Law Center, 2003). For comparison, water is has a density of 3.76 kg (8.3 pounds) per gallon. If water and LNG come in contact, LNG will not mix with the water, instead forming a layer on top of both fresh and salt water. However, contact with water causes LNG to warm and rapidly vaporize. The resulting vapor cloud absorbs heat from the surrounding air and after reaching minus 107° C (-160° F), the cloud will begin to rise and dissipate (FERC, 2003). This vapor cloud is initially denser than air due to the cold temperature, which causes the moisture in the air to condense and form a cloud that resembles ground fog (LNG in Vallejo, 2003). Vaporized gas, or ground fog, above a standing pool of LNG poses an asphyxiation risk, due to the displacement of oxygen (FERC, 2003).

Safety Issues Associated with LNG

The vapor cloud from LNG is also flammable in the range of 5 to 15 percent concentration in air. Below 5 percent, there is not enough gas to sustain a burn. Above 15 percent, the gas concentration is too high to burn (LNG in Vallejo, 2003). When burning in an open space, the flame speed of methane is relatively slow at 40 cm per second (0.88 miles per hour). Methane is not capable of a boiling-liquid expanding-vapor explosion (BLEVE). It does not have explosive properties in open spaces. However, if the cloud is in a confined area and in the 5-15 percent concentration range, exposure to an ignition source will cause an explosion (LNG in Vallejo, 2003). A vapor cloud within the flammable concentration range generally needs an outside ignition source, such as a flame or spark, to begin combustion. Auto-ignition can occur with a heat source of 540° C (1004° F) or greater (New York State Energy Plan, 1998). A third type of explosion, a transitional explosion, can happen when a large volume of LNG is spilled onto water and quickly transitions to gas (LNG in Vallejo, 2003).

LNG as a Transitional Fuel

With the advent of fuel cell, solar, and wind power technology, significant effort is being made to move away from fossil fuels. Unfortunately, even the best-case scenarios do not forecast a significant shift away from fossil fuels in the near future. Therefore, natural gas, as a cleaner-burning alternative to traditional fossil fuels, should be considered as a transitional fuel until renewable energy sources become more available.

LNG/Natural Gas and Global Warming

Although a complete analysis of natural gas and its contribution to global warming is beyond the scope of this study, it is important to recognize the possible effects of natural gas on our planet's climate.

According to the Intergovernmental Panel on Climate Change (IPCC), "human activities are changing the atmospheric concentrations and distributions of greenhouse gases and aerosols. These changes can produce a radiative forcing by changing either the reflection or absorption of solar radiation, or the emission and absorption of terrestrial radiation" (IPCC, 1996). This radiative forcing equates to a net increase in the absorption of energy by the Earth, or an increase in global temperatures. The global average surface temperature of the Earth has increased by between 0.6±0.2°C (33±0.2°F) during the 20th century (IPCC, 2001). The IPCC's Third Assessment Report concluded that "[I]n light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations" (IPCC, 2001).

Methane, the primary component of natural gas, is a naturally occurring greenhouse gas. Other naturally occurring greenhouse gases include water vapor, carbon dioxide, nitrous oxide and ozone. These gases are constantly emitted to and removed from the atmosphere by natural processes. But anthropogenic activities cause additional quantities of these and other greenhouse gases to be emitted or sequestered, altering their natural global concentrations (U.S. EPA, 2002). In the case of methane, it is primarily released to the atmosphere through anaerobic decomposition of organic matter in biological systems. Agricultural processes, enteric fermentation in animals, decomposition of animal wastes, and decomposition of municipal solid wastes all emit methane (U.S. EPA, 2002). In addition, the production and distribution of natural gas and petroleum, coal mining, and incomplete fossil fuel combustion all contribute to methane emissions. The IPCC estimates that slightly more than half of the current methane flux to the atmosphere is anthropogenic, from activities such as agriculture, fossil fuel use, and waste disposal (IPCC, 2001). According to the Energy Information Administration, U.S. methane emissions from natural gas production have increased over the last decade (Figure 3).

Table 3 - U.S. Methane Emissions from Natural Gas Systems, 1990-2002. *Source: Energy Information Administration*

U.S. Methane Emissions from Natural Gas Systems, 1990-2002

	Methane	Carbon Dioxide Equivalent
Estimated 2002 Emissions (Million Metric Tons)	6.5	148.9
Change Compared to 2001 (Million Metric Tons)	0.1	2.0
Change from 2001 *(Percent)*	*1.4%*	*1.4%*
Change Compared to 1990 (Million Metric Tons)	0.9	19.9
Change from 1990 *(Percent)*	*15.5%*	*15.5%*

The 2002 estimate is preliminary, because pipeline data for 2002 had not been finalized as of the publication of the EIA report. However, about two-thirds of the 15.5% increase over the last decade is attributed to an increased number of natural gas distribution pipelines, while one-third is attributed to increases in gas withdrawals (EIA, 2003). These methane emissions are all inadvertent by-products of natural gas production and distribution. In other words, these increases are stemming from the process itself, not from the use of natural gas. According to Schlesinger, inadvertent releases of fossil methane during mining and use of coal and natural gas must account for 15-20% of the total annual flux of methane to the atmosphere (Schlesinger, 1997). In addition to inadvertent methane releases during the natural gas process, greenhouse gases are also released during combustion of natural gas.

Methane is richer in hydrogen than other conventional fossil fuels. This means that during combustion the fuel forms more water vapor and less carbon dioxide per unit energy delivered than any other fossil fuel (Table 4).

Table 4 - 1998 Fossil Fuel Emission Levels. *Source: EIA – Natural Gas Issues and Trends 1998*

Emission Levels
- Pounds per Billion Btu of Energy Input

Pollutant	Natural Gas	Oil	Coal
Carbon Dioxide	117,000	164,000	208,000
Carbon Monoxide	40	33	208
Nitrogen Oxides	92	448	457
Sulfur Dioxide	1	1,122	2,591
Particulates	7	84	2,744
Mercury	0.000	0.007	0.016

Only pure hydrogen would release smaller amounts of greenhouse gases per unit energy delivered (Siu, J. S. Herring et al., 1998). This reduction of greenhouse gases emitted during combustion is one reason natural gas has been cited as a cleaner burning fuel for the future.

Although other greenhouse gases, such as carbon dioxide, are reduced with the use of natural gas, will the inadvertent releases of methane discussed above overpower these benefits? Methane has the ability to trap heat almost 21 times more effectively than carbon dioxide (Natural Gas Supply Association, 2003). Consequently, releases of methane will have a larger global warming potential than a comparable release of carbon dioxide. In 1997, the U.S. Environmental Protection Agency and the Gas Research Institute performed a major study to determine whether a possible increased level of methane emissions would offset the reduction in carbon dioxide emissions from increased natural gas use. The study concluded that the reduction in emissions from increased natural gas use strongly outweighs the detrimental effects of increased methane emissions. These findings suggest that the increased use of natural gas, instead of dirtier burning fossil fuels, can help to lessen the emissions of greenhouse gases in the United States (Natural Gas Supply Association, 2003).

2.3.4 Liquefied Petroleum Gas

Liquid Petroleum Gas (LPG) is often confused with LNG and vice versa. LPG is composed primarily of propane or butane or a mixture of these gases. These turn into liquid under pressure and are then stored in cylinders or tanks. When the pressure is released, the liquid becomes a gas. Unlike LNG, which will rise if released into the atmosphere, LPG is heavier than air, meaning it will settle in low-lying areas. It is not possible to liquefy natural gas solely by pressurizing it (University of Houston Law Center, 2003).

2.4 History of LNG

2.4.1 LNG in the U.S.

Natural gas liquefaction, as a practice, has existed for a little over a century, with experiments in gas liquefaction dating back to the early 19th century. In 1873, the first practical compressor refrigeration machine was built in Munich. In 1912, the first LNG plant was built in West Virginia. The year 1941 saw the creation of the first commercial peak-shaving plant that was built in Cleveland, Ohio (Marks, 2003). Increased development of LNG halted in 1944 when a severe LNG related incident in Cleveland claimed the lives of 128 people. Please refer to Appendix A for a complete history of LNG related incidents in the U.S and abroad.

In 1959, *The Methane Pioneer* made the world's first transcontinental LNG voyage. The LNG cargo, safely transported from Lake Charles, Louisiana to Canvey Island, United Kingdom, served as a global demonstration that large volumes of LNG could be transported across the oceans (University of Houston Law Center, 2003).

In the late 1960s, 20 years after the Cleveland incident, exploration of LNG as an alternative source of natural gas resumed in the U.S. Federal price controls on interstate gas transactions in the late 60's created the *appearance* of a natural gas shortage. As a result of these controls, natural gas could be sold within the state it was produced for a price above what could be received for interstate transactions. When producers opted to sell gas almost solely to the producing state, as opposed to dealing with the federal controls that regulated interstate transactions, the illusion of a natural gas shortage was produced. As a result of this "shortage," the United States turned to imported natural gas sources, primarily from Algeria. Four U.S. LNG import terminals were constructed in the following locations: Everett, Massachusetts, Cove Point, Maryland, Elba Island, Georgia and Lake Charles, Louisiana.

In 1978, Congress passed the Natural Gas Policy Act, which lifted price controls on all domestic natural gas discovered after 1977. As price controls disappeared, natural gas exploration and drilling expanded, and producers made domestic natural gas available to the interstate market. This new federal policy diminished the cost advantage of imported LNG. As a consequence, U.S. imports of LNG peaked in 1979 at 253 billion cubic feet (Bcf).

Around the same time, price disputes occurred between Algerian suppliers and U.S. LNG companies. These disputes were never resolved, and, in 1980, Algeria ceased deliveries to Elba Island, Georgia, and Cove Point, Maryland, leading to the closure of both facilities.

In 1983, LNG imports were suspended to the Lake Charles, Louisiana facility, resulting in the shutdown of the terminal. According to the U.S. import/distribution company, the high price of the LNG made it unmarketable. LNG imports were resumed during the late 1980s, in part, because of Algeria's willingness to enter into more flexible long-term contracts.

U.S. LNG imports have rebounded significantly over the past seven years, from the decade-low volume of 18 Bcf in 1995, to the second highest volume of LNG ever imported into the U.S., 238 Bcf in 2001. This increase is attributable to both a 14% increase in natural gas demand in the U.S. from 1990 to 2001, as well as declining prices for imported LNG. Declining prices are said to result from substantially lower capital and operating costs over all segments of the LNG supply chain. In fact, in 2000, the annual average price of imported LNG was actually lower than the price of pipeline gas (Marks, 2003).

Declining prices led the owners of the Elba Island and Cove Point LNG import facilities to resume operations. The Elba Island LNG facility reopened in 2001 and received its first LNG shipment in more than 20 years. In early October 2001, the Federal Energy Regulatory Commission (FERC) authorized the Cove Point facility to reactivate its LNG receiving terminal and expand storage capacity. Following the terrorist attack of September 2001, however, FERC reconsidered its order, due to the fact that a nuclear power plant is located only four miles from the terminal. After review of confidential evidence submitted by the FBI, Coast Guard, Nuclear Regulatory Commission, and Department of Transportation - Office of Pipeline Safety, FERC reaffirmed its finding that the proximity of the nuclear power plant to the Cove Point LNG facility does not raise a specific national-security concern. The facility was reopened in late

2003. In 2002, FERC also granted final approval for expansion of the LNG terminal in Lake Charles, Louisiana.

2.4.2 LNG in California

In 1973, Pacific Gas and Electric and Pacific Lighting Company, in a venture known as Western Liquefied Natural Gas Terminal Associates (WLNG), sought approval to build an LNG import terminal on the California coast. Due to the complex regulatory climate, both at the state and federal level, agencies could not reach a siting agreement (Weems and Keenan, 2002).

After a concentrated lobbying effort on the part of WLNG, the California state legislation passed the California LNG Terminal Siting Act of 1977. The Act not only contained requirements for terminal siting, but also shifted approval authority from the California Coastal Commission (CCC) to the California Public Utilities Commission (CPUC) (Weems and Keenan, 2002). The CCC still played a role in ranking potential sites.

In 1977, WLNG submitted an application for an onshore receiving terminal at Little Cojo near Point Conception (CCC, 1978). In accordance with the Terminal Siting Act of 1977, the CCC identified, evaluated and ranked potential sites in conjunction with the application site. The CCC ranked four potential onshore LNG sites: Horno Canyon on Camp Pendleton, Rattlesnake Canyon in San Luis Obispo County, Little Cojo near Point Conception, and Deer Canyon in Ventura County (CCC, 1978). All four sites were rejected for various reasons: conflicts with existing military operations, possible environmental impacts, public safety concerns, and seismic considerations. According to the CCC, all proposed facilities would cause major adverse impacts to natural marine and wildlife resources, public recreation areas, and other resources protected by the California Coastal Act of 1976 (CCC, 1978).

In addition to these findings, there was strong public opposition to a possible terminal at Point Conception. Environmental NGOs such as the Environmental Defense Center rallied to increase pressure on approval agencies. Despite public opposition and lawsuits, the project was eventually approved (Maul, 2003). However, gas prices begin to rise in the U.S., and the WLNG eventually abandoned its proposal. The 1977 LNG Terminal Siting Act has since expired.

2.4.3 U.S. LNG Import Terminals

Everett, Massachusetts – 1971: Built by Distrigas Corporation, the Everett terminal was the first LNG import terminal built in the United States. This onshore terminal is located northwest of central Boston, Massachusetts, on the Mystic River (EIA, 2001). With an output capacity of 435 mmcfd (million cubic feet per day), Everett terminal is the only U.S. terminal that has been consistently operational since it's opening. In the summer of 2003 the terminal's output capacity was expanded from 435 mmcfd to approximately 700 mmcfd (University of Houston Law Center, 2003).

Cove Point, Maryland – 1974: The Cove Point terminal is located on the Chesapeake Bay at Cove Point in Lusby, Maryland, about 50 miles south of Washington, D.C. The terminal was operational from 1978-1980, but was shut down in 1980 due to economic constraints and supplier contract disputes. The facility resumed operation in 2003 and plans to expand output capacity to 1000 mmcfd (University of Houston Law Center, 2003).

Elba Island, Georgia – 1978: Similar to Cove Point, Elba Island terminal was also operational from 1978-1980. Elba Island is located downriver from Savannah, Georgia, on the Savannah River. The facility was recently recommissioned. In October 2001, Elba Island received it's first cargo shipment since 1980.

Lake Charles, Louisiana – 1982: Built in 1982, the Lake Charles terminal was closed down in 1983 due to LNG price constraints. The facility was reopened in 1989 and has remained in operation since that time (EIA, 2001). Should planned expansion be completed, the Lake Charles facility will have the largest output capacity of the four existing U.S. terminals, with approximately 1,200 mmcfd production capabilities (University of Houston Law Center, 2003).

2.4.4 U.S. Export Facilities

Kenai, Alaska – 1969: The Bechtel/Phillips LNG export terminal is the only export facility in the United States. The facility has been in operation consistently since 1969 (Zeus Development Corporation, 2003). The output of the facility is a dedicated supply for Tokyo Electric Power Company and Tokyo Gas Company until the year 2009. The exported LNG is perfectly suited for the U.S. market because of its high methane concentrations, so that option may be explored as current contracts expire.

2.4.5 Global LNG Facilities

For many years, liquefied natural gas has been a reliable source of energy around the globe. LNG exports come primarily from locations where large gas discoveries have been made, such as Algeria, Indonesia, Trinidad, Nigeria, Malaysia, Qatar, Oman, and Australia. Typically these locations are far from areas of high natural gas demand, making LNG exportation an economically viable industry. LNG import terminals are found throughout Europe and the Pacific Rim (Figure 10).

Figure 10 - Global LNG Terminals. *Source: CH-IV International*

Global demand for LNG is on the rise, with ten percent growth annually during 1999 and 2000. LNG demand continued to increase during 2001, albeit at a slower rate (4.5 percent) due to a weak global economy. According to the Energy Information Administration, the global natural gas demand is estimated to nearly double over the next two decades. A study released in July 2002 by the energy research firm DRI-WEFA concluded that "the global proliferation of LNG liquefaction and regasification terminals will make natural gas a global commodity by 2025, much like oil is today" (Marks, 2003).

2.5 LNG Process

The LNG supply chain involves a complicated technological process, which begins at the production field and ends with the consumption of natural gas by households, commercial, industrial, and power generation facilities. There are four main steps in the LNG supply chain (Figure 11):

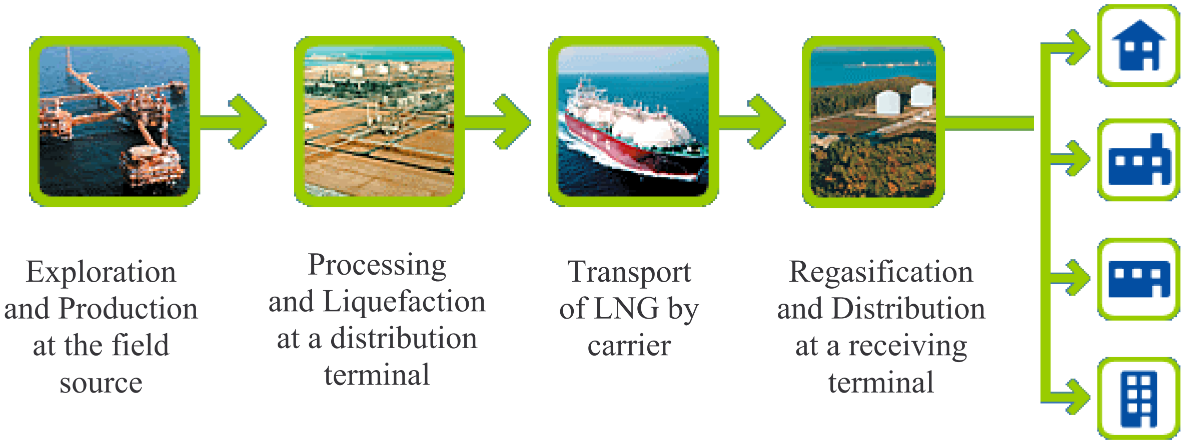

Figure 11 - LNG Process. *Source: South Hook LNG*

Exploration and Production

Due to significant advances in seismic imaging over the last 15 years, the practice of locating natural gas and petroleum reserves has transformed dramatically. Probability of recover (recovery rates) has gone from 25 to 30 percent, in the earlier days of exploration, to upwards of 70 percent success utilizing modern 4-Dimentional seismic imaging (NaturalGas.org, 2003). Contrary to earlier estimates, experts now believe worldwide natural gas supplies are abundant. According to World Oil, for the year 2001, worldwide proven reserves of natural gas were 5919 trillion cubic feet (Tcf), an increase of 8.4 percent over the year 2000, and more reserves of natural gas continue to be discovered (University of Houston Law Center, 2003).

Processing and Liquefaction

Once extracted from the reservoir, the amount of natural gas processing required prior to liquefaction depends primarily on the quality specifications set by regulatory agencies, wholesale marketers, and the needs of industrial and domestic consumers. Before natural gas is distributed, it first must be sent to a processing, or "stripping" plant, where it is cleaned and separated. At the processing plant, the natural gas is sent through a separator where secondary byproducts, such as heavier hydrocarbons (including ethane, propane, and butane) and impurities (including water, carbon dioxide, oxygen, nitrogen, and hydrogen sulfide) are removed. Impurities must be removed to prevent solids from forming during the cooling process, which will damage equipment. This purification process will also prevent equipment damage caused by internal corrosion.

Once quality specifications are achieved through processing, the natural gas is processed through a liquefaction system, cooling it to minus 162° C (-260° F). Once liquefied, LNG can be stored in specially designed containers or transferred directly to an LNG carrier. Due to the cryogenic nature of LNG, storage tanks, associated equipment, and piping must meet stringent design standards. For example, exposing carbon steel to the extremely low temperature of LNG can cause embrittlement failure.

Onshore storage usually consists of large insulated inner tanks made of nickel, aluminum, or stainless steel. Outer containment usually consists of either an additional shield of concrete or steel (a double walled tank) and/or secondary containment dikes. Both are designed to hold the entire contents, if the primary tank were to fail. Most peak-shaving and import terminal storage tanks in the U.S. are single wall construction (University of Houston Law Center, 2003).

Transportation of LNG

LNG is transported at slightly above atmospheric pressure in thermos® like containers. According to Keith Bainbridge, director of global shipping at LNG Shipping Solutions, most of the carrier ships used today are either Moss™ (spherical) or membrane style containment systems.

Moss™ carriers are easily identified by the domed tanks protruding above the carrier deck (Figure 12). Membrane carriers look more like the traditional oil tankers with a lower profile deck structure (Figure 13). As of late 2003, 141 LNG carriers were in service, 74 of which are Moss™, 61 membrane, and 6 represent other types. An additional 54 ships are on order, of which 36 are membrane, 18 Moss™, and 2 others. As a safety precaution, both vessel types utilize insulated double-hull construction, nitrogen purging, gas detection monitoring, and emergency shut down systems. Many carriers have duel fuel capabilities. For example, a diesel-powered ship can switch over to electric or natural gas, thereby reducing emissions when entering a port or approaching areas with strict air emission rules, i.e. a non-attainment zone.

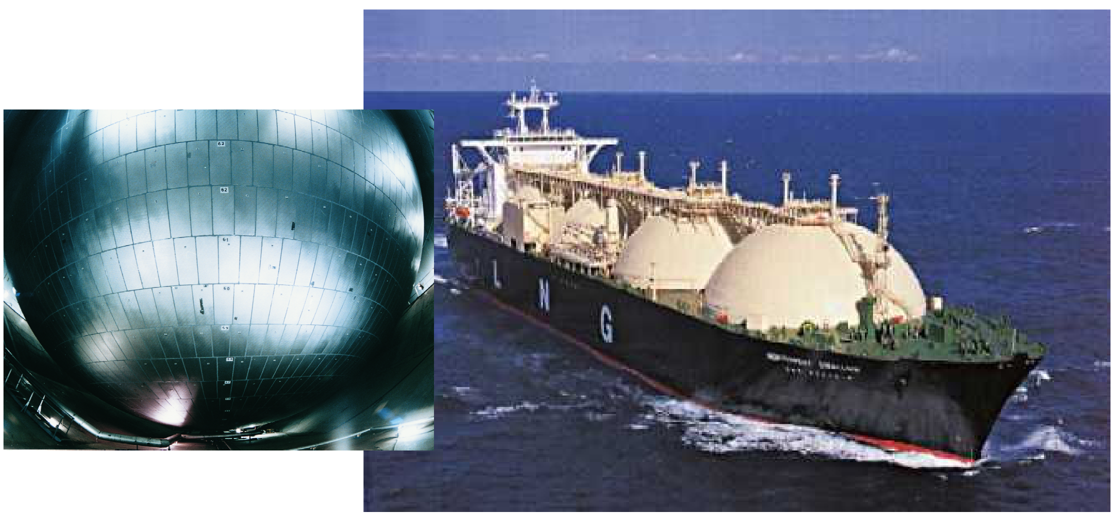

Figure 12 - Moss™ Spherical Container. *Source: http://www.mossww.com/mossmaritime/*

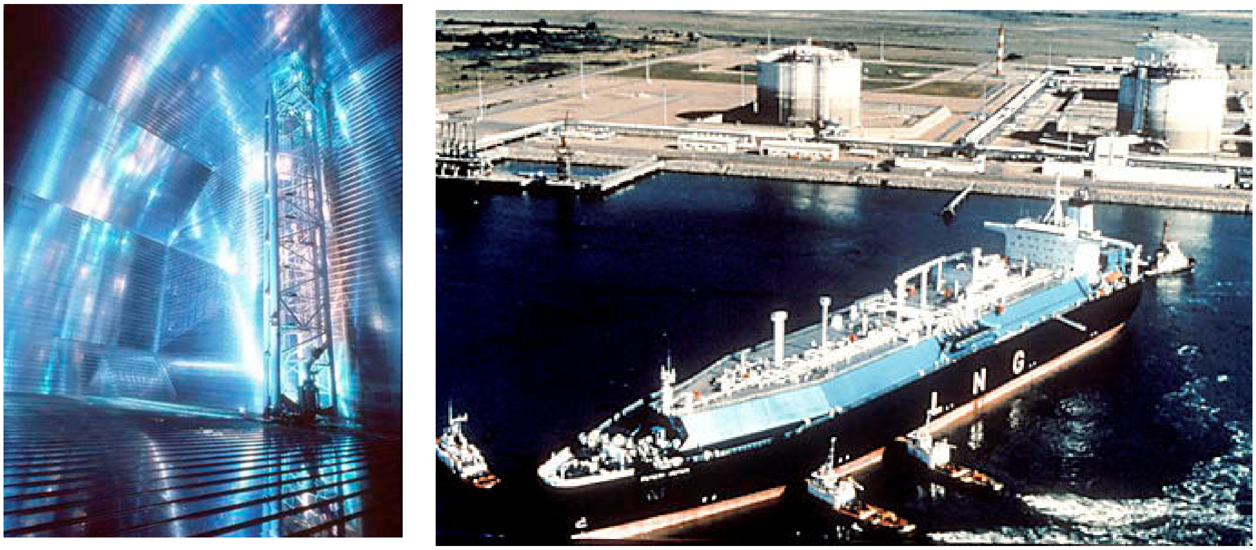

Figure 13 - Membrane Carrier. *Source: http://www.nickelmagazine.org/index.cfm/ci_id/12207.htm*

Regasification and Distribution at Receiving/Import Terminal

At the receiving terminal, LNG is warmed to around 5ºC (41ºF) by passing through a heat exchanger using either seawater or freshwater as a medium. There are three types of regasification units available: Intermediate Fluid-type Vaporizer (IFV), Direct Exchange Vaporizer (DXV) and Submerged Combustion Vaporizer (SCV). The IVF and DXV typically utilize seawater, which passes through a heat exchanger, warming the LNG. A major drawback of these units is the high volume of seawater (millions of liters per day) needed for operation. The SCV unit does not use seawater, instead generating heat through the combustion of natural gas, which heats a fresh water bath, thereby heating and vaporizing the LNG.

Once vaporized, natural gas is delivered to the existing pipeline network, which currently serves about 175 million American consumers through more than 2 million miles of existing underground pipelines (American Gas Association, 2003).

3 METHODOLOGIES

3.1 Introduction

This study analyses the potential impacts of three LNG import terminal types. Actions during facility life stages are analyzed for possible impacts in three categories: community safety, environmental, and socioeconomic. Each category is then subdivided into specific areas of concern (subcategories). The final analysis is presented in matrix form to allow rapid visual evaluation (Table 5).

The following descriptions detail why each subcategory is selected as an important criteria for evaluating the impacts of an LNG facility, and the methodologies by which impacts are assessed for each of these subcategories. The analysis includes a numerical weighting of the impact magnitude, as well as a ranking of the relative likelihood of impact occurrence. While magnitude rankings vary by category, relative likelihood estimates are consistent for all categories (Table 6).

Table 5 - Sample Matrix

Community Safety Effects	FSRU	construction	operation & maintenance	accidents			decommission
				minor - within facility	moderate - within exclusion zone	major - outside exclusion zone	
	operational failure						
	maritime accidents						
	natural phenomena						
	terrorism/sabotage						

Table 6 - Definition of Likelihood for All Categories

1	highly likely	expected to happen at least once a year
2	likely	expected to happen once in a ten year period
3	possible	expected to happen once during lifetime of facility
4	unlikely	not expected to happen during lifetime of facility

3.2 Community Safety

The Community Safety section describes specific accident scenarios and the potential effects from different types of accidents. This allows a more detailed comparison of the terminals by contrasting impacts resulting from different accident events. Each facility type has inherent strengths and weaknesses stemming from design, location, and operational differences. All three terminals have crews that are at higher risk of injury due to their proximity to the center of accident impacts. Therefore crew injuries are included in this comparative analysis. Only effects to the public community are considered for ranking.

Estimates of the magnitude and likelihood of effects for different accident scenarios are based on previous studies and research. Efforts are made to use published material that is peer reviewed, however, much of the information available on LNG safety is in the form of internal reports that are not written for publication and may not have been subject to peer review. Estimates from recent sources are used whenever possible. The definitions used to rank the magnitude of effects to community safety are summarized in Table 7.

Table 7 - Definition of Magnitude as Applied to Community and Safety

a	catastrophic	irreversible injuries or damage to facility requiring closure
b	severe	irreversible injuries or temporary disruption of operations
c	important	reversible injuries or temporary disruption of operations
d	minimally important	reversible injuries or no disruption of operations
e	neutral	no injury, no disruption of operations
f	minimally beneficial	not applicable (n/a)
g	beneficial	n/a

The four accident scenarios considered are: operational failure, maritime accidents, natural phenomena, and terrorism/sabotage. This list is not comprehensive of all possibilities, but instead represents the main safety issues. Construction and decommission of the facilities is not evaluated because there will be no LNG present at these times. Operations & maintenance is not separately evaluated because the accident category is inclusive of any impacts that would occur during this time.

3.2.1 Operational Failure

Operational failure of machine equipment over time is a reality and includes the malfunction of systems that unload, store, or vaporize LNG. Occasional failures are expected, making monitoring equipment, leak detection systems, and safety valves integral parts of facility design. Good design minimizes spill potential and subsequent impacts. LNG terminals have multiple safety features designed to detect and prevent operational failures from resulting in an LNG release. This report assumes that all facilities have similar systems that process and transport LNG within the facility and so these systems are excluded from evaluation. The most likely type of release from operational failures occurs during unloading operations (LNG in Vallejo, 2003) and this scenario is used to represent the average operational failure.

A spill from loading arms releasing a jet of LNG into the water between tankers and the docking station could result in a rapid phase transition explosion (RPT) and could escalate a small accident (Koopman, 2004). A rapid mixing of water and LNG causes the RPT. Although not extensively studied, RPT has a smaller dispersion than vapor clouds and pool fires (Havens, 2003). RPTs are not specifically addressed in this evaluation.

The different services offered by the facility, as well as the size of the community at risk under each accident category, is the main focus of impact magnitude assessment.

3.2.2 Maritime Accidents

Maritime accidents are split into three categories: groundings, collisions, and allisions. Groundings occur when a moving vessel enters water that is too shallow, causing the ship hull to collide with the coastal bottom. The water depth around the facility will be considered for potential grounding damage. Collisions between two moving vessels are of concern especially when involving LNG carriers. Allisions are collisions between a moving vessel and a stationary object, such as a pier or docked ship. The amounts of vessel traffic and facility surroundings, such as commercial businesses or residential districts, are compared to determine matrix rating.

3.2.3 Natural Phenomena

Seismic activity must be considered in planning any facility in California. This evaluation will assume that each facility will be exposed to the same seismic disturbances. State guidelines classify a fault as active if there has been displacement in the last 11,000 years. A fault segment is classified as potentially active if there has been displacement in the last 1.6 million years. Effects of earthquakes include ground shaking, ground rupture along the fault line, ground subsidence, ground liquefaction, and tsunami. Ground liquefaction occurs in loose saturated soils and causes the ground material to have liquid characteristics, which causes a loss of stability for the structure foundation. On a slope, ground liquefaction can also cause slope failure and land slides.
Tsunamis are the result of submarine faults breaking or creating underwater landslides. The wave pattern created radiates out in concentric circles and creates periods of waves with low heights and high propagation speeds. The waves go unnoticed until they move into shallow water and the coastal bottom modifies wave height resulting in rapidly rising water levels (Entrix, 2003). The vulnerability of a facility to damage from a seismic shock as well as location relative to fault lines is the basis for evaluating impact magnitude.

The offshore location of two of the terminals being examined requires additional evaluation of possible damage from severe coastal weather with associated wave stresses.

3.2.4 Terrorism/Sabotage

Terrorist activity cannot be predicted but the probability of attack is low (LNG in Vallejo, 2003). However, it is still prudent to prepare for the possibility, if only to reveal possible weaknesses not previously considered. These are events, such as a crash with an airplane or a boat filled with explosives, which may result in a large-scale release of LNG that cannot be anticipated and prevented. The attractiveness of a facility as a potential target determines likelihood of event. This evaluation assumes that symbolic value and economic disruption will be alike. The potential to create fear is tightly related to the potential to cause injury. Potential for injury is assumed to translate into public fear equivalently across all three facilities. The evaluation scenario is of a collision, such as from an airplane or a kamikaze ocean vessel, which succeeds in the rupture of an LNG tank. The potential for large-scale injury is the main determinant of the comparison ranking.

Criteria for Terrorism Targets:

- High potential to cause death & injury to large number of persons
- High potential to create a feeling of fear and vulnerability (to public at large)
- Strong symbolic value of the facility
- High potential to disrupt economy by damaging the facility

Derived from LNG in Vallejo

3.3 Environmental

In 1970, the National Environmental Policy Act (NEPA) was enacted which requires that an environmental impact statement be written for any project that might have a significant environmental impact and involve any agency of the federal government. One of the purposes of this act was to promote efforts to prevent environmental damage by disclosing information about how projects could impact the environment (Bass, Herson et al., 2001). General NEPA guidelines have been set forth for the sections of the environment that should be reviewed. From these guidelines, terrestrial and freshwater biology, marine biology, water quality, and air quality are selected for this analysis. These categories are separated into specific subcategories of impact including: benthic marine communities, pelagic marine communities, water quality, air quality, soil quality, and freshwater and terrestrial biology.

Regulations require that a detailed environmental analysis for each proposed project be written and made available to the public (Bass, Herson et al., 2001). These are peer-reviewed reports and are available to the public approximately one year after an application is submitted. However, as the applications for the proposed projects were only recently submitted, a peer-reviewed environmental impact statement (EIS) and environmental impact report (EIR) is not yet available for any of the projects.

Estimates of the likelihood and magnitude of environmental effects are heavily based on materials submitted with the project applications. An Environmental Analysis (EA), the preceding document to an EIS/EIR, has been written for the proposed FSRU Cabrillo Port project. The EA is heavily used in this analysis to determine environmental impacts caused by the FSRU. At the time of this analysis, similar documents, while not a formal EA, exist for the onshore facility proposal at the Port of Long Beach. The project application for the platform

Grace facility is used to analyze possible impacts of the platform project. The platform application includes a chapter on environmental impacts that should be considered. These documents have not yet been peer-reviewed. Due to the heavy use of these materials in this analysis, the accuracy of this study depends heavily on the accuracy of these documents.

For each project, the anticipated impacts are assigned a magnitude based on the potential impact to the existing environment. Table 8 describes how magnitude rankings are assigned in this analysis. CEQA guidelines vary between resource categories; the CEQA guidelines used to determine if an impact is significant are explained as they apply to each subcategory. Likelihood is assigned according to Table 6 within the methodologies introduction. Likelihood is weighed based on two factors: 1) the likelihood that the event will occur, 2) the likelihood that impacts will occur when the event occurs.

Table 8 - Definitions of Magnitude as Applied to Environment

a	catastrophic	not applicable (n/a)
b	severe	a significant impact (per CEQA guidelines)
c	important	an impact but not significant *with* mitigation (per CEQA guidelines)
d	minimally important	an impact but not significant (per CEQA guidelines)
e	neutral	no impact on the environment
f	minimally beneficial	n/a
g	beneficial	n/a

3.3.1 Marine Communities

Each of these proposed LNG import terminals have the potential to affect the marine communities in the vicinity of the terminal. The three proposed terminals fall in the area known as the Southern California Bight (SCB). The SCB is an area of the California coast stretching from Point Conception past San Diego. It's referred to as the "Bight" due to the significant curvature (indentation) of the coastline (DiGiacomo, Holt et al., 2004). The SCB includes the coastline, the Channel Islands, and the local portion of the Pacific Ocean. The communities of concern for this analysis include both benthic and pelagic communities within the Southern California Bight. CEQA guidelines are used to determine the magnitude of impacts to these communities. The same CEQA guidelines are used for both benthic and pelagic communities.

Benthic Community

Benthic communities are those communities that exist on or at the bottom of a body of water and include such areas as shores, littoral or intertidal areas, coral reefs, and the deep-sea bed. This community consists of a wide range of plants, animals, and bacteria from all levels of the food web (Chesapeake Information Management System, 2003). Impacts to benthic communities are important to consider because benthos, organisms that make up the benthic community, link primary producers with higher levels of the food chain, by consuming plankton and detritus and then being consumed by larger organisms. They also play essential roles such as breaking down organic material and providing habitat for juvenile fish.

Benthic habitats are divided into distinctive ecological zones, which differ in terms of depth, temperature, light availability, degree of immersion (tidal vs. subtidal), and type of substrate. Due to the great physical variety of habitats, the number of phyla and species of benthic animals (benthos) exceeds those of pelagic communities (Lalli and Parsons, 1997). Benthos are typically divided into three communities (Lalli and Parsons, 1997):

- Infauna: benthos that live within the sediment
- Epifauna: benthos that are attached to the hard bottom/substrate; those capable of movement; or those that live on the sediment surface
- Demersal: bottom-feeding fish that feed on the benthic infauna and epifauna

Pelagic Communities

Pelagic communities are those found in the water column, from the surface to the greatest depths. The pelagic community is composed of two types of organisms: plankton, organisms incapable of swimming against a current, and nekton, the free-swimmers. The plankton can be further divided into phytoplankton (plants) and zooplankton (animals). For the purpose of this analysis, the pelagic communities of concern are plankton, marine fishes, marine mammals, and marine reptiles.

Impacts to Marine Communities

Impacts to marine biological resources (both benthic and pelagic) are considered significant if the impacts cause (CEQA, 2003):

- Adverse change to or the reduction in a population or habitat used by a State or Federally listed endangered, threatened, regulated, or sensitive species. Any "take" of a listed species shall be considered significant
- Adverse change to or the reduction in a population or habitat of a species that is recognized as biologically or economically significant in local, State, or Federal policies, statutes, or regulations
- Adverse change in community composition or ecosystem relationships for species that are recognized for scientific, recreational, ecological, or commercial importance
- Any impedance of fish or wildlife migration routes that lasts for a period that significantly disrupts migration
- Any alteration or destruction of habitat that prevents re-establishment of biological communities that inhabited the area prior to the project
- Long-term (more than one year) loss or disturbance to biological communities or to ecosystem relationships

Changes in marine biological resources caused by the Project are considered significant if the changes (CEQA, 2003):

- Last longer than a month for toxicological impacts (e.g. those caused by oiling events or toxicity caused by the discharge of drilling muds and cuttings)
- Last longer than one year for impacts caused by habitat disturbance (e.g. construction activities) or habitat reduction (e.g. damage to hard-bottom structures during construction activities)

3.3.2 Air Quality

Air quality impacts are determined based on source emissions, meteorological conditions, and the existing air quality of the site. Section 109 of the Clean Air Act (CAA) has established National Ambient Air Quality Standards (NAAQS) for six criteria air pollutants: nitrogen dioxide (NO_2), carbon monoxide (CO), particulate matter (PM_{10} and $PM_{2.5}$), ozone (O_3), lead (Pb), and sulfur dioxide (SO_2). NAAQS are used in air quality plans and are an important consideration when evaluating a project under CEQA.

According to CEQA guidelines, air quality impacts are considered significant if the project (CEQA, 2003):

- Conflicts with or obstructs implementation of the applicable air quality plan as outlined by the regional air quality board
- Violates any air quality standard or contributes substantially to an existing or projected air quality violation
- Results in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standards
- Exposes the public to substantial pollutant concentrations
- Creates objectionable odors affecting a substantial number of people

An air pollutant is released into the atmosphere as a puff or a plume (Watts, 1998). A puff release is instantaneous, while a plume release is continuous. Models are used to predict the dispersion of each release scenario. During normal operations, an LNG facility will have continual emissions. Therefore, a plume model should be used to model the dispersion of criteria air pollutants from an LNG facility.

According to a plume model, as an air pollutant is released, it is highly concentrated at the source of the release. Through dispersion, the plume will decrease in concentration as it moves downwind. It is important to consider the meteorological conditions of the area when modeling emission dispersion. Wind is the most important factor in the dispersion of a pollutant (Watts, 1998). Another important consideration is atmospheric turbulence. If the atmospheric conditions are turbulent, the air pollutant will disperse more quickly than if the atmosphere is stable. A stable atmosphere will allow the plume to travel further from the source of emissions before dissipating than would a turbulent atmosphere.

Inputs into the Gaussian-Plume Model:

- Expected emissions from the project,
- Wind speed and wind direction,
- Distance between the project and the receptor,
- Atmospheric stability class,
- Height of the release,
- Height of the receptor

For this analysis a simple Gaussian-plume model is used to determine the concentration of air pollutants at the receptor (Watts, 1998). Some general assumptions in the model include: the receptor is the shoreline that lies downwind of the project, and the height of the receptor is 1.5 meters (approximate height of an adult person). The output from the model is a concentration of the air pollutant of concern at the receptor.

Ozone is not modeled with the Gaussian-plume model. Ozone is a photochemical oxidant and is generated by complex reactions involving volatile organic compounds (VOCs), NO_x, and ultraviolet radiation. The complexity of these reactions is beyond Gaussian-plume modeling capabilities and outside the scope of this project.

Attainment of air quality is calculated based on established state and federal air quality standards. For this analysis, the concentrations estimated by the Gaussian-plume model are compared to the NAAQS for each criteria pollutant. Both state and federal ambient air quality standards exist for each criteria pollutant. These air quality standards are in units of concentration per time. The standard with the lowest concentration – regardless of time – was used for comparison to the model output. Significance is based upon the fraction of the air quality standard that is exceeded by the project. These standards are listed in Table 9.

Table 9 - Ambient Air Quality Standards and Health Effects of Criteria Pollutants. *Source: http://www.arb.ca.gov/research/aaqs/aaqs.htm*

Air Pollutant	Ambient Air Quality Standard* Concentration/Time (s) = state / (f) = federal	Health Effects*
Particulate Matter (PM_{10} / $PM_{2.5}$)	20 µg/m^3, annual arithmetic mean for PM_{10} (s) 15 µg/m^3, annual arithmetic mean for $PM_{2.5}$ (f)	Long-term exposure leads to increased respiratory and cardiac illness, asthma exacerbation, and increased death rates. Short-term exposure to PM_{10} leads to an increase in emergency room visits and an increase in days with restricted activity.
Carbon Monoxide (CO)	9 ppm, 8-hr average (10 mg/m^3) (f)	Exposure to CO near the levels of the ambient air quality standards: • can lead to fatigue, headaches, confusion, and dizziness • interferes with the blood's ability to carry oxygen • is especially harmful to those with heart disease, because the heart has to pump harder to get enough oxygen to the body • has been associated with aggravated symptoms of coronary heart disease, decreased exercise tolerance in people with peripheral vascular disease and lung disease, impairment of central nervous system functions, and possible increased risk to fetuses.
Nitrogen Dioxide (NO_2)	0.053 ppm, annual arithmetic mean (100 µg/m^3) (f)	NO_2 exposure has been associated with respiratory symptoms, episodes of respiratory illness, and reduced lung function. NO_2 exposure may also worsen the effect of allergens in asthmatics.
Sulfur Dioxide (SO_2)	0.030 ppm, annual arithmetic mean (80 µg/m^3) (f)	Effects from SO_2 exposures include bronchoconstriction accompanied by symptoms, which may include wheezing, shortness of breath, and chest tightness, especially during exercise or physical activity. Children, the elderly, and people with asthma, cardiovascular disease or chronic lung disease (such as bronchitis or emphysema) are most susceptible to these symptoms. Continued exposure at elevated levels of SO_2 results in increased incidence of pulmonary symptoms and disease, decreased pulmonary function, and increased risk of mortality.
Ozone (O_3)	0.08 ppm, 8-hr average (157 µg/m^3) (f)	Exposure to levels of ozone above the current ambient air quality standard leads to: • lung inflammation and lung tissue damage • reduction in the amount of air that lungs inhale • may result in symptoms such as coughing, chest tightness, shortness of breath, worsening of asthma symptoms • may render lung cells more susceptible to toxins and microorganisms • can reduce crop and timber yields, damage native plants, and also damage materials such as rubber, paints, fabric, and plastics.
* Modified from California Air Resources Board (CARB)		

Table 10 demonstrates the magnitude designations for the air quality analysis. If the criteria pollutant concentration (as modeled by the Gaussian-plume model) generated by the project exceeds the ambient air quality standard, a magnitude of severe is given to the project. Note that if the concentration is greater than 1/10 of the air quality standard, then it is given a magnitude of important. The reasoning for this designation is because if one source is responsible for 10% of the problem, then it is an important source. It is assumed in this analysis that these designations generally align with NEPA/CEQA criteria for significance. However, this analysis does not examine objectionable odors created by the project; it is beyond the scope of this project.

Table 10 - Magnitude Designations for Air Quality

a	catastrophic	not applicable (n/a)
b	severe	concentration exceeds Ambient Air Quality Standard
c	important	concentration is/exceeds 1/10 Ambient Air Quality Standard
d	minimally important	concentration is/exceeds 1/100 Ambient Air Quality Standard
e	neutral	concentration is less than 1/100 Ambient Air Quality Standard
f	minimally beneficial	n/a
g	beneficial	n/a

3.3.3 Terrestrial and Freshwater Biology

The FSRU and platform projects have the potential to affect terrestrial and freshwater biology where the pipelines come onshore. The entire onshore facility, because of its placement, has the potential to affect terrestrial and freshwater biology. The particular receptors (areas of importance) that are examined in this analysis are special habitats, endangered species, and water bodies. According to CEQA guidelines (CEQA, 2003), an impact may be considered significant if it:

- Has a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive or special status species in local or regional plans, policies or regulations or by the California Department of Fish and Game (CDFG) or the US Fish and Wildlife Service (USFWS)
- Has a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the CDFG or USFWS
- Has a substantial adverse effect on federally protected wetlands as defined by section 404 of the Clean Water Act through direct removal, filling, hydrological interruption or other means
- Interferes substantially with the movement of any native resident or migratory fish or wildlife species, or with established native resident or migratory wildlife corridors, or that impedes the use of native wildlife nursery sites
- Conflicts with any local policies or ordinances protecting biological resources
- Conflicts with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan or other approved local regional or state habitat conservation plan

All proposed projects have a high-pressure pipeline that will be used to deliver gas to a central distribution system. In each case the routes may be different but the central issues remain the same. For the purpose of this study, the environmental impacts of these high-pressure pipelines will not be analyzed beyond where the project pipeline connects to the existing natural gas tie-in, on Ormond Beach for the FSRU and at Mandalay Generating Station for the platform project, or beyond the footprint of the onshore facility.

3.3.4 Marine Water Quality

The impacts to marine water quality from any of these three projects are expected to be minimal. During operations, there are only a few major sources that could cause impacts to marine water quality. Oily bilge water discharged from assist vessels and atmospheric deposition from the combustion of fuels will add to the petroleum hydrocarbon load deposited into the ocean. For each LNG terminal type, there is a minimal increase in vessel traffic. However, the impacts of the increase of petroleum hydrocarbons, as reported by the Cabrillo Port FSRU Environmental Assessment, are considered to be less than significant. A similar number of assist vessels will be used for each project. The FSRU and the platform projects will also have crew supply vessels. Due to the similarity in vessel traffic, the onshore and platform projects are also assumed to have an impact that is less than significant.

Another concern for water quality during operations is the accidental release of any fuels stored for emergency power generation. The probability of these storage systems failing is very low. With all projects, such an accident could pose a significant threat to marine water quality and to marine communities. However, the impacts from this type of accident to marine water quality are not expected to differ between the three projects. For these reasons, marine water quality will not be comparatively analyzed between the three proposed terminals.

3.4 Socioeconomic

Building an LNG receiving terminal may have beneficial and detrimental socioeconomic effects. Socioeconomics is defined as relating to a combination of social and economic factors. For the purposes of this study, socioeconomic categories include: population affected, economy and employment, property value, housing, public services, and traffic effects. The magnitude of these effects varies depending on the life cycle of the project. The greatest demands on society will occur during initial construction and at the end of the project life cycle, i.e. decommissioning stage. During these periods, a significantly larger number of construction workers and equipment are required in comparison to normal operations and maintenance activities. These effects vary according to the specific type of project (onshore, platform or FSRU), size of terminal, and associated length of the pipeline system necessary to deliver natural gas to the utility company pipeline network. The definitions used to rank the magnitude of these socioeconomic effects are summarized in Table 11.

Table 11 - Definition of Magnitude as applied to Socioeconomics

a	catastrophic	catastrophic impact to society
b	severe	detrimental to society
c	important	minor detriment to society, significant
d	minimally important	minor detriment to society, not significant
e	neutral	no noticeable impact either positive or negative to society
f	minimally beneficial	minor beneficial impact to society
g	beneficial	significant benefit to society

3.4.1 Population Affected

Local population may be affected in several ways if an LNG receiving terminal is built within close proximity. To determine appropriate rating within the matrix, population data is collected and analyzed from the U.S. Census 2000 data. To determine the number of people affected by the project, population data is compared at the state, county, and city level nearest each proposed project. For example, the population density (persons/square mile) of California is compared to the other US states to determine magnitude of potential impact. Similarly, at the county and city level, the population densities of all other counties and cities within California are compared and ranked in the same manner.

If the population density surrounding a proposed project does not exceed the state, county or city average**,** a neutral or minimal importance rating within the matrix is assigned. Population densities that exceed the average are assigned a magnitude rating according to perceived significance, i.e. important, severe, or catastrophic. For example, a project that is proposed in the most heavily populated city in the state would be assigned the highest level of magnitude due to the potential impact to local residents. In comparison, a project proposed in a moderately populated area, yet still exceeding the state average would be assigned a less significant rating. This analysis is performed under the premise that site suitability is inversely related to population density.

To prevent duplication of analysis performed within the community and safety section of this study, population effects as they apply to accident scenarios will not be evaluated within the socioeconomic section of the matrix.

3.4.2 Economy and Employment

Building an LNG receiving terminal can influence the economy and employment within the region. Local economic sectors, per capita income, and employment data influenced by proposed projects are analyzed. This data is compared to state averages. Economic and employment benefits are rated according to significance to local population. Projects that create a noticeable impact on the local employment and/or economic community receive a beneficial ranking (higher than neutral). A neutral rating is assigned to categories where neither beneficial nor detrimental effects are identified. It is assumed that an LNG terminal project will not have detrimental effects to the economy and employment. This assumption is based on the premise that during all phases of an LNG project, positive influences to employment and economic revenue should be expected through the generation of jobs.

3.4.3 Property Value

Property has the potential to be de-valued by the installation of an industrial facility. Ranking within this category requires an evaluation of compatibility with existing and proposed land uses and consistency with local and regional land use plans, policies, and regulations. Proposed projects that adhere to the community master plan are ranked as neutral. Facilities that propose incompatible land use goals are assumed detrimental to society and ranked according to perceived significance.

3.4.4 Housing

Temporary housing availability varies seasonally and geographically within each of the proposed settings. Temporary housing is available in the form of daily, weekly, and monthly rentals in numerous motels, hotels, campgrounds, rooming houses, RV parks, and resorts located within these communities. Vacancy rates are evaluated within commuting distance from the proposed projects to determine effects on property demand. Vacancy rate is an indication of available accommodations, measured as a percentage of total accommodations. A vacancy rate less than 10 percent generally assumes the housing market is tight, i.e. a sellers market. Vacancy rates greater than 10 percent normally indicates a surplus of homes are available in the market, i.e. a buyers market. A vacancy rate of over 10 percent implies that there will likely be sufficient housing for tourists, non-local workers, and other visitors to an area. For the purpose of ranking housing within the matrix**,** a vacancy rate of 10 percent assumes a neutral weight. Vacancy rates greater that 10 percent assumes an LNG terminal in the community will be beneficial to society, and less than 10 percent, detrimental.

3.4.5 Public Services

All of the proposed project areas have well-developed health, police, fire, emergency, and social services. Existing capacity of the public service infrastructure with regard to health, police, and fire response is compared to acceptable service and response times. Acceptable service and response times vary according to location. In most cases, information with regard to these indicators is obtained directly from the public service providers. Based on this information, projects that place additional burden on public services are ranked accordingly. For this analysis, a determination is made of the ability for existing infrastructure to absorb the impact on public services. Projects that constrain capacity, public service, or response time are ranked according to magnitude within the matrix.

3.4.6 Traffic

Construction activities, such as the influx of construction equipment, materials, and personnel to the project area, could result in road traffic congestion and roadside parking hazards. Additionally, marine traffic due to LNG carriers, tugs, and supply and crew boats will certainly add to the congestion of existing ports. To rate this category within the matrix, effects on road and marine traffic are evaluated.

Ranking Criteria for Road Traffic

Road circulation conditions are analyzed to determine the amount of traffic on a roadway versus its design capacity. Roadway capacity is generally measured as the number of vehicles that can reasonably pass over a given section of roadway in a given period of time. The Highway Capacity Manual, prepared by the National Transportation Research Board, identifies travel speed, freedom to maneuver, and proximity to other vehicles as important factors in determining the level of service (LOS) on a roadway (Transportation Research Board, 1980). Daily traffic volumes are used to estimate the extent to which peak hour traffic volumes equal or exceed the maximum desirable capacity of a roadway.

LOS, ranging from LOS A to LOS F, classifies traffic flow. LOS A is defined as free flow traffic with no delays and LOS F is defined as forced flow with substantial delays as defined in Table 12.

Table 12 - Level of Service Description Volume/Capacity Ratio. *Source: Transportation Research Board, Transportation Research Circular No. 212*

Level of Service	Description
A	EXCELLENT. No vehicle waits longer than one red light.
B	VERY GOOD. An occasional approach phase is fully utilized; many drivers begin to feel somewhat restricted within groups of vehicles.
C	GOOD. Occasionally drivers may have to wait more than one red light; backups may develop behind turning vehicles.
D	FAIR. Delays may be substantial during portions of the rush hours, but enough lower volume periods occur to permit clearing of developing lines, preventing excessive backups.
E	POOR. Represents the most vehicles intersection approaches can accommodate; may be long lines of waiting vehicles through several signal cycles.
F	A FAILURE. Backups from nearby locations or on cross streets may restrict or prevent movement of vehicles out of the intersection approaches. Tremendous delays with continuously increasing queue lengths.

If a proposed project has a scale large enough to influences LOS conditions, a magnitude ranking is assigned according to perceived impact to society. Projects that utilize roads with LOS ratings of A, B or C are assumed to have no noticeable impact to society and are ranked as neutral. As defined in the Highway Capacity Manual, LOS conditions D or worst are considered unacceptable and are ranked according to degree of severity.

Ranking Criteria for Marine Traffic

Marine traffic is analyzed by determining the estimated marine traffic necessary during the construction, normal operations, and decommissioning phase of an LNG terminal project. This data is compared to the normal port traffic and rated accordingly.

4 FLOATING STORAGE AND REGASIFICATION UNIT

4.1 Terminal Description

A floating storage and regasification unit (FSRU) is a new type of facility that utilizes existing technologies in an unconventional way. Similar in appearance to an LNG tanker, the FSRU is designed to be permanently moored offshore and function as a deepwater port. The FSRU project is proposed to be moored approximately 22 km (13.9 miles) off the California coast, between Oxnard and Malibu, at coordinates, 33 51.518 N and 119 02.015 W. This type of facility has never been built, so the currently proposed Cabrillo Port FSRU project will be used as the model for this terminal type.

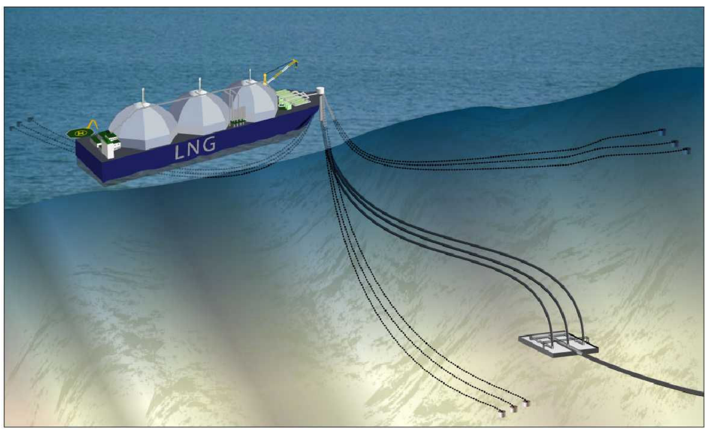

Figure 14 - Proposed FSRU. *Source: Cabrillo Port EA*

The proposed FSRU terminal will be built outside the U.S. and towed to the mooring point. Initial cost estimates indicate a $400 million price tag for completion of the FSRU terminal (Entrix, 2003). After arrival off the coast of Oxnard, the FSRU mooring construction is expected to take approximately 45 days. The proposed facility is designed with an average gas throughput capacity of 600,000 – 900,000 mmcfd. The project developer has requested an exclusion zone of 1 nautical mile (1852 meters). An exclusion zone is defined as an area restricted to any unrelated/unnecessary vehicles. Additional terminal specifics are outlined in Table 13.

Table 13 - FSRU Terminal Description. *Source: Cabrillo Port EA*

Terminal Description - Floating Storage and Regasification Unit	
Dimensions	286 meters (312 yards) long, 65 meters (71 yards) wide and 45 meters (49 yards) high.
Facility design life	25 years that can be extended to 40 years.
Construction of FSRU	Fabricated outside US and towed to mooring point.
Hull type	Double hull.
Mooring	Singe turret moored by nine cables, in sets of three, 120 degrees apart with associated drag-in anchors. Latitude 33˚ 51.518´ N, longitude 119˚ 02.015´ W; 22.4 km (13.9 miles) from shore; Approx 884 m (2,900 ft) deep at mooring point.
Carrier berthing	20 hours, 3 times a week.
Transfer rate	302,833 liters (80,000 gallons) per minute.
Tank type	Moss spherical type (100 year life expectancy); Internal aluminum shell, surrounded by insulating material, external steel shell. Each tank supported by steel skirt ring braced inside double hull.
# of storage tanks	3 Moss spherical tanks.
Storage capacity	273,000 m^3; 91,000 m^3 per tank.
# of loading arms	4 on starboard side (space for 3 more on port side).
Throughput capacity	600,000 – 900,000 million cubic feet/day average rate; 1 billion cubic feet/day max rate.
Regasification method	Submerged combustion vaporization (SCV).
Operating pressure	1 atm normal, 30 psi max.
Crew facilities	Houses up to 40 permanent crew members; Helideck positioned at the aft end.
Exclusion zone	1.0 nautical miles (1852 meters) requested by project developer
Safety systems	Gas Detection: Continuously operating catalytic type detectors and infrared line of site detectors connected to electronic Fire and Gas panel. Gas detection also provided for regas plant, deck areas, machinery spaces where high-pressure gas is piped
	Emergency shutdown: Emergency shutdown manually activated at control room.
	Heat detecting thermal fuse plugs and manual release valves located at strategic points in pipe loop, tank domes, loading arms and process areas.
	Emergency depressurizing and venting: Cold stack 76 m (250 ft) above water line, 24 m (80 ft) above top of storage tanks. Additionally equipped with electric heating system to heat and emergency LNG releases.
Fire protection system	Cooling exposed surfaces: Freshwater deluge – excess freshwater from SCV process
	Firefighting: Foam system, Carbon dioxide systems

Pipeline	Gas flows through turret mooring point into three 40 cm (16 inch) diameter flexible risers extending from ocean floor and into pipeline ending manifold (PLEM) with many shut down and isolation valves along line and fail safe mechanism in case of loss of control.
	Subsea: 76 cm (30 inch) diameter from PLEM to onshore tie-in facility. First 27 km (17 miles) in fed waters, 6.6 km (4.1 miles) in state waters. Approx. 1 km (0.65miles) of buried pipe will connect to tie-in at Ormond Beach. Approx 7 acres occupied by subsea pipeline, 4 acres onshore. 200x200ft (.9 acres) needed for temp construction of onshore pipeline.
Tie-in facility	Located at Ormond beach, 200x200ft (.9 acres – the same space used during construction of onshore pipeline)
	Additional areas for work, pipe storage and contractor offices TBD.

4.2 Community Safety Analysis

4.2.1 Introduction

This section considers the impact of the proposed FSRU on community safety, and will focus on four potential accident scenarios. The community safety matrix section is shown below (Table 14) and is followed by detailed explanations of rankings.

Table 14 - FSRU Community Safety Matrix

Community Safety Effects	FSRU	construction	operation & maintenance	accidents			decommission
				minor - within facility	moderate - within exclusion zone	major - outside exclusion zone	
	operational failure	not evaluated	not evaluated	e-1	e-3	c-4	not evaluated
	maritime accidents	not evaluated	not evaluated	e-2	c-3	c-4	not evaluated
	natural phenomena	not evaluated	not evaluated	e-2	e-2	c-3	not evaluated
	terrorism/sabotage	not evaluated	not evaluated	c-4	c-4	b-4	not evaluated

4.2.2 Operational Failure

Assuming sound design, construction, and maintenance of the facility, including safety features, equipment failures will be detected and emergency shut down of the affected areas initiated before LNG breeches containment systems. Injuries and operational disturbances are not expected.

If the spill were to exceed containment levels, the LNG could spill onto water causing quick evaporation and the formation of a vapor cloud. The LNG vapor quickly spreads and mixes with air. Depending on spill size and meteorological conditions, a natural gas plume could form. The concentration of natural gas in the air decreases from the center to the edge of the plume. The boundary of a vapor cloud is usually defined by the lower flammability limit (LFL), where the concentration of natural gas in air is 5%. Below the 5% concentration, the cloud is no longer flammable.

The project developer modeled LNG pool formation under different spill sizes. Under the mid-size spill scenario, the pool around the facility would only reach 1.2 meters (3.9 feet) (Table 15) and would remain well within the facility exclusion zone.

Under the full rupture scenario, the spilled LNG could form a pool that extends as far as 70 meters (0.4 miles) from the facility (Table 15). Vapor cloud migration and thermal radiation associated with pool formation is not included in the Cabrillo Port Environmental Analysis and it is unclear the scope of the effects. Facilities handling hazardous materials incorporate emergency response systems into facility design to prevent spillage during operational failure, therefore the likelihood of a large rupture is considered unlikely.

Table 15 - Leak/rupture of LNG from loading arm onto water. *Source: Cabrillo Port EA*

Hole Size (mm)	Release Rate (kg/s)	LNG Pool Extension and Duration
10	1.0	Entire release evaporates before forming LNG Pool on sea surface.
50	24.3	LNG pool between vessels of 1.2 m diameter. Duration of LNG on water is 10 minutes.
full rupture	692	Large LNG rainout to sea. LNG pool will fill the area between the vessels (4 m) and extend as pools (70 m diameter) at bow and stern areas, creating a dumbbell type shape. Duration of LNG on water is 5 minutes.

A study by Dr. Ronald Koopman, at Lawrence Livermore National Laboratory, modeled a similar full rupture scenario. It assumes as worst case, a guillotine-type break of the loading system that releases about 208,200 liters per minute (55,000 gallons per minute) for ten minutes. The simulation predicted a plume that reached the lower flammability concentration 0.6 km (0.4 miles) from the spill (Koopman, 2002). Thermal radiation from an ignited pool fire reaches farther than vapor cloud migration and is the main concern for community safety. The effects from a pool fire of this size could be felt beyond the facility exclusion zone. The proposed FSRU will be moored approximately 22.4 km (13.9 miles) offshore; therefore crews on passing ships in the traffic lane, approximately 6.4 km (4 miles) away, are potentially effected by a large pool fire. The lack of ignition sources nearby and the location of the facility decrease the likelihood of a pool fire.

4.2.3 Maritime Accidents

The FSRU mooring point is located 7.9 km (4.9 miles) from the centerline of the nearest shipping lane. The remoteness of the location makes the likelihood of a collision with a moving vessel and the FSRU very low. Because it will be moored in deep water, grounding would not be possible near the facility. Allisions are the most likely type of maritime accident. Although there has never been an LNG cargo spill as a result of a maritime accident (LNG in Vallejo, 2003), a cargo spill is possible. The magnitude of impact would range depending upon the severity of allision.

A small ship, such as a recreational boat, colliding with the FSRU is unlikely to cause any significant damage. A larger vessel, such as a carrier, would have enough mass to cause a cargo breach. The Environmental Assessment, submitted with the project application, indicates that a full rupture of an FSRU tank with a maximum capacity of 91,000 m^3 would result in a pool of LNG on the water surrounding the facility at a maximum diameter of about 1000 meters (0.64 miles). However, the assessment does not estimate the distance of associated vapor cloud travel and distance to heat burns due to fire. In a vessel collision, there are sparks that could provide an ignition source causing a pool fire and disruption of operations due to fire. In this case, the thermal radiation could reach beyond the exclusion zone, but actual effects are unknown. The distance to shore is great enough that the community is not likely to be affected. Southbound shipping lane traffic is the closest to impact and could feel some minor thermal effects.

If the LNG storage tank was not full or the breach was near the top of the cargo hull, the release volume and therefore impact area would be less. The effects are expected to remain within the exclusion zone and magnitude of impact is expected to be low. Assuming the facility is designed to maintain structural integrity under some thermal stress, operational disturbances will be temporary.

4.2.4 Natural Phenomena

The proposed project is located near six active or potentially active fault lines. There are no documented active or potentially active fault lines crossing the pipeline that transfers natural gas from the FSRU terminal to the onshore tie-in station. However, there are two inferred or uncertain fault lines along the pipeline route. The location of the project in relation to known fault lines in the region is illustrated in Figure 15.

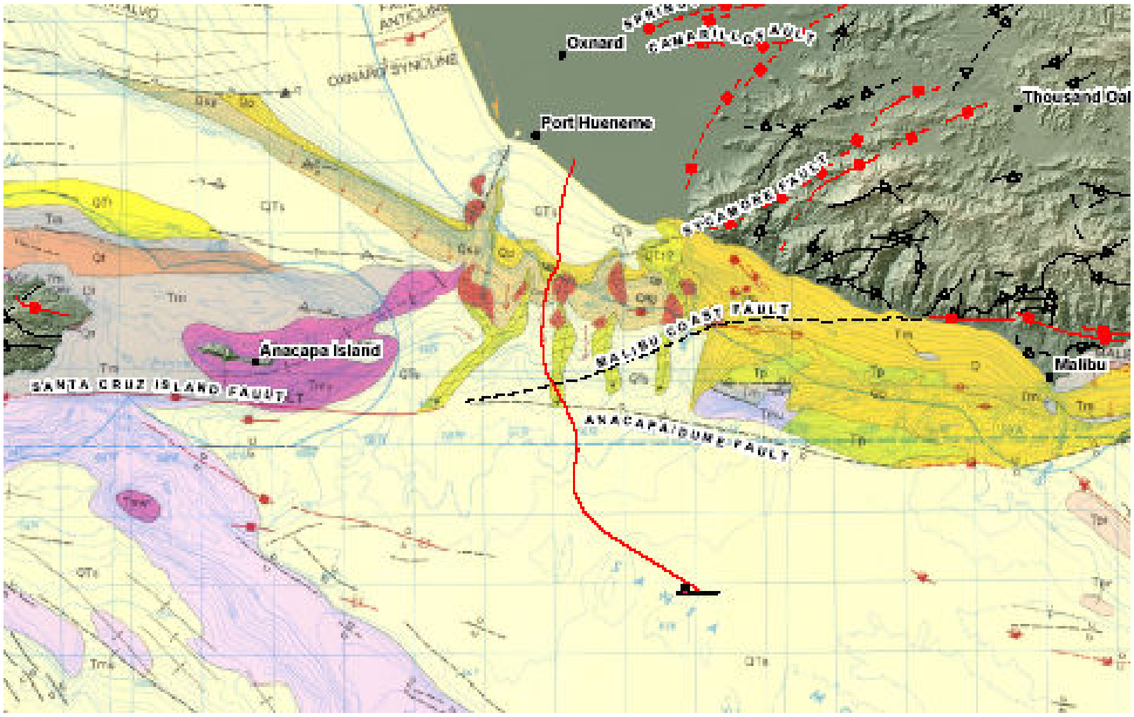

Figure 15 - Regional Offshore Geologic Map. *Source: Cabillo Port EA*

The Anacapa/Dume Fault and Malibu Coast Fault are possible faults in the vicinity of the project. However, they are inferred faults that have not been documented and have not been known to be active (Entrix, 2003). They may be connected to the Santa Cruz Island Fault that is an active, documented fault. Data suggests that the average time between earthquakes on this fault is between 4,000-5,000 years with an average Richter scale magnitude as high as 7.4 (Entrix, 2003). The Santa Cruz Island Fault last broke approximately 5,000 years ago and it could break again within the life of the project. Considering the numerous other faults in the Southern California region, it is likely that there will be an earthquake during the lifetime of the facility.

The anchoring system and pipeline are not located over an active fault line so the risk of ground rupture is very small (Entrix, 2003). The submarine pipeline system is located along the sea floor and is susceptible to ground shaking, subsidence and liquefaction as previously defined in the Methodology section. The soil profile at the proposed site is susceptible to liquefaction, which can cause a loss of stability and damage the mooring system and pipelines. These systems are designed to withstand some disturbance and should show no effect during a small, localized earthquake. However, a larger magnitude disturbance could result in some subsidence and liquefaction causing small pipeline leaks. The proposed anchor site is on a low slope, minimizing risk of movement, and the subsea pipeline system is a set of two pipes that can operate independently of each other and decrease risk of non-operation. Tsunamis can occur as a result of seismic activity, however they have low wave heights in deep water and should go unnoticed at the project site (Entrix, 2003).

The California Geologic Survey provides an interactive tool to assess the probabilistic seismic hazards of a given location. The location of the FSRU has a lower probability of ground shaking as compared to the onshore and platform sites, which were equivalent (California Geological

Survey, 2004). Strong seismic activity could cause a pipeline rupture (Entrix, 2003). The major accident scenario assumes a break near the midsection of pipeline. The actual magnitude of effect depends upon the amount of natural gas released from the pipeline. In the event of a pipeline rupture, the natural gas within the subsea pipeline cannot be contained and would bubble to the surface. The amount released is dependent on the number and position of shutdown valves along the pipeline route as well as the location of the pipe break relative to shore. The FSRU is moored 22.4 km (13.9 miles) offshore and the midsection of the subsea pipe is approximately 11.26 km (7 miles) from shore. This distance indicates that the magnitude of effect from a midsection pipeline rupture is low. The gas would likely be dispersed in the atmosphere before reaching shore, causing negligible impact.

Aside from seismic events, the FSRU is subject to regular wave forces that can build up and cause damage to tanks. Wave forces are strongest on partially filled non-spherical tanks so filling restrictions are used to limit the risk of tank damage. To avoid filling restrictions, the FSRU will use spherical tanks, which are able to withstand wave forces at any tank fill level. In addition, the tanks are designed with an external steel shell and a “leak-before-failure” philosophy that gives a 15-day lag time between leak and tank failure (Entrix, 2003). The tank design combined with emergency containment allows a 2-week period for thorough tank inspections after seismic disturbances. Leak detection is crucial in preventing large-scale accidents.

4.2.5 Terrorism/Sabotage

Terrorism is something that cannot be predicted and no degree of preparedness can eliminate the risk of becoming a target. The population at risk will vary according to location of the facility and the population density in the surrounding neighborhood.
A minor and moderate terrorism accident would have similar impacts as moderate and major maritime accidents, respectively.

September 11, 2001 changed the way terrorism threat is perceived and has prompted many experts to include malicious acts into risk analyses. According to the LNG Release Hazards study by Dr. Koopman, the estimated impact area from a Boeing 747 aircraft crashing into an LNG tank indicated that the plane and aviation fuel alone could create a fire hot enough to cause skin blisters on a person standing as far away as 3.4 km (2 miles). If just 1% of a 25,000 m^3 tank’s contents were included in the model, the impact radius nearly doubled, to 6.4 km (4 miles) (Koopman, 2002). The complete results are represented in Table 16. These calculations are simple estimations of impact zones and should not be considered absolute.

The FSRU differs in several ways from the scenario presented by Dr. Koopman. The study considered a Boeing 747 crashing into a stationary object. The FSRU is not completely stationary and the resulting fire could be different (Koopman, 2004). The tanks on the FSRU also have a substantially larger capacity and would be expected to have a larger impact distance. The likelihood of an aircraft crashing into the project is very small given the constant air and water traffic control monitoring, but the magnitude of impact would be unprecedented. An accident of this scale could not be contained and would result in the release of most of the tank. Traffic in the shipping lanes could suffer severe damages. Depending on the fill level of the

LNG storage tanks, the community onshore may feel some of the effects, however any impacts would likely be limited to skin blisters. The remoteness of the FSRU gives a large buffer zone to a densely populated area and is the main mitigation factor in community safety.

Table 16 – Effect of 747 crashing into LNG storage tank. *Source: Ron Koopman,LNG Release Hazards*

	Distance to:		
	Skin Blister	2nd Degree Burn	3rd Degree Burn
747 Plane + Fuel	3600 meters (~2 miles)	2000 meters (~1 mile)	1500 meters (~1 mile)
747 Plane + Fuel + LNG	6400 meters (~4 miles)	3400 meters (~2 miles)	2600 meters (~1.5 miles)
* Numbers are only estimates of impact zone and should not be considered firm.			

4.2.6 Conclusions

There is an inherent uncertainty when evaluating a project that has never been built. Conceptual facilities do not have the benefit of experience and retrospect. The evaluation of the proposed FSRU terminal did not indicate any highly likely, high magnitude events. The Cabrillo Port project is used to illustrate the potential hazards associated with safety of the surrounding community and the impact evaluations should not be directly applied to another project. This evaluation is merely a guide to indicate estimates and provide a framework for the evaluation of other similar projects. The remote siting of this specific project is a strong factor in the probable low magnitude of impacts on community safety, and siting for other possible terminals must be examined carefully.

4.3 Environmental Analysis

4.3.1 Introduction

This section focuses on the proposed FSRU's impacts to the surrounding environment. Possible impacts to the following subcategories will be analyzed: benthic communities, pelagic communities, water quality, air quality, and terrestrial and freshwater biology. The matrix below (Table 17) outlines environmental impact rankings for the proposed FSRU project. The matrix is followed by detailed explanations of the rankings.

Table 17 – FSRU Environmental Matrix

Environmental Effects	FSRU	construction	operation & maintenance	accidents			decommission
				minor - w/in facility	moderate - w/in exclusion zone	major - outside exclusion zone	
	benthic community	d-1	d-1	e-2	e-3	e-4	d-2
	pelagic community	d-2	c-2	e-2	d-3	d-4	e-1
	air quality	not evaluated	d-1	not evaluated	not evaluated	not evaluated	not evaluated
	terrestrial/freshwater biology	d-1	d-2	e-1	e-3	e-4	c-2

4.3.2 Benthic Community

Construction activities that are likely to affect the benthic communities of the project area are pipeline installation and placement of the seabed anchors. Impacts to the benthos from operations may be caused by a natural gas leak from a pipeline rupture and by drag created by chains mooring the FSRU to the sea floor.

Benthic habitats may be defined based on two features: depth and the substrate (sand, mud, rock or water column). This analysis is broken into the intertidal and shallow subtidal zones (less than 30m (100 ft) deep) and the subtidal zone (greater than 30m (100 ft) deep). The intertidal and subtidal zones are examined separately because the intertidal zone is a more biologically diverse environment (Lalli and Parsons, 1997). The impacts that occur within this area will typically affect more organisms and are therefore considered more significant than the same impacts occurring in the subtidal area.

Intertidal communities are those that occur between high and low tides. The environmental matrix that dominates this area is fine to medium sands. Sandy beaches make up about 93% of the Ventura County coastline. Wave and tidal action causes continual shifting of beach sands. The intertidal system is an area of rapid transition between fully terrestrial and fully marine systems. Species may migrate in and out of this system while others exist only within the intertidal system (Lalli and Parsons, 1997).

The organisms predominantly found in the Southern California Bight (SCB) intertidal zones are crustaceans, mollusks and polychaetes. Other common species found in the intertidal zone include *Excirolana chiltoni*, several species of polychaetes, *Emerita analoga,* nemerteans, the large sand crab (*Blepharipoda occidentalis*), the Pismo clam (*Tivela stultorum*), and the bean clam (*Donax gouldii*). (Straughan, 1983) There are between 15 and 22 macrofaunal invertebrates within the Ormond Beach area. (Dugan, D.M Hubbard et al., 2000) Several species of marine birds are also found in this intertidal area. These are discussed in detail in the Terrestrial and Freshwater Biology section. Within the proposed project area, Ormond Beach does not have any rocky intertidal areas. The nearest rocky areas are north of the project outfall and at the entrance to Port Hueneme (Entrix, 2003).

Subtidal benthic communities are any community that exists beyond 30 m (100 ft) depth. Along the FSRU project route, the continental shelf extends to a depth of approximately 60 m (200 ft) at approximately 6.4 km (4 miles) offshore. The offshore substratum consists mainly of fine sand and muds. Less than three percent of the continental shelf within the project area consists of rocky outcrops that can support hard-substratum communities. See Appendix B for a list of species commonly found in the subtidal benthic communities of the SCB. The dominant species of the Santa Monica Basin, the basin of the SCB in which the project is located, are the galathaid crabs *Munida quadrispinosa* and *Munidopsis hysterix*. (Thompson, Dixon et al., 1993).

Impacts from Construction

The installation of the subsea pipeline will be the primary cause of construction impacts to the benthic communities. The 76 cm (30 inch) pipeline will be placed along the ocean floor and will crush whatever organisms lie in its path. Starting at 0.9 km (3,000 ft) offshore, at a depth of 13 meters, to avoid impact to the most biologically rich zone of marine benthos, the FSRU project will be using horizontal directional drilling (HDD) to bury the pipeline, beneath the intertidal zone.

With HDD there is a chance that during the drilling of the pipeline tunnel, drilling fluids from the borehole could be released from a fracture in the ground. A fracture could release tens to hundreds of liters of drilling fluid into the nearshore environment. The only drilling fluid used is bentonite, which is fine-grained, high-density clay. If bentonite were released by a fracture, the expected result would be short-term burial of the nearshore environment and changes in grain size distributions of the environmental matrix. Since the small particles of bentonite are easily transported by water, it is expected that a release would likely result in a quick dispersal over a wide area. The bentonite particles in the water will reduce the water clarity. However, this is unlikely to have a noticeable effect on visual predators or photosynthetic processes, as this area is typically highly turbid. A fracture could occur if the pipeline is drilled at too high a pressure, if there is a soft region in the sediments, or if there are active faults along the pipeline route. However, a fracture is not probable. Bentonite exposure impact is considered less than significant (Entrix, 2003).

Beyond 13 meters depth, the pipeline will be placed directly on the sea floor. No trenching will be done for this pipeline installation. Any infaunal or epifaunal organisms present in the immediate vicinity of the pipe placement would be crushed or buried. The total impact area of the 33.9 km (21.1-mile), 76 cm (30 in) pipe is expected to be 2.6 hectares (6.4 acres). The most significant part of this impact would occur on the shelf habitats where a higher density of organisms is found. However, as the total area of impact represents only a very small fraction of the total benthic community in the area, the impact from pipe placement is considered less than significant.

In order to moor the proposed FSRU, nine anchors will be placed on the seabed floor, each connected to a heavy chain. The anchors will crush any invertebrate fauna. Again, the area of this anticipated impact represents only a small fraction of the benthic habitat present in the region. Impacts are expected to be less than significant and relatively short term.

Impacts from Operations

The benthos is unlikely to be affected by typical operational procedures. Natural gas will travel through the pipeline to shore without disturbing benthic communities. As the vessel on the water's surface responds to winds, currents and waves, the chain connecting the FSRU to the anchors may drag across the bottom of the ocean floor and the anchors may potentially move, disturbing local invertebrate communities. This would crush or displace the invertebrate fauna present in the area. The impact area is small compared to the total benthos; therefore this impact is less than significant.

Two issues arise if natural gas escapes the pipeline either from a pipeline leak or a pipeline rupture. One issue concerns potential toxic effects of the natural gas to marine life. The natural gas transported by this project is over 85% methane. The other 15% of natural gas is mostly ethane. Both methane and ethane have low solubility in water so escaped natural gas is expected to rapidly volatilize out of the water (Schwarzenbch, Gschwend et al., 1993). Methane is considered non-toxic to the organisms with which it has been tested (Entrix, 2003). The other issue that could arise is that bubbles from the released natural gas could create turbulence in the water column, which may release sediments and cause increased turbidity. The increase in turbidity will vary depending on the size of the leak. It is expected that if a rupture were to occur, the area disturbed would likely be small relative to the entire benthic community. The impact is considered less than significant.

Impacts from Decommissioning

FSRU is a floating vessel and can be released from its anchors and towed away without impact to the benthos except crushing species directly in the vicinity of the anchors and chains. The proposed pipeline will be left in place, possibly filled with concrete. This is expected to cause minimal disturbance to benthic communities.

Impacts from Accidents

The benthic communities are far removed from the primary operational activity of unloading and regasifying liquefied natural gas. The benthic community below the FSRU is 900 meters below the normal operational activities of the facility. If there was an accidental release of LNG on any scale, it is extremely unlikely that it would affect the benthic communities in the project area.

4.3.3 Pelagic Communities

The activities most likely to impact the pelagic communities within the proposed project area result mainly from normal operations, including increased noise during project construction and normal operations, the regasification process, oil and diesel discharge and marine ships colliding with marine mammals. There is also a possibility of impacts from an accidental release of LNG into the marine environment.

Appendix C lists fish commonly found in the vicinity of the FSRU project. The sandy and muddy intertidal environments are important for juvenile fish. The white croaker species accounts for more than sixty percent of the nearshore fishes (Allen, Moore et al., 1998). There are three special status species located in and around the project vicinity. These include the steelhead, which is listed as an endangered species under the Endangered Species Act (ESA); the bocaccio, which is currently being petitioned to list as threatened under the ESA; and the pacific rockfish, which is currently under investigation under the ESA. While bocaccio and pacific rockfish may be located in the general vicinity of the project, only the steelhead is expected to be located in the immediate project area because no suitable habitats for the bocaccio and pacific rockfish exist in this area.

The Marine Mammal Protection Act of 1972 protects all marine mammals (1972). There are three groups of marine mammals found in the project vicinity including pinnepeds, fissipeds and cetaceans. The marine mammals that are likely to be present in the project vicinity are listed in Tables 18 and 19. Note that the southern sea otter is listed as a threatened species under the ESA. The minke whale, while never seen in large numbers, is most abundant from late spring through late summer (NOAA, 2000). The California gray whale is most abundant from late October to December during their southerly migration. The northbound migration for the gray whale begins in February and continues into May (Bonnell and Dailey, 1993). The toothed whales are residents of the Project area year round.

Table 18 - Pinnipeds and Fissipeds Found in the Southern California Bight. *Source: Bonnell and Daily 1993 as cited in Cabrillo Port EA.*

Species	Abundance and Seasonality	Occurrence in Project Area
California sea lion (*Zalophus californianus californianus*)	Abundant, year-round resident.	Yes
Pacific harbor seal (*Phoca vitulina richardsi*)	Common, year-round resident.	Yes
Southern sea otter (*Enhydra lutris nereis*) * Threatened under ESA	Locally abundant in nearshore waters in vicinity of San Nicolas Island with scattered individuals near mainland and other islands, year-round resident.	Possible

Table 19 - Cetaceans found in the SCB. *Source: Bonnell and Daily 1993 as cited in Cabrillo Port EA.*

Species	Abundance	Occurrence in Project Area
Baleen Whales (Suborder Mysticeti)		
Gray whale (*Eschrichtius robustus*)	Common during winter and spring migrations.	Yes
Minke whale (*Balaenoptera acutorostrata*)	Migratory population; common year-round with peak numbers in spring and summer.	Possible
Toothed Whales (Suborder Odontoceti)		
Short-beaked common dolphin (*Delphinus delphis*)	Common; year-round resident.	Yes
Long-beaked common dolphin (*Delphinus capensis*)	Common; year-round resident.	Yes
Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)	Common; year-round resident.	Yes
Risso's dolphin (*Grampus griseus*)	Common; year-round resident; peak abundance in summer and autumn.	Yes
Dall's porpoise (*Phocoenoides dalli*)	Common; year-round resident; peak abundance in autumn and winter.	Yes
Bottlenose dolphin (*Tursiops truncatus*)	Common; year-round resident; two populations may be present in SCB.	Yes
Short-finned pilot whale (*Globicephala macrohynchus*)	Common prior to 1982; year-round population with increases in winter.	Yes

There are four species of marine reptiles found in the project area: the east pacific green sea turtle, the loggerhead sea turtle, the olive ridley sea turtle, and the leatherback sea turtle. The east Pacific green sea turtle and the leatherback sea turtle are endangered under the ESA and the other two marine reptiles are listed as threatened under the ESA (Entrix, 2003).

Populations Affected

Construction and normal operations of the project are unlikely to significantly impact marine fish. Due to larger populations, mobility, and size, marine fish populations in the project area are less likely to be significantly affected by construction activities, entanglement with mooring cables, and collisions with project vessels than other marine organisms. Potential spills of LNG or oil, which generally float on the surface of water, would not significantly impact marine fish populations (Entrix, 2003).

Marine mammals and marine turtles could be impacted by LNG spills, fuel/lubricating oil spills, noise, vessel strikes, disturbance, or construction. These impacts are discussed in the following sections.

Impacts from Construction

Construction is not likely to affect the pelagic marine environment. Construction of the pipeline is expected to take place over a period of 45 days. HDD is also expected to take 45 days. Offshore construction will occur between May 1st and December 1st as to avoid gray whales during the southerly migration (December to February) and the northerly migration (February to April).

Impacts from Operations

Noise levels can potentially impact marine mammals and turtles.

Marine mammals may be impacted by noise created by the operations of the FSRU project. Studies have concluded that continuous noise levels over 120 dBA results in 50% probability of avoidance in gray whales (Malme, Miles et al., 1984). Avoidance, which is when an animal moves away from a sound source, can cause individual whales to become disoriented or lost during migration (Gisiner, 1998). The criteria of 120 dBA have informally been accepted as the threshold for acoustic impacts to marine mammals (Entrix, 2003). Noise levels from the project are expected to range from 85 dBA to 120 dBA. The FSRU is expected to operate at 75 dBA (Entrix, 2003). LNG carriers moored at the FSRU could emit noise levels between 85 dBA and 120 dBA. Noise levels sustained at 120 dBA could cause harassment of marine mammals in the area. It is expected that the duration of the 120 dBA noise level would be short-term and not significant. Little is known of marine reptile responses to acoustic impacts (Gisiner, 1998).

Fuel or lubricating oils may spill from the FSRU or shuttle tankers.

The proposed FSRU stores approximately 113,400 liters (30,000 gallons) of diesel fuel for emergency power generation. If diesel fuel spills into the ocean, marine mammals in the oil spill trajectory could be impacted at various levels. Petroleum products can cause skin and eye irritation in marine mammals and are toxic if ingested (Engelhardt, 1983). Oil can also severely impact sea otters. If oil gets in the fur of sea otters, it will cause the fur to become sticky and matted. Between the fur and the skin of a sea otter is an insulating air layer that keeps the sea otter warm. If oil mats the fur, the sea otter has a reduced chance of survival (Stewart and Yochem, 1986).

If a petroleum spill occurs and petroleum comes in contact with sea turtles, it could cause skin irritation, decrease of blood glucose levels, changes in respiration, and total shut down of salt gland function (Florida Institute of Oceanography, 1986). Loggerhead turtles will ingest debris, such as tar balls. Ingested petroleum products have a toxic effect on sea turtles and can cause obstruction of the esophagus (NMFS/USFWS, 1998).

In the event of a spill, facilities must make rapid decisions about clean up and remediation to minimize environmental impacts. Past studies of oil spills in the early 1970’s show that response to spills suffered not only from a lack of equipment and specialized techniques, but also from a lack of organization and expertise to deal with such emergencies (Fingas, 2000). Facilities can reduce possible impacts of spills by developing a comprehensive contingency plan, to coordinate various aspects of the response, including stopping the flow of oil, containment, and subsequent clean up. Contingency plans should include organizations and resources from the immediate area, and escalating plans for spills of greater impact (Fingas, 2000).

A Project vessel could potentially strike a marine mammal or turtle.

Vessels may accidentally strike marine mammals or turtles causing injury and death from impact. There have been two documented strandings of green and olive ridley sea turtles caused by boat collisions (NOAA, 1997). Vessel strikes are considered a potentially significant impact to the pelagic environment. The possibility of vessel strikes are reduced if a person is stationed on vessels who is responsible for a plan to prevent such a strike, such as a marine mammal observer.

Impacts from Accidents

While unlikely, LNG could spill from the LNG tankers, the FSRU storage tanks, or from the loading arms of the shuttle tanker during transfer. Methane (primary component of LNG) is an asphyxiant because it displaces oxygen, but it does not appear to have any toxic effects on the marine environment. If spilled LNG were to reach the marine surface, it would quickly receive the energy needed to evaporate from the comparatively warm seawater. Routes of exposure in humans are through inhalation and skin contact. The same routes of exposure would likely apply to marine mammals/turtles, although, to a lesser degree.

The proposed FSRU concept safety assessment states that there are no credible scenarios that will result in a large LNG tank release (expected frequency of one incident in a million years) (Entrix, 2003). Small spills from the tanks, or small to large spills during transfer from shuttle tankers are a possibility. In a small LNG spill, the entire spill would evaporate before it could pool on the sea surface. Larger or more prolonged spills could cause LNG to pool on the surface for minutes before evaporating. A marine mammal/turtle could experience frostbite if it were to surface directly into an LNG pool. In addition, a marine mammal/turtle could experience temporary asphyxia if exposed to the LNG vapors.

4.3.4 Air Quality

Impacts from Operations

The emissions from the FSRU were modeled using a Gaussian-plume model as explained in the air quality methodologies. Values for stack height, emissions, prevailing wind direction, and wind speed were obtained from the Cabrillo Port Environmental Analysis. Emissions from operations, LNG carriers, and assist vessels were used to calculate total operational air emissions. The maximum hourly emissions of NO_2, PM_{10}, SO_2, and CO were input into the model. A stack height of 30 meters was assumed. The model was run using C class air stability parameters.

The distance to shore in the prevailing wind direction of WSW is 38 km (23.6 miles). From the model, the concentration of each criteria pollutant was determined as the plume reached shore (Table 20).

Table 20 – Criteria Pollutant Concentrations resulting from Gaussian-Plume model (WSW winds)

Pollutant	Concentration at Ventura Harbor (38 km from source)	Ambient Air Quality Standard	Magnitude of Impact
NO_2	3 µg/m^3	100 µg/m^3	Minimally important
CO	0.7 µg/m^3	10,000 µg/m^3	Neutral
SO_2	0 µg/m^3	80 µg/m^3	Neutral
PM_{10}	0.05 µg/m^3	20 µg/m^3	Neutral

When prevailing winds are WSW, air emissions travel 39 km (23.6) miles before they reach the shore, allowing for considerable dissipation of air pollutants. However, the designation of prevailing wind conditions is based on the *annual average* conditions obtained from Los Angeles International airport (LAX). If the wind were to shift SW, the plume would reach shore much more quickly. Therefore, model outputs were also examined at a distance 22.5 km (14 mi) from the emission source, which is the distance from the FSRU project to the closest shore.

Table 21 - Peak Concentrations of Criteria Pollutants resulting from Gaussian-Plume model

Pollutant	Concentration 22.5 km from Source	Peak Concentrations (600m)
NO_2	8 $\mu g/m^3$	1500 $\mu g/m^3$
CO	1.8 $\mu g/m^3$	375.8 $\mu g/m^3$
SO_2	0 $\mu g/m^3$	0.33 $\mu g/m^3$
PM_{10}	0.12 $\mu g/m^3$	24.8 $\mu g/m^3$

As shown in Figure 16, as the plume moves away from the emission source, the concentration of the air pollutant initially increases, peaks, and then declines as it disperses. Reported in Table 21 is the peak concentration of each criteria pollutant. The peak concentrations of NO_2 and PM_{10} are higher than the ambient air quality standards. Peak concentrations of CO and SO_2 remain well below ambient air quality standards. The peak in concentration occurs 600 meters away from the emission source, which may affect people on ships in the Santa Barbara Channel. However, the magnitude of air quality impacts are assessed based on concentrations on shore, not within the Santa Barbara Channel, and the time of exposure for someone in the Santa Barbara channel is likely to be small.

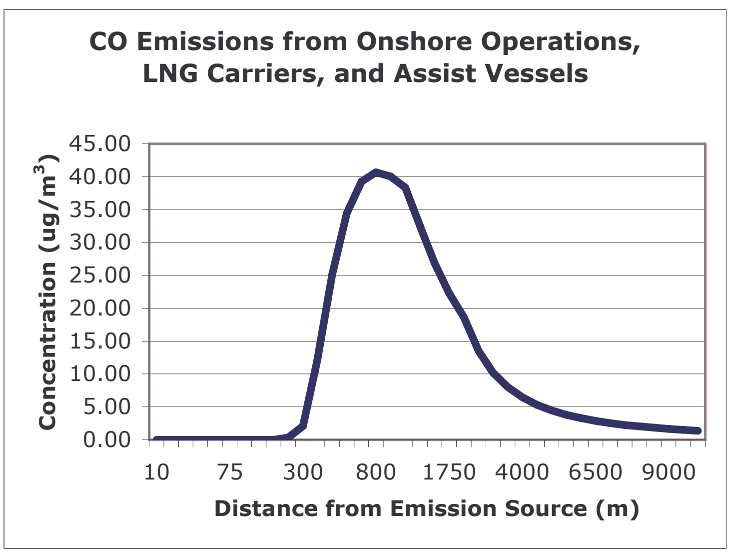

Figure 16 - CO Air Plume as it Moves Away from Emission Source

Ozone, another criteria pollutant, is formed from complex chemical reactions involving NO_x, volatile organic compounds (VOCs), and solar radiation. Ozone concentrations cannot be predicted with a simple Gaussian-plume model; therefore ozone is not evaluated by this analysis.

4.3.5 Terrestrial and Freshwater Biology

Most of the proposed FSRU project has an insignificant impact on the terrestrial and freshwater biology of the land. The onshore impact comes solely from the installation of the 76 cm (30 inch) pipeline that connects the FSRU to the SoCalGas tie-in. The onshore length of the pipeline is approximately 1 km (0.65 miles). Starting approximately 900 meters out into the sea, the proposed pipeline is installed using horizontal directional drilling. The use of HDD avoids most potential impacts to the intertidal zone and Ormond Beach by installing the pipeline underneath these environments. The pipeline will surface 480 meters (0.30 miles) inland. Once the pipeline surfaces, the remaining 560 meters (0.35 miles) of pipeline is installed by trenching to the SoCalGas tie-in.

All potential terrestrial and freshwater biological impacts from this project will result from the surface activity where the pipeline terminates at the SoCalGas tie-in adjacent to Ormond Beach Generating Station. This area is already a disturbed area. For the purpose of this analysis, a radius of 1609 meters (one mile) around this tie-in is analyzed with respect to terrestrial and freshwater biological resources.

The shoreline in the project area consists of sandy beach backed by low dunes or wetlands, with generally level agricultural fields or urbanized areas on the interior margins. Due to the diversion of the creeks upland, the primary source of water to these wetlands is direct precipitation and not from creek flow. The wetlands in the area are fragmented and, for the most part, highly degraded (Entrix, 2003). However, these wetlands still provide valuable wildlife habitat and have a high potential for restoration. To the north and south of the project area are densely vegetated marsh communities. Directly adjacent to the project are agricultural areas and patchy spots of coastal scrub. Most of the project construction area is developed. However, southern foredunes and Venturan coastal scrub may be present between the ocean and the on-shore end of the pipeline (Entrix, 2003).

The Ormond Beach area is rich in bird diversity. The beach has a freshwater lagoon, fed by urban and agricultural runoff and groundwater, that provides habitat for several bird species and is also a resting area for migratory birds.

Several special-status species are located in the project vicinity. These species of concern are described in detail in Appendices D and E. The appendices also describe the habitat and possible occurrence of species within five miles of the project area.

Impacts from Construction

The onshore portion of the project consists of laying the pipeline and installing a mainline valve, pig launcher/retriever station, and metering station. A pig launching/receiving facility is an access point within a pipeline where a bullet shaped cleaning or measuring device (a pig) that travels through the pipeline, can be installed or retrieved, depending on the needs of the pipeline operator. It is anticipated that a 4-acre section of land will be affected during both construction and operation of the project. A 45-day construction period is expected.

The pipeline corridor route was chosen to avoid impacts to dune resources and rocky intertidal resources. Grading and excavation activities are expected to occur at the HDD staging area, onshore along the proposed pipeline corridor, and along the pipeline trenching area, between 480 meters and 1 km (0.30 and 0.65 miles) inland behind the coastal dunes. This 560 meters (0.35 mile) trench is located on disturbed, unvegetated land formerly used for industrial purposes. HDD is used to minimize environmental impacts, including disruption of wetland habitat and beach habitat. Grading and excavation have the potential to impact wildlife moving through the area. Runoff from construction activities could potentially cause impacts to biological resources, including some listed under the species of concern. With mitigation, potential impacts of construction are expected to be less than significant (Entrix, 2003).

Beyond the facility tie-in point, SoCalGas will construct a 19.3 km (12 mile) connection line from the project tie-in to their main delivery line located near the 101 Freeway. This onshore section of pipeline is not included in this analysis.

Impacts from Operations and Maintenance

During normal operations, the onshore pipeline will deliver natural gas to the SoCalGas tie-in unit without impacting terrestrial habitats. Ground maintenance could affect wildlife species that enter the project area, but the onshore operating areas will be fenced to exclude wildlife. The effect of operations is expected to be less than significant.

Impacts from Decommissioning

During decommissioning, the onshore meter, mainline valve, odorant injection facility and other facilities associated with the project will be removed and scrapped or salvaged as appropriate. The pipeline will be abandoned and filled with concrete slurry, preventing any movement of the pipeline in the future. It is beyond the scope of this analysis to determine what biological and freshwater resources will be present at the project site in 25 to 40 years (expected lifetime of FSRU). It is expected that no impacts will be associated with the pipeline abandonment. However, scrapping and salvaging the associated facilities and equipment may impact the terrestrial and freshwater biology.

Impacts from Accidents

There is no credible accident scenario where an LNG related accident affects the terrestrial and freshwater biology.

4.3.6 Conclusions

The information for the analysis of the environmental impacts anticipated from the proposed FSRU is derived primarily from the Cabrillo Port EA. Analysis shows expected impacts to most environmental resources are, at most, only minimally important. The environmental impacts of most concern are those to marine mammals, reptiles, and air quality. If a vessel strikes a marine mammal or reptile, the impact is considered severe. However, this possibility exists with all three of the proposed LNG projects. Air quality analysis using a simple Gaussian-plume model, revealed onshore air quality impacts of CO, SO_2, and PM_{10} are ranked neutral. NO_2, accounting for less than 1/10 of ambient air quality standards, is considered minimally important. The peak concentration of NO_2 exceeds ambient air quality standards at a distance 600 meters from the facility. However, this peak is not expected to impact sensitive onshore receptors.

4.4 Socioeconomic Analysis

4.4.1 Introduction

This section considers the impact of the proposed FSRU on socioeconomic aspects. Results of the collective socioeconomic rankings are illustrated within Table 22 below. A detailed explanation of these results follows.

Table 22 - FSRU Socioeconomic Matrix

	FSRU	construction	operation & maintenance	accidents			decommission
				minor - w/in facility	moderate - w/in exclusion zone	major - outside exclusion zone	
Socioeconomic Effects	population affected	c-1	c-3	not evaluated	not evaluated	not evaluated	c-2
	economy & employment	f-1	f-2	e-1	e-3	f-4	f-2
	property value	e-1	e-1	e-1	e-3	d-4	e-1
	housing	c-2	d-3	c-1	c-3	b-4	c-2
	public services	e-3	e-3	e-3	d-3	c-3	e-3
	traffic	d-2	d-1	e-2	d-3	c-4	d-2

4.4.2 Population Affected

To analyze the proposed FSRU project's effect on the population, a population review is conducted at the state, county, and city level. The population of California on April 1, 2000 was 33,871,648**.** The proposed FSRU is located offshore, near the City of Oxnard in Ventura County. The gas pipeline that will distribute natural gas from the FSRU to shore surfaces at the Reliant Energy power plant located at Ormond Beach in Oxnard, California. Oxnard's population in 2000 was 170,358.

State Analysis

Based on state population statistics obtained from the year 2000 U.S. Census, California is the most populous state and ranks number twelve in population density. Therefore it is assumed that any project proposed in California will affect more than the average population density nation wide (Table 23).

Table 23 - State Population Summary. *Source: U.S. Census Bureau 2000*

Average State Population	Average State Population Density	California Population	California Population Density
5,616,997	70.3 (182.2)	**33,871,648**	**83.9 (217.2)**

Population Density in persons/square kilometer or (persons/square mile)

County Analysis

As of 2004, there are fifty-eight individual counties in California. As with the state data, county population statistics were obtained from the 2000 U.S. Census.

Ventura County ranks number twelve in California based on total population and thirteenth in population density. Based on this calculation, Ventura County exceeds the average population, yet has considerably less than the average population density. Average county population density within the state exceeds the population density of Ventura County by roughly 35 percent. In other words, on average, counties have approximately 217 more people per square mile than Ventura County. For this reason it is assumed that any project proposed in Ventura County will not affect more than the average county population density in the state.

Table 24 – County Population Summary. *Source: U.S. Census Bureau 2000*

Within California			
Average County Population	Average County Population Density	Ventura County Population	Ventura County Population Density
583,994	241.8 (626.2)	**753,197**	**157.6 (408.2)**

Population Density in persons/square kilometer or (persons/square mile)

City Analysis

Population data obtained for two hundred and seventeen of the states' most populated cities were compared. Cities with less than 25,000 persons based on 2000 U.S. Census data are excluded.

Oxnard is the most populous city in Ventura County. It ranks twenty in California on overall population and fifty-five based on population density. A project proposed in the City of Oxnard, which exceeds the average city population and population density, is assumed to affect more than the average population.

Table 25 - City Population Summary. *Source: U.S. Census Bureau 2000*

Within California			
Average City Population	Average City Population Density	Oxnard City Population	Oxnard City Population Density
111,915	2,166.6 (5,611.5)	**170,358**	**2,599.8 (6,733.5)**

Population Density in persons/square kilometer or (persons/square mile)

Based on this information, it is generally expected that the population surrounding a proposed project within the City of Oxnard will be greater than the state and city average, and less than the county average.

Ranking Population

It is anticipated that the general population will experience the greatest impacts of the FSRU project during the initial construction phase. Nearly half of the estimated 103 workers on the project will be needed during initial construction. Additionally, materials and equipment necessary to complete the onshore section of the pipeline and supply the offshore operations will be greatest during this phase.

To account for the distance from local population centers, the significance will be de-rated for an offshore project located beyond ten miles from shore. The FSRU project is proposed near a state (California) that exceeds the average population density, a county (Ventura) that is less than the average population density, and a city (Oxnard) that exceeds the average city population density by more than 17 percent. FSRU population data exceeds the average population density in two of the three criteria examined, thus is initially rated as severe within the matrix. However, de-rating criteria are used for LNG projects proposed offshore. With the exception of the onshore pipeline infrastructure, which is the type commonly used by utility companies for high pressure supply, more than 90 percent of the proposed FSRU project is located offshore. Given its location, the project is de-rated by one level on the magnitude scale. Magnitude rating for this criterion is therefore rated as important rather than severe across the entire life cycle of the project.

4.4.3 Economy and Employment

As designed, the FSRU project is expected to employ an estimated 45 full-time workers during the temporary construction phase, which is expected to take approximately 45 days for the pipeline and 30-45 days for the mooring project. Of the 45 workers, seven are expected to be from local communities (Entrix, 2003). Normal operation and maintenance activities at the facility are expected to employ 58 workers (29 people on each 7 day work week). Personnel will be on board the FSRU 24 hours a day, 365 days a year, subject to weather conditions unique to the offshore environment. Operations and maintenance activities are expected to continue for the lifetime of the project, which is estimated to be between 25 and 40 years (Entrix, 2003). FSRU employment estimates are summarized in Table 26. Much like the initial construction phase, it is assumed that decommissioning entails a temporary increase in employment depending on the removal strategy approved by regulators. According to the Cabrillo Port Environmental Assessment, the FSRU Project's estimated annual labor cost is $5.7 million and its preliminary operating expenses are $13.4 million per year. The workers typically spend 25 to 30 percent of their income on temporary housing, food, and entertainment onshore between shifts. The Project will contribute to the local revenue through purchases of construction goods and materials. The significance of this economic benefit is determined by analyzing potential state, county, and local data.

Table 26 – FSRU Employment Estimates. *Source: Cabrillo Port EA*

Activity	Total Estimate	Estimated Local Workers	Estimated Non-Local Workers	Estimated Family Members of Non-Local Workers*	Total Immigration (Non-Local + Family)
Pipeline & FSRU Construction	45	7	38	0	38
Operations and Maintenance	58	29	29	23	52
Total	**103**	**36**	**67**	**23**	**90**

California Analysis

According to the U.S. Department of Commerce, Bureau of Census (2000), the largest economic sectors in California are: (1) education, health, and social services, (2) manufacturing, (3) professional, scientific, management, administrative, and waste management services. Management, professional, and related occupations are the largest employers in the state followed by sales, office, and service occupations. Unemployment in the state during 2003 was 6.4 percent (State of California, 2003).

Ventura County Analysis

Population estimates for Ventura County in 2000 were 753,197 persons. The largest economic sectors in Ventura County are: (1) education, health, and social services, (2) manufacturing, (3) retail trade. As with the state, management, professional, and related occupations are the largest employers in the county followed by sales, office, and service occupations.

Unemployment in Ventura County during 2003 was 5.3 percent (State of California, 2003).

City of Oxnard Analysis

Year 2000 population estimates for the City of Oxnard were 170,358 persons. The largest economic sectors in the City of Oxnard are: (1) manufacturing, (2) education, health, and social services, (3) retail trade. Sales and office occupations are the largest employers followed by management, professional and related occupations, production, transportation, and material moving occupations.

Unemployment in the City during 2002 was 7.8 percent (State of California, 2003).

City of Port Hueneme Analysis

Population estimates in 2000 for the City of Port Hueneme (the closest port city to the proposed FSRU project) were 21,845 persons. The largest economic sectors in the City of Port Hueneme are: (1) education, health, and social services, (2) manufacturing, (3) professional, scientific, management, administrative, and waste management services.
Occupational information is the same for Port Hueneme as the City of Oxnard. Sales and office occupations are the largest employers followed by management, professional and related occupations, production, transportation, and material moving occupations.

Unemployment in the City during 2000 was 7.8 percent (State of California, 2003).

Ranking Economy and Employment

Economic and employment benefits are rated according to significance to local population. Projects that create a noticeable impact on the local unemployment rates and/or economic community receive a beneficial ranking (higher than neutral). According to 2000 census data, there are an estimated 25,589 workers employed in construction/extraction and maintenance occupations in Ventura County which represents approximately 6.3 percent of the total employment in the County (Table 27). There are an estimated 915,023 jobs within the California construction economic sector (Table 28). The FSRU project, at best, adds an additional 103 workers to the local economy. According to the Cabrillo Port environmental assessment, only 36 of these workers are actually expected to come from the local population. Based on this analysis, the FSRU project adds less than 0.14 percent to the local construction/extraction and maintenance occupations in Ventura County, and less than 0.0039 percent to the entire construction sector: beneficial to the local economy and employment but not significantly. Given this result, a minimally important ranking is assigned to the economy and employment section of the matrix throughout the life cycle of the project.

Based on the FSRU project description, minor benefits to society occur due to the additional employment offered to the local community. Community benefits are also derived from the purchase of goods and services by non-local workers. Most of the benefit is absorbed into the economy during initial construction. For this reason, a rating of minimally beneficial is used during the life cycle of the project (construction, operations, decommissioning), with highly likely used during construction and likely assigned for the normal operations and decommissioning phase of the FSRU project.

Economic and employment numbers can be dramatically different in the event of an accident. It is anticipated that a minor LNG accident, defined as one that occurs within the boundaries of the facility, will have no noticeable impact to economy and employment, so is assessed a magnitude of neutral. A moderate accident within the perimeter of the exclusion zone (approximately 1 nautical mile (1852 meters)) is assumed to have slightly more significance but is still rated neutral. A major accident beyond the perimeter of the exclusion zone could theoretically cause a significant boost in economy and employment if a large influx of non-local personnel were to respond. For this reason, a major event as it relates to economy and employment, is also ranked minimally beneficial.

Table 27 – Occupational Employment Summary. *Source: U.S. Department of Commerce, Bureau of Census (2000)*

Occupation	California		Ventura County		City of Oxnard		Port Hueneme	
	Employed	**%**	**Employed**	**%**	**Employed**	**%**	**Employed**	**%**
Management, professional, and related occupations	5,295,069	36.0	127,157	36.5	15,233	21.6	2,232	25.6
Service occupations	2,173,874	14.8	46,762	13.4	10,597	15.1	1,179	13.5
Sales and office occupations	3,939,383	26.8	95,006	27.3	17,555	24.9	2,714	31.2
Farming, fishing, and forestry occupations	196,695	1.3	10,869	3.1	6,879	9.8	255	2.9
Construction, extraction, and maintenance occupations	1,239,160	8.4	28,589	8.2	6,327	9.0	963	11.1
Production, transportation, and material moving occupations	1,874,747	12.7	39,955	11.5	13,804	19.6	1,362	15.6
Total	**14,718,928**	**100**	**348,338**	**100**	**70,395**	**100**	**8,705**	**99.9**

Table 28 – Industry Employment Summary. *Source: U.S. Department of Commerce, Bureau of Census (2000)*

Economic Sector	California		Ventura County		City of Oxnard		Port Hueneme	
	Employed	**%**	**Employed**	**%**	**Employed**	**%**	**Employed**	**%**
Agriculture, forestry, fishing & hunting, & mining	282,717	1.9	14,265	4.1	7,563	10.7	356	4.1
Construction	915,023	6.2	21,946	6.3	3,910	5.6	622	7.1
Manufacturing	1,930,141	13.1	48,154	13.8	11,003	15.6	1,153	13.2
Wholesale trade	596,309	4.1	13,811	4.0	3,395	4.8	401	4.6
Retail trade	1,641,243	11.2	38,539	11.1	8,203	11.7	949	10.9
Transportation & warehousing, & utilities	689,387	4.7	11,385	3.3	2,477	3.5	293	3.4
Information	577,463	3.9	14,639	4.2	1,733	2.5	213	2.4
Finance, insurance real estate & leasing	1,016,916	6.9	28,328	8.1	3,446	4.9	439	5.0
Professional, scientific, management, administrative, & waste management services	1,711,625	11.6	38,476	11.0	6,186	8.8	977	11.2
Educational, health & social services	2,723,928	18.5	59,820	17.2	10,156	14.4	1,550	17.8
Arts, entertainment, recreation, accommodation & food services	1,204,211	8.2	23,669	6.8	4,816	6.8	558	6.4
Other services (except public administration)	761,154	5.2	16,377	4.7	3,547	5.0	421	4.8
Public administration	668,811	4.5	18,929	5.4	3,960	5.6	773	8.9
Total	14,718,928	100	348,338	100	70,395	99.9	8,705	99.8

4.4.4 Property Value

This analysis includes an evaluation of existing property uses at the proposed FSRU site. California law requires each city and county to adopt a comprehensive, long-term, internally consistent general plan that among other things identifies land use and open space uses consistent with community needs. Property value ranking criteria are determined using the following general plans: City of Oxnard 2020, Ventura County 2000, and the City of Oxnard Coast Land Use Plan (2000).

In addition to the general plan provisions, the FSRU project is reviewed for compatibility with the Channel Island National Marine Sanctuary (CINMS). The CINMS was given special status as a marine sanctuary in 1980, and now represents a 342,266-hectare (1,252 square mile) portion of the Santa Barbara Channel off the Coast of California. The sanctuary's primary goal is the protection of the natural and cultural resources contained within its boundaries (CINMS, 2004). It encompasses the waters that surround Anacapa, Santa Cruz, San Miguel, and Santa Barbara Islands extending from mean high tide line to six nautical miles offshore around each of the five islands.

Proposed Property Use

Onshore infrastructure related to the proposed FSRU is limited to a 60.9 meter by 60.9 meter (200 ft by 200 ft) above ground facility. The proposed pipeline runs adjacent to the existing Reliant Energy Ormond Beach Generating Station, north of Ormond Beach, and south of Port Hueneme. The facility plans include: a shutdown valve used for emergencies, normal operation, and maintenance activities, a meter station used to log the volume of gas distributed through the pipeline, a pig launcher/receiver station for cleaning and servicing, and a gas odorant injection station where a "rotten egg" smell (mercaptan) is added to the gas as a safety requirement (Entrix, 2003).

Beyond the facility tie-in point, Southern California Gas Company (SoCalGas) plans to construct a 19.3 km (12 mile) connection line from the Project tie-in to their main delivery line located near the 101 Freeway. This onshore section of pipeline is not included in this analysis.

Adherence to the General Plan

The onshore portion of the proposed FSRU project is located on the boundary separating the City of Oxnard and the unincorporated area of Ventura County. According to the Ventura County General Plan, the area is located within the City of Oxnard's "Sphere of Influence" which means the area is subject to annexation to the City as development occurs, i.e. the area will become the domain of the City of Oxnard. According to Ventura County's General Plan, the onshore portion of the project is located in an area designated for industrial use.

Zoning ordinances govern the type and intensity of land uses and set standards for development. The Oxnard 2020 General Plan and Land Use Plan designates the area within the Coastal Zone as industrial, with priority to coastal-dependent uses, coastal recreation, resource protection, and public utility/energy facilities (City of Oxnard, 1990).

Offshore Analysis

The FSRU project, as proposed, is located 33.8 km (21 miles) south of Anacapa Island. This location is 28.9 km (18 miles) from the CINMS and outside of existing shipping lanes. The proposed pipeline traverses through federal and state water and comes ashore in Ventura County.

Ranking Property Value

After careful review of the applicable general plan(s) associated with the FSRU project, the analysis shows that the project does not conflict with the community vision of the area. According to the County and City General Plans, the onshore portion of Ormond Beach is zoned as for industrial use and does not require modifications as a result of the FSRU project. According to National Oceanic and Atmospheric Administration (NOAA) charts, the FSRU project is proposed more than 18 miles (28.9 km) from the CINMS (NOAA, 2003). Based on these considerations no significant impacts to land use and/or property values are expected as a result of the FSRU project. Based on this information, property value impacts associated with the FSRU project are ranked neutral, i.e. no noticeable impact throughout the life cycle of the project.

It is anticipated that a minor LNG accident, defined as a spill that occurs within the boundaries of the facility, will have no noticeable impact to property value, or a magnitude of neutral. A moderate accident within the perimeter of the exclusion zone (approximately 1 nautical mile (1852 meters)) is assumed to have slightly more significance but is still rated neutral. A major LNG accident representing a spill beyond the perimeter of the exclusion zone could theoretically cause detriment to property value, however a worst case scenario offshore is not expected to significantly impact the shoreline. For this reason, a major event, as it relates to property value, is also ranked minimally important.

4.4.5 Housing

Of the estimated 103 personnel required for both the construction and operation phase of the FSRU, 85 percent of the personnel are expected to come from outside the community (Entrix, 2003). This represents approximately 67 non-local workers that are expected to migrate either temporarily or permanently to the area as a result of the FSRU project. Including family members, total migration estimates could exceed 90 people (Entrix, 2003). All of these persons will require housing.

Local Vacancy Rates

Housing Occupancy data is obtained from the U.S. Census Bureau (2000). Vacancy rate calculations are made based on occupied housing and vacant housing units available for Ventura County, the City of Oxnard, and Port Hueneme. For comparison, homeowner vacancy rates and overall California data are included in the analysis.

Results indicate that all three of the local demographic areas near the proposed FSRU site exhibit a substantially low vacancy rate. Furthermore, all three areas exhibit a lower vacancy rate than the overall California average. The City of Oxnard exhibited the lowest rental vacancy rate of 1.8 percent and the second lowest homeowner vacancy rate of 1 percent. Homeowner vacancy rates, an indication of residential housing supply, at the county and city level are also lower than the state average (Table 29).

Table 29 - Housing Occupancy. *Source: U.S. Census Bureau 2000*

HOUSING OCCUPANCY	California	Ventura County	City of Oxnard	City of Port Hueneme
Occupied housing units	11,502,870	243,234	43,576	7,268
Vacant housing units	711,679	8,478	1,590	640
For seasonal, recreational, or occasional use	236,857	2,653	709	234
Total housing units	**12,214,549**	**251,712**	**45,166**	**7,908**
Homeowner vacancy rate (percent)	1.4	0.9	1	1.1
Rental vacancy rate (percent)	**3.7**	**2.6**	**1.8**	**3**

Ranking Housing

In accordance with socioeconomic matrix ranking criteria, housing availability is ranked as important (a minor detriment to society) through the construction and abandonment phases of the project life cycle, with a minimally important ranking during normal operations. Given the relatively small number of vacant housing units available at the state, county, and city level (Table 29) a small increase in total migration is expected to influence the local housing market.

A total of 1,590 vacant housing units are available in the City of Oxnard (2000). If 67 additional families migrate to the area, as estimated for the construction phase of the FSRU, they would absorb more than 4 percent of the available housing, which is significant. However, only 29 non-local workers are expected to migrate to the area during normal operations. Given the same scenario, Oxnard would only have to absorb 2 percent of the available housing. Although additional rental housing units are available within the "seasonal, recreational, and occasional" use areas, they are not considered in the analysis.

Based on the analysis, it is assumed local housing availability will be strained during the initial construction and decommissioning phase, yet significantly less during normal operation. For this reason, a likelihood rating of neutral is used during normal operations and likely is assigned for the construction and decommissioning phase of the project.

Housing availability should not change dramatically when evaluating the effects of an accident. In each accident scenario (minor, moderate and major) the LNG release is not expected to reach the shoreline, therefore additional migrant workers are not expected. For this reason minor and moderate accidents are ranked as important. However, given the potential influx of response personnel and news crews in the event of a major LNG release, outside the exclusion zone, a temporary drain on housing availability is expected. Given this scenario, a major accident is ranked as severe.

4.4.6 Public Services

Ventura County has a well-developed infrastructure to provide health, police, fire, emergency, and social services near the proposed FSRU site. The FSRU Project would employ about 7 local and 38 non-local workers for the construction phase, and about 58 total workers for terminal operations. Because the workforce is expected to be small relative to the current population of the area, construction, operations, and maintenance of the FSRU terminal and piping is expected to have minor, temporary, or no impact on local community facilities and services.

Ranking Public Services

During the normal life cycle of the project, local emergency medical services may be necessary to treat injuries as a result of work site accidents. This demand is not expected to strain public services, thus magnitude and likelihood ranking is neutral for all phases of the project. However, public services may experience additional demand in the event of an accident. For this purpose the proposed FSRU project receives a progressively increased magnitude of significance based on severity of the LNG accident. In the case of a minor LNG accident contained within the facility, no drain on public services is expected, thus a neutral ranking is assigned. A moderate LNG accident within the exclusion zone is defined as minimally important, and a major LNG accident outside the exclusion zone is ranked as important. Similarly, the likelihood of an accident is reduced as severity is increased. Likelihood rankings as they apply to accidents are derived from the community and safety section of this report, which describes minor accidents as highly likely, moderate accidents as likely or neutral, and major accidents as unlikely.

4.4.7 Traffic

Building and operating an FSRU terminal is expected to increase congestion on access roads in route to the Port of Hueneme and traffic within the port. Most of this increase is expected to occur during initial construction activities. The influx of construction equipment, materials, and personnel to the project area can result in traffic congestion, roadside-parking hazards, and less capacity at the Port. Marine traffic outside the harbor and traffics effects on commercial fishing, military operations, or existing oil and gas operations are excluded from the analysis.

Roadway Traffic

There are various surface streets used to transport personnel, supplies, and equipment to the FSRU project site. During the initial construction phase of the project, both the onshore pipeline landing area at Ormond Beach and the Port of Hueneme are expected to receive an increase in traffic flow. After the initial, and temporary, construction phase of the FSRU project is completed, most of the traffic is routed to the Port of Hueneme. The Port is located about 97 km (60 miles) northwest of Los Angeles, 64 km (40 miles) southeast of Santa Barbara, and 542 km (337 miles) south of San Francisco. It is the only deepwater port between Los Angeles and San Francisco bay. Supply vessels and crew boats related to the FSRU project will operate out of this port during normal operations. The City of Oxnard, in cooperation with the California Department of Transportation (Caltrans), is proposing to improve the Rice Avenue/U.S. 101 Interchange, which will dramatically improve the level of service (LOS) of access roads heading to the Port of Hueneme. This expansion is scheduled for completion prior to the initial phase of the FSRU project. Once complete, project traffic will be able to access the Port off Highway 101 as follows:

To Port of Hueneme from North or South

- On Highway 101
- Exit 101 at Rice Road and go south to Hueneme Road
- Hueneme Road west into the Port

Table 30 – Annual Average Daily Traffic (AADT) volumes - FSRU project. *Source: Ventura County 2001*, ***http://www.ventura.org/vcpwa/transportation/traffic.htm#volume***

	AADT	A.M. Peak LOS	P.M. Peak LOS
Hwy 101 jct with Rice Avenue (s/b)	137,000	A	C
Hwy 101 jct with Rice Avenue (n/b)	122,000	N/A	N/A
Rice Avenue/Channel Islands Blvd. (s/b)	28,000	A	B
Rice Avenue/Channel Islands Blvd. (n/b)	43,000	A	B
Hueneme Road (n/b)	N/A	A	A
Hueneme Road (n/b)	N/A	A	A

The construction phase of the Project requires approximately 15 semi-trucks to deliver construction materials to the staging area in Port Hueneme (Entrix, 2003). Up to 45 workers per day are needed at the Edison road tie-in. During normal operations of the FSRU, approximately 60 auto trips to the Port area once a week are necessary for operations personnel. Assuming the Rice Avenue/Highway 101 interchange is completed prior to the commencement of the FSRU project, no significant impact to traffic is expected. This determination is based on the LOS indicators of the main access road to the Port of Hueneme (Table 30).

Marine Traffic

Marine traffic is analyzed by determining the estimated port traffic necessary during the construction, normal operations, and abandonment phase of an LNG terminal project. This data is compared to the normal port traffic and rated according to significance. In part, ranking criteria for port traffic is derived from personal interviews with the Oxnard Port Authority.

Port Hueneme is a cargo port that received in excess of 915 deep draft (defined as requiring a water depth greater than 4.5m (15 feet)) vessel entries in 2002, which included an estimated 385 large car carriers, conventional ships, floating barges, and bulk container vessels. Specialty boats for commercial fishing and livestock transport accounted for 245 entries into the port that same year. Offshore support and other shallow draft vessels exceeded 285 entries in 2002. On average the port receives 4 vessel entries each day.

During the 45-day construction phase of the FSRU, one pipeline barge, two supply vessels, and one pipelay (used to install offshore pipelines) vessel are required. The pipelay vessel becomes an offshore stage area and remains on site, thus not adding to the congestion of the port. The pipeline barge will require 4 round trips to transport pipe and materials from Port Hueneme to the offshore site. Supply vessels will make 2-4 trips out of the port over each 24-hour period. According to the Cabrillo Port Environmental Analysis, the pipe lying construction phase adds approximately 145 vessel trips to Port Hueneme over a 45-day period. This equates to approximately 3.22 trips over each 24-hour period.

During the 45-day FSRU mooring phase, two Anchor Handling Tug Supply (AHTS) vessels, two supply vessels, and two barges are necessary to complete the installation. According to the Cabrillo Port Environmental Analysis, the mooring phase adds approximately 135 vessel trips to Port Hueneme over a 45-day period. This equates to approximately 3 trips over each 24-hour period.

Normal operations require the periodic use of crew and supply vessels to deliver operations personnel, supplies, and collect waste. Estimated port traffic increases due to normal operations of the FSRU are 11 trips weekly, or less than two trips per day.

Ranking Traffic

Due to the relatively small amount of onshore traffic versus LOS, the project is assumed to have little effect on the existing road traffic congestion. Conversely, the marine traffic expected during the initial construction and mooring phases of the FSRU project is expected to increase daily marine traffic by 75 percent, 50 percent during normal operations, given both phases are completed independently. Although this increase is substantially less than the capacity of the port, it is of some significance to port congestion. Given this determination a magnitude ranking of minimally important is assigned to this category for the construction, normal operations and decommissioning. Traffic projections during normal operations are highly likely with construction and decommissioning ranked likely.

Traffic congestion both onshore and in the port may experience additional demand in the event of an accident. For this purpose the FSRU proposed project receives a progressively increased magnitude of significance based on severity of the LNG accident. In the case of a minor LNG accident contained within the facility no drain on public services is expected, thus assigned a neutral ranking. A moderate LNG accident within the exclusion zone is defined as minimally important and a major LNG accident outside the exclusion zone is important. Similarly, the likelihood of an accident is reduced as severity is increased.

4.4.8 Conclusions

None of the socioeconomic impacts evaluated as a result of the FSRU project stand out as either significantly beneficial or detrimental to society.

Economy and employment represent the only category that appears to benefit as a result of building the FSRU receiving terminal. However, in comparison to the size of the local economy and historic unemployment within the project vicinity, the benefits are expected to be of minimal importance to society.

Based on this analysis, housing availability within the vicinity of the proposed FSRU project is already in short supply, thus creating a project in the area will certainly add to this societal problem. Most of the impact to housing availability will occur during initial construction and decommissioning phases. Although less likely and temporary in nature, it is expected that a moderate to major accident could compound the housing shortage due to the influx of media and emergency response personnel.

4.5 General FSRU Conclusions

With regard to community safety impacts, the proposed FSRU terminal's remote siting (away from densely populated areas) is an important factor in its low magnitude ranking Environmental impacts appear to be of minimal importance and occur mainly during construction, or as a result of vessel strikes. The FSRU does not appear significantly beneficial or detrimental to socioeconomic aspects.

5 ONSHORE TERMINAL

5.1 Terminal Description

An onshore LNG receiving terminal is proposed for the Port of Long Beach in Los Angeles County. The potential site for the terminal is Pier T, Berth 126. This facility is designed to receive LNG tankers and store the LNG on site as depicted in Figure 18. The imported LNG can either be regasified and sent into a distribution grid or transferred to a smaller storge unit on site that provides LNG for motor vehicles.

Figure 17 - Photo of Proposed Onshore Project Site. *Source: Port of Long Beach*

A 47 month construction period is estimated for the Long Beach terminal, with annual labor costs estimated to be $3.6 million during normal operations. The proposed facility has a planned average throughput capacity of 700,000 mmcfd. Although an official exclusion zone is yet to be defined by the developer, for the purpose of this analysis the exclusion zone is assumed to be the boundaries of the Port of Long Beach.

Figure 18 - Artist rendition of Proposed Onshore Terminal. *Source: Sound Energy Solutions*

Table 31 - Onshore Terminal Description. *Source: SES Draft Resource Report 1*

Terminal Description - Onshore Facility	
Location	25 acre site at the Port of Long Beach; Pier T, Berth 126; currently paved with concrete or asphalt.
Facility design life	40 year lease with POLB.
Construction	Additional 20-30 acres needed for construction; location not yet decided.
Carrier berthing	70 vessels per year (one ship every 5 days).
Carrier size range	95,000-145,000 m^3 capacity, possibly larger. Between 75,000-125,000 yd^3 of sediment will be dredged to accommodate these carriers creating a depth of approx 15 meters (50 feet) mean low water (meant to provide at least 0.6 meters (2 feet) under the deepest draft ships as required by the USCG).
Transfer rate	12 hours to unload a 145,000 m^3 capacity vessel (anticipated to be the typical size class of vessels at this terminal).
Tank type	Full containment tank Primary tank of 9% nickel steel; Secondary tank of pre-stressed concrete walls and concrete bottom and top; Stainless steel or 9% nickel steel support deck suspended from outer tank over the inner tank Both are designed to be able to independently hold the stored LNG; Perlite and cellular glass will be used for insulation.
# of storage tanks	2, approx 78 meter (255 feet) diameter, 54 meter (176 feet) height.
Storage capacity	320,000 m^3; 160,000 per tank.
Loading arm range of motion	Arms will be equipped with swivel joints.
# of loading arms	3 liquid arms, 1 vapor recovery arm.
Throughput capacity	700,000 million cubic feet/day average rate; 1 billion cubic feet/day max rate
Regasification method	Shell tube vaporizers; closed loop water system heated with three direct fired heaters and circulation pumps.
Fire protection system	Underground firewater distribution system with hydrants, hose reels and deluge and sprinkler systems; Dry chemical and carbon dioxide fire extinguishers; Emergency shut down system.
Pipeline	92 cm (36 inch) diameter pipeline for 3.7 km (2.3 miles) to tie into So Cal Gas Line.
Truck Loading Facility	Trailer truck loading facility with a 3800 m^3 storage tank.
Personnel	Terminal operators will be trained in potential hazards associated with LNG, cryogenic operations, and proper operation of equipment and will meet the training requirements of USCG, and the Long Beach Fire Dept.
Exclusion Zone	Not specified by developer – is assumed to be boundary of POLB

5.2 Community Safety Analysis

5.2.1 Introduction

In the United States, there have been two accidents in the history of LNG facility operations; one at a Cleveland, Ohio peak shaving plant in 1944 and another at Cove Point LNG import terminal in Maryland in 1979. The Cleveland accident was the only accident in the U.S. to cause fatalities to the general public. The four import terminals in the U.S. have since operated with good safety records (CH-IV International, 2002). Accidents are not anticipated, however safety impacts to the general public should still be considered.

This section considers the impact of the onshore LNG terminal on community safety, and focuses on four specific accident scenarios. Federal law requires that storage tanks be placed a minimum distance from the property line, equal to 0.7 times the diameter of the tank. Exclusion zones also need to be set based on safety modeling results, to protect citizens from thermal radiation and vapor plumes. Sound Energy Solutions is modeling thermal and vapor impact zones using LNG Fire III and DEGADIS (SES Resource Report 1, 2003). Specific model results and additional details are not yet available for the Long Beach proposal. Because of the lack of specific information, impact analysis is based solely on data extrapolated from other studies. Before making a firm appraisal of impacts of the proposed facility on the surrounding community, specific safety information must be reviewed.

The actual buffer zones and facility plans also are not available for this evaluation. For the purposes of defining boundaries for evaluation, the approximate dimensions are estimated at 500 meters by 200 meters (0.31 miles by 0.13 miles). The dimensions are based on the proposed site map provided on the project developer's webpage. This property line is assumed as the boundary for minor accidents and the exclusion zone is set as the Port of Long Beach, defining moderate and major accidents. The proposed terminal is centrally located with a rough radius of approximately 2400 meters (1.5 miles) to the boundary of The Port of Long Beach. Table 32 outlines community safety rankings for the onshore facility.

Table 32 - Onshore Community Safety Matrix

	ONSHORE	construction	operation & maintenance	accidents			decommission
				minor - within facility	moderate - within exclusion zone	major - outside exclusion zone	
Community Safety	operational failure	not evaluated	not evaluated	e-1	b-2	a-4	not evaluated
	maritime accidents	not evaluated	not evaluated	e-1	b-2	a-3	not evaluated
	natural phenomena	not evaluated	not evaluated	e-2	b-2	a-3	not evaluated
	terrorism/sabotage	not evaluated	not evaluated	b-2	a-3	a-4	not evaluated

5.2.2 Operational Failure

According to the facility proposal, LNG carriers unload the LNG at an unloading platform, which includes unloading arms to transfer the LNG from the vessel into storage tanks. Like the FSRU, these unloading arms are designed to prevent spillage of LNG and the likelihood of a spill during normal operations is very small. The likelihood and magnitude of a small accident at the onshore terminal is very similar to the rankings for the FSRU. An area of the facility is set aside for distribution trucks loading LNG for vehicle fuel. This storage and transfer operation represents additional risks of operational failure. However, this operation is located inland and should present less risk due to lower mobility of any spilled LNG.

In case of a larger leak surpassing containment capabilities, the LNG could spill onto the water between the dock and the vessel. This proposed facility has a disadvantage in that there is no physical buffer area that extends on the waterside of the facility. If the spill is large enough to form a sustained pool, LNG vapors could easily migrate the short distance across facility boundaries, into the harbor channel, and onto adjacent plots. With nearby industries and ships in the area providing numerous sources of ignition, it is probable that a vapor cloud would be ignited. Dependent on actual flame spread, the fire and thermal radiation could temporarily interrupt operations and seriously injure ship crews in the area and employees at neighboring facilities.

Using Dr. Koopman's estimate of a guillotine-type break resulting in a 643.9 meter (0.4 miles) long vapor cloud, representing a credible worst case operating failure scenario, the impact magnitude of this accident is catastrophic (Koopman, 2002). Measured from the center point of the site, a vapor cloud 643 meters long extends beyond the neighboring plots. If ignited, the thermal radiation would have far reaching effects. If the plume only reached half that distance, it is still enough to intrude onto neighboring facilities owned by Hanjin Shipping Co., Fremont Forest Products and British Petroleum (The Port of Long Beach, 2004) (Figure 19). The potential for ignition sources and the flammability of products in the surrounding area are variables that could exacerbate any accidents. The proposed facility does have safety systems to ameliorate the effects of a serious spill during unloading operations, so a release reaching neighboring facilities is unlikely. The pumps have automatic release valves and the facility is equipped with an emergency shut down system that stops all transfer operations. Typically, both safety systems would be activated well before LNG is allowed to discharge for ten minutes. However if the break cannot be contained within 10 minutes, or if emergency shut down systems fail, the resulting accident has the potential to impact a much larger area and reach beyond the boundaries of the Port of Long Beach.

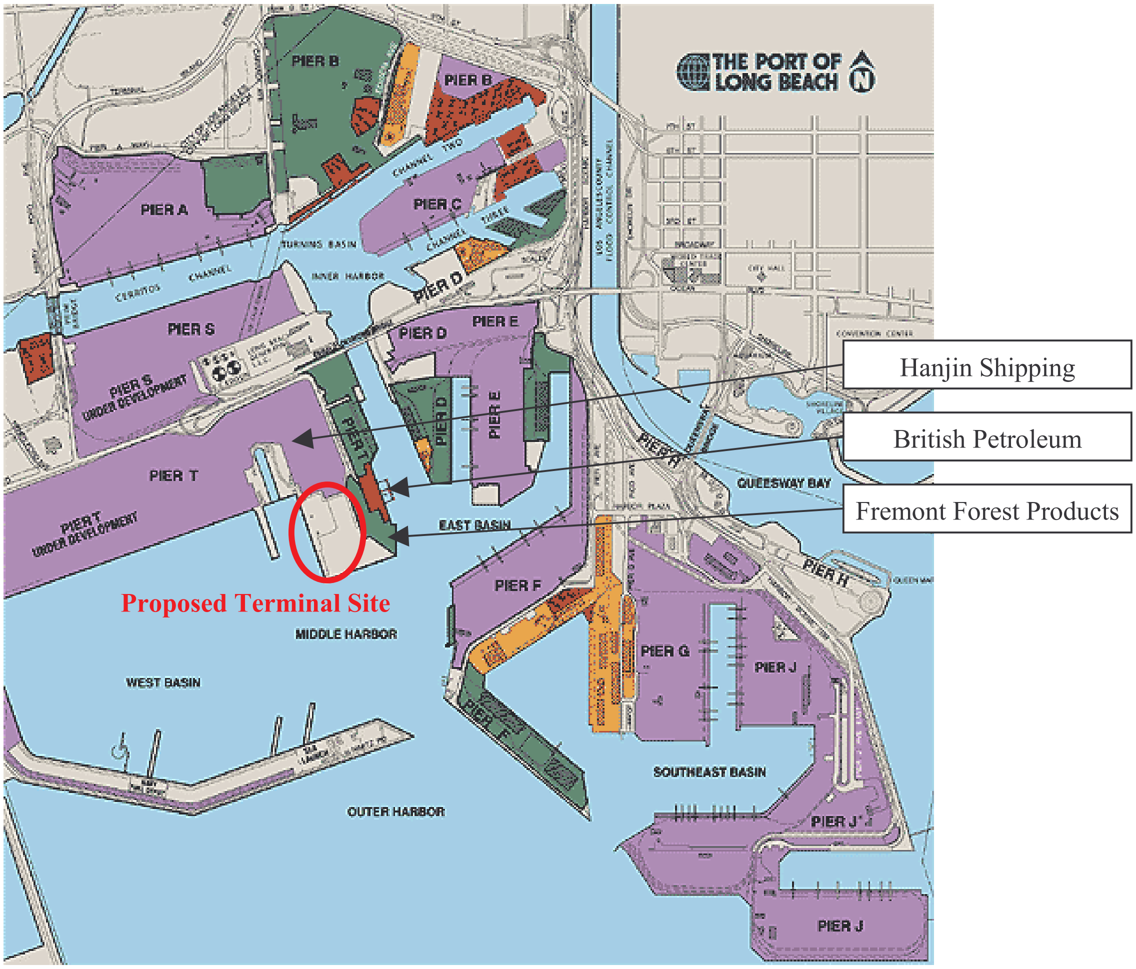

Figure 19 - Map of Proposed Onshore Terminal Site. *Source: Port of Long Beach*

Although this evaluation centers on unloading operations as the typical operational failure, tank failure is a special concern for onshore facilities due to a past accident in Cleveland, Ohio that killed 128 people. The accident was caused by a tank failure, attributed to inadequate storage tank construction (steel with a low nickel content (3.5%) for an inner tank and a carbon steel outer tank). Both of these materials are now recognized as incompatible with cryogenic temperatures (CH-IV International, 2002). The current onshore proposal uses storage tanks consisting of a cryogenic compatible steel inner tank and concrete outer tank. Both are designed to be able to hold the LNG independently (SES Resource Report 1, 2003). Technology has improved since the accident in 1944 and a repeat of this type of accident for the same reasons is very unlikely.

5.2.3 Maritime Accidents

Grounding is not likely assuming the Port of Long Beach regularly maintains the waterways, is aware of their depth clearance, and directs traffic accordingly. The Port of Long Beach is the second busiest port in the U.S. (The Port of Long Beach, 2004). Even though traffic is regulated, the increased number of vessels per area increases the likelihood of collisions and allisions.

Collision with a small ship is not expected to cause much damage to the facility or docked vessel, and spills during operations are within containment capabilities.

A larger ship with more mass could damage the loading platform, causing a temporary disruption of operations until the area is inspected for safety. It is assumed that a moderate accident of this type results in spillage of LNG onto water. A collision produces sparks that can ignite the gas and pose a threat to neighboring facilities. We assume the facility emergency system is able to control the spillage before the LNG spreads far enough to have impacts beyond the exclusion zone.

If a marine accident involving an LNG vessel resulted in the full release of a tank, the resulting impact could be devastating. A leading LNG expert (Jerry Havens) insists that a fire following the loss of LNG from a single carrier tank is enough to envelop the entire carrier, killing the crew. This type of fire is too hot for another vessel to approach in an attempt to tow it, and if it hits land or another vessel, the accident level would worsen (Raines and Finch, 2003). The proximity to other dangers is a key hazard for both causes and effects of accidents.

5.2.4 Natural Phenomena

Concrete tanks are very strong and the primary hazards are from earthquakes or terrorist bombs (LNG in Vallejo, 2003). The proposed facility is located near two documented active faults, the Palos Verdes and Newport-Inglewood (Figure 20). The interval between major ruptures on these faults is unknown; however the probable magnitude of an event is between 6.0-7.4 (SES Resource Report 6, 2003).

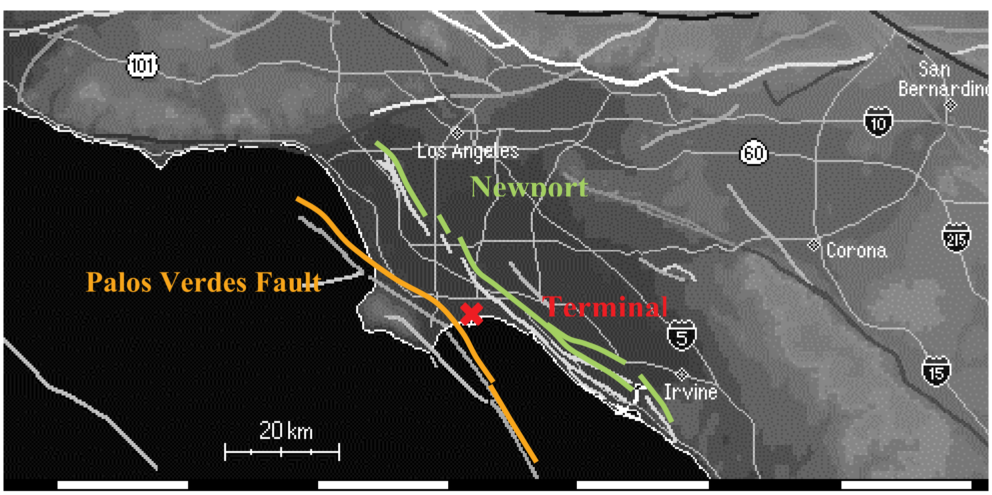

Figure 20 - Fault Lines in Vicinity of Proposed Onshore Terminal. *Source: Southern California Earthquake Data Center*

The likelihood of earthquakes is high due to the proximity of active faults. On February 10, 2004 a small earthquake of 1.9 magnitude occurred approximately 11 km (7 miles) from the terminal site (SCEDC). A small earthquake like this would have no impact on the facility, assuming it meets earthquake safety requirements.

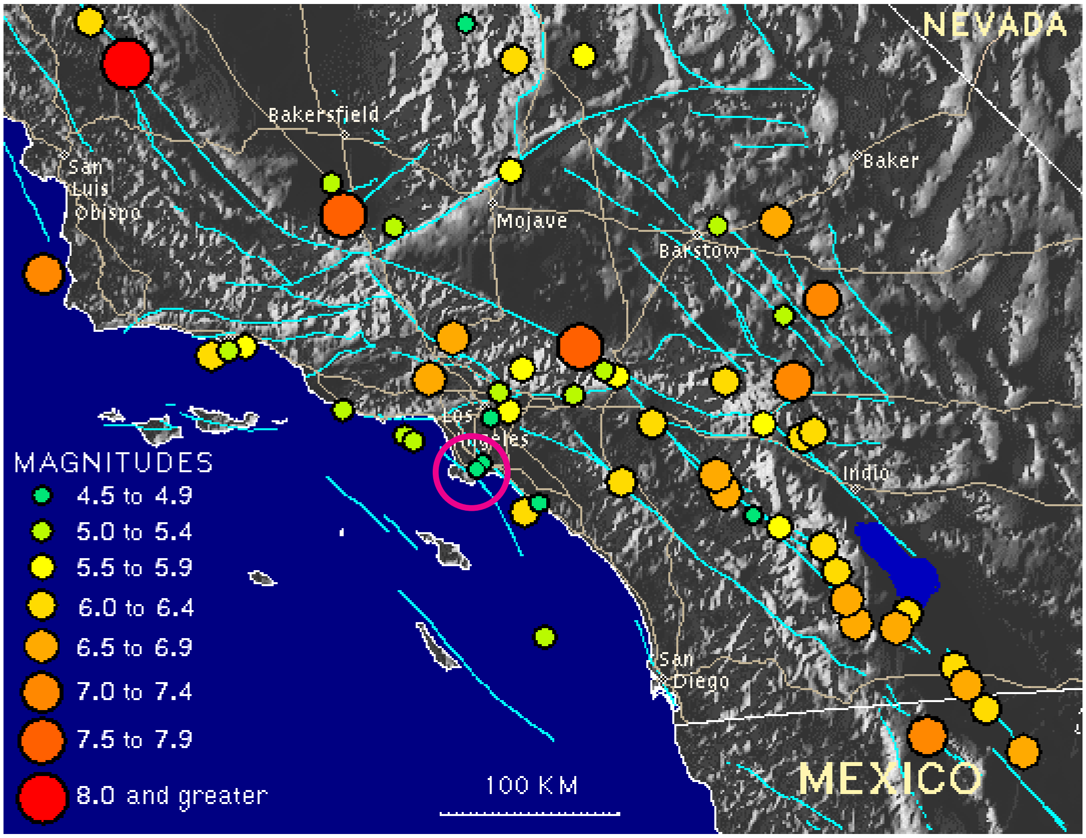

Figure 21 - Historic Earthquakes in Vicinity of Proposed Onshore Terminal. *Source: Southern California Earthquake Data Center*

In 1941, a pair of earthquakes occurred near the proposed terminal site (Figure 21). They both had magnitudes of 4.8 and Modified Mercalli Intensities of VII and VIII. Earthquakes of the same magnitude can be felt at different intensities due to differences such as population densities, making it difficult to estimate impact. The Mercalli scale is used to give a clearer picture of earthquake effects (Table 33). There were no injuries or fatalities reported during these quakes, in part due to the timing of the earthquakes (10:57 PM and 12:42 AM). However, an earthquake during working hours would undoubtedly increase the number injured.

Table 33 - Modified Mercalli Intensity Scale. *Source: University of Nevada Seismology Lab*

Modified Mercalli Intensity Scale	
I	People do not feel any Earth movement.
II	A few people might notice movement if they are at rest and/or on the upper floors of tall buildings.
III	Many people indoors feel movement. Hanging objects swing back and forth. People outdoors might not realize that an earthquake is occurring.
IV	Most people indoors feel movement. Hanging objects swing. Dishes, windows, and doors rattle. The earthquake feels like a heavy truck hitting the walls. A few people outdoors may feel movement. Parked cars rock.
V	Almost everyone feels movement. Sleeping people are awakened. Doors swing open or close. Dishes are broken. Pictures on the wall move. Small objects move or are turned over. Trees might shake. Liquids might spill out of open containers.
VI	Everyone feels movement. People have trouble walking. Objects fall from shelves. Pictures fall off walls. Furniture moves. Plaster in walls might crack. Trees and bushes shake. Damage is slight in poorly built buildings. No structural damage.
VII	People have difficulty standing. Drivers feel their cars shaking. Some furniture breaks. Loose bricks fall from buildings. Damage is slight to moderate in well-built buildings; considerable in poorly built buildings.
VIII	Drivers have trouble steering. Houses that are not bolted down might shift on their foundations. Tall structures such as towers and chimneys might twist and fall. Well-built buildings suffer slight damage. Poorly built structures suffer severe damage. Tree branches break. Hillsides might crack if the ground is wet. Water levels in wells might change.
IX	Well-built buildings suffer considerable damage. Houses that are not bolted down move off their foundations. Some underground pipes are broken. The ground cracks. Reservoirs suffer serious damage.
X	Most buildings and their foundations are destroyed. Some bridges are destroyed. Dams are seriously damaged. Large landslides occur. Water is thrown on the banks of canals, rivers, lakes. The ground cracks in large areas. Railroad tracks are bent slightly.
XI	Most buildings collapse. Some bridges are destroyed. Large cracks appear in the ground. Underground pipelines are destroyed. Railroad tracks are badly bent.
XII	Almost everything is destroyed. Objects are thrown into the air. The ground moves in waves or ripples. Large amounts of rock may move.

The proposed LNG storage tanks have secondary containment capabilities in case of damage to the primary tanks. Assuming sound construction and maintenance of the LNG storage tanks, seismic activity will not result in any spillage. A seismic disturbance may disrupt unloading operations and spill impacts, similar to a moderate accident due to operational failure, could occur.

The most pressing danger from a larger earthquake is the failure of both inner and outer LNG storage tanks. As designed in the proposed facility, these tanks are surrounded with a security barrier wall, approximately 6 meters (20 feet) high to restrict LNG movement in the case of a spill (SES Resource Report 1, 2003). However, it is not prudent to assume that the barrier wall would remain intact in an earthquake strong enough to break both tanks. There is no other containment measure mentioned in the general project description that could contain the spread of released LNG. Water barriers are often used in attempts to prevent vapor cloud migration in a certain direction. However, with the port and surrounding community being densely populated on all sides, this is probably not a solution, but instead a temporary aid. Without a containment dike, the spilled LNG may run into the harbor, rapidly increasing the evaporation rate and creating a much larger impact zone. With an uncontained accident in an industrial zone, which provides multiple ignition sources, the fire can reach beyond the Port of Long Beach and into the general population.

In addition, large earthquakes can generate tsunamis, which are characterized by low wave heights moving at high speeds and manifesting in shallow waters as rapidly rising water levels. Tsunamis travel at speeds over 320 km per hour (200 miles per hour) and if an earthquake on one of the above mentioned faults generated a tsunami, there could be insufficient time to clear the area (Entrix, 2003). A large change in water level might cause damage to the facility, collisions, or allisions if a vessel is docked at the facility.

5.2.5 Terrorism/Sabotage

As mentioned previously, terrorist bombs are a threat to LNG concrete tanks. A minor and moderate terrorism accident would have similar impacts as a moderate and major maritime accident, respectively. Again using the estimated impact zone of Koopman's study of a Boeing 747 aircraft flying into the facility to evaluate the impacts of a major terrorism accident, the results are catastrophic. The study gives a radius of 6,400 meters (4 miles) as the distance away that humans will develop skin blisters from the extreme heat of the fire created from Boeing 747 fuel and 1% of a 25,000m^3 tank (Table 34). A 6,400 meter radius encompasses all of the Port of Long Beach, major highways, and residential areas. The proposed facility has two 160,000m^3 tanks planned. The actual area of impact cannot be determined without computer modeling, but the distances will be substantially larger than Dr. Koopman's results.

Table 34 – Effects of 747 crash into LNG storage tank. *Source: Koopman, LNG Release Hazards*

	Distance to:		
	Skin Blister	2nd Degree Burn	3rd Degree Burn
747 Plane + Fuel	3600 meters (~2 miles)	2000 meters (~1 mile)	1500 meters (~1 mile)
747 Plane + Fuel + LNG	6400 meters (~4 miles)	3400 meters (~2 miles)	2600 meters (~1.5 miles)
* Numbers are only estimates of impact zone and should not be considered firm.			

From the various accident scenarios, it is clear that an onshore facility in a populated area has the potential for death and injury to the public. Being an energy related terminal, it is closely linked to industry and therefore economy. The specific location of this project is an additional risk since it is a large and active harbor. With high potential for human casualty, psychological stress, and economic damage, this facility can be considered a possible target.

5.2.6 Conclusions

Many dangers are specific to this particular location, and cannot be directly applied to another facility. Additional site-specific concerns include: Los Angeles Harbor, Long Beach Municipal Airport, Torrance Municipal Airport, and US Navy Fuel Depot. The facility is located near dense populations and other operations that may compound risk. This is one of the reasons that remote siting was encouraged in past LNG safety regulations (Powers, 2003).

5.3 Environmental Analysis

5.3.1 Introduction

This section focuses on the proposed onshore facility's impacts to the surrounding environment. Possible impacts to the following subcategories will be analyzed: benthic communities, pelagic communities, water quality, air quality, and terrestrial and freshwater biology. Environmental impact rankings for the proposed facility are outlined in the matrix below (Table 35). The matrix is followed by detailed explanations of said rankings.

Table 35 - Onshore Environmental Matrix

Environmental Effects	ONSHORE	construction	operation & maintenance	accidents			decommission
				minor - within facility	moderate - within exclusion zone	major - outside exclusion zone	
	benthic community	b-1	e-2	e-2	d-3	d-4	d-3
	pelagic community	c-3	d-2	e-4	d-3	d-4	e-3
	air quality	not evaluated	b-1	not evaluated	not evaluated	not evaluated	not evaluated
	terrestrial/freshwater biology	d-1	d-1	e-2	b-4	b-4	d-3

5.3.2 Benthic Communities

Pier T is located in what is considered the middle harbor (The Port of Long Beach, 2004) and supports a community somewhere between the sparse benthos within the inner harbor and the abundant and diverse benthos found on the outer harbor (SES Resource Report 3, 2003). The shoreline of Pier T East consists of a rocky substrate within the intertidal and subtidal zones. This substrate provides habitat for various epifauna that provide food to both shorebirds and subtidal fish. The middle harbor also supports a complex sediment profile (mixture of type and grain size) that contributes to a healthy infauna community.

Impacts from Construction

The greatest impact to the benthic community will occur during the construction phase of the proposed project. Both infauna and epifauna are significantly impacted through construction activities, particularly dredging. Infauna are eliminated by dredging, due to collection with dredged material and subsequent burial. The proposed project anticipates a 47-month construction period with plans to dredge 75,000–120,000 cubic yards of sediment (SES Resource Report 3, 2003). During this time, benthos will experience significant habitat disturbance and or destruction. It is estimated that resettlement of disturbed benthos (infauna particularly) can take over two years (SES Resource Report 3, 2003). In addition to habitat disturbance, dredging can suspend large amounts of fine sediments in the water column that can effectively smother benthos. Best management practices and requirements from POLB, RWQCB and Army Corps of Engineers will be implemented to minimize long-term impacts to the benthic community. However, based on the lengthy construction period and dredging requirements, impacts will be rated as significant and highly likely.

Impacts from Operations

Once the proposed project is constructed, day-to-day operations are not expected to significantly affect benthic communities. LNG tanker arrivals may disturb intertidal benthic communities through increased wave action, but it is likely that there will be no impact.

Impacts from Decommissioning

Decommissioning requirements of the proposed terminal are uncertain at this time. However, it is anticipated that decommissioning activities will occur primarily onshore. Should removal of the ship berth, bulkheads, or pier pilings be required, benthos would be affected, but the time frame and extent of this scenario is unknown. Therefore, based on currently available information, the impacts are deemed minimally important.

Impacts from Accidents

In the event of an LNG spill during carrier unloading, shallow, intertidal benthos could be impacted. Impacts only occur if the spill is large enough (moderate or major) to create an LNG pool on the water surface and the pool reaches the shoreline, thereby coming in direct contact with intertidal benthos. In addition, a low-lying vapor cloud resulting from a spill could cause asphyxiation of benthic organisms along the water line.

5.3.3 Pelagic Communities

Los Angeles – Long Beach Harbor provides habitats for a diverse number of fish species (Stephens, Terry et al., 1974). In addition, the harbor is considered a nursery area for several fish species (Horn and Hagner, 1982). Table 36 outlines the six most common fish species found in the Los-Angeles–Long Beach Harbor.

Table 36 - Representative Fish Species. *Source: SES, Draft Resource Report, No.3*

Common Name	*Scientific Name*	Comment
White croaker	*Genyonemus lineatus*	Occurs in more than 90% of harbor surveys
Queenfish	*Seriphus politus*	Occurs in more than 90% of harbor surveys
Northern Anchovy	*Engraulis mordax*	Pelagic schooling species, also common on open coast
Top Smelt	*Atherinops affinis*	Pelagic species, a prey of California least terns
Pacific Sardine	*Sardinops sagax*	Very abundant in harbor
Specklefin midshipman	*Porichthys myriaster*	Is found throughout the two harbor areas, especially abundant at night in the harbor

It is important to note that the POLB area is designated as Essential Fish Habitat (EFH) for two Fish Management Plans (FMP): the Coastal Pelagics and Pacific Groundfish Management Plans. Although 14 of the 86 species managed under these plans occur in the Los Angeles – Long

Beach harbors, NOAA Fisheries suggests that the proposed project will have no impact on the EFH (SES Resource Report 3, 2003). This determination is partially based on species occurrence and abundance within the harbor.

Table 37 lists federal and state special status species that are known to potentially occur in the proposed project area. While sea turtles are at risk world wide, they are seldom seen in the Southern California coastal area. The few that do migrate through coastal areas are infrequently seen in the POLB area (SES Resource Report 3, 2003).

Table 37 - Federal and State Listed Species Known to Potentially Inhabit Project Area. *Source: Sound Energy Solutions, Drafty Resource Report, No. 3*

Common Name	***Scientific Name***	**Status**
CA Brown Pelican	*Pelecanus occidentalis alifornicus*	F/S: E
CA Least Tern	*Sterna antillarum californicus*	F/S: E
American peregrine falcon	*Falco peregrinus anatum*	S: E
Western snowy plover	*Charadrius alexandrinus nivosus*	F: T
Steelhead	*Oncorhynchus mykiss*	F: E
Green sea turtle	*Chelonia mydas*	F: E
Olive Ridley sea turtle	*Lepidochelys olivacea*	F: T
Loggerhead sea turtle	*Caretta caretta*	F: T
Leatherback sea turtle	*Dermochelys coriacea*	F: T/E

F = Federal; S = State; E = Endangered; T = Threatened; SC = Special Concern

Impacts from Construction

During construction disturbances, most adult fish populations will move out of the area. A few burrowing fish species may be more severely impacted by dredging activities and a loss of larval northern anchovy is possible (SES Resource Report 3, 2003). In addition, the removal of pilings and bulkheads results in a short-term loss of habitat (2-3 years) for some FMP species. The loss is considered short term due to mitigation measures in the form of the addition of new pilings and additions to the bulkhead.

Marine mammals and reptiles within (or migrating through) the proposed project area are expected to practice avoidance during construction, due to increased noise and turbidity. Although pelagic species have the ability to practice avoidance, the construction impacts are considered important based on potential disturbances to FMP species habitats.

Impacts from Operations

As the main operations of the proposed terminal take place on shore, expected operational impacts to the pelagic community are minimal. The main impacts are derived from incoming LNG tankers into the POLB. As the Port is a heavily industrialized, high volume shipping area, the addition of LNG tanker traffic is not expected to significantly affect pelagic communities. However, the following scenarios below are impacts that could occur during operations.

Fuel or lubricating oils may spill from LNG tankers

As with any large tanker, fuel and oil spills or leakage is a possibility. As noted in the FSRU analysis, petroleum products have several adverse impacts to pelagic communities, especially marine mammals and turtles.

As stated in the FSRU analysis, a comprehensive facility contingency plan can help mitigate impacts to the environment resulting from a fuel or oil spill.

A Project Vessel could strike a marine mammal or turtle
Vessel strikes to marine mammals or turtles can cause injury and death. With the high volume of tanker traffic in the POLB area, the possibility of ship strikes must be considered. The possibilities will vary dependent upon seasons and marine mammal migration patterns. Such a strike would be considered a significant impact; however, the likelihood of a strike is reduced through trained personnel onboard vessels that are responsible for helping to prevent such strikes.

Impacts from Decommissioning

The proposed projects decommissioning requirements are unknown at this time. The majority of activity will take place onshore and therefore the impacts are considered neutral.

Impacts from Accidents

Should LNG spill from a loading arm during transfer to shore, the pelagic community could experience adverse effects. As the loading arms are designed with safety measures to prevent such accidents, the likelihood of a spill of this nature is very small. If systems fail and a large spill/leak occurs, the LNG will spill into the water between the tanker and dock. Methane is not considered toxic to the marine environment and the spilled LNG will evaporate quickly. If a sustained pool of LNG does form on the water surface, marine mammals or turtles may experience frostbite or be asphyxiated.

The majority of accident scenarios associated with the proposed facility occur onshore. Therefore, impacts to pelagic communities due to minor accidents are considered neutral and unlikely. Moderate and major accidents receive a higher impact rating, due to possible pooling of LNG on the water surface.

5.3.4 Air Quality

Impacts from Operations

The impacts of emissions from the onshore project were analyzed using the Gaussian-plume model as described in the Air Quality Methodologies. Ambient air quality standards for PM_{10} are already exceeded in Long Beach (SES Resource Report 9, 2003). Air quality impacts of the FSRU and platform projects were analyzed based on the concentration of air pollutants as they reached the shore. For the onshore facility, the proposed terminal is located at the shoreline. Therefore, instead of measuring the air quality at a specific distance from the project, this analysis examines the plume generated by project emissions, what the maximum pollutant concentrations are, and determines at what point from the project the plume becomes dissipated enough to be given an impact of minimally important. Emissions data for the onshore project is derived from the Sound Energy Solutions draft resource report on air and noise quality. Peak daily sources are used for calculating emissions from operations, LNG carriers, and assist vessels. The on-road vehicles associated with the onshore project, such as delivery trucks, LNG tank trucks, etc are not included in the air quality analysis.

Figures 22 through 26 show the likely concentrations of NO_2, SO2, PM_{10}, and CO as each pollutant moves downwind from the emission source. It appears that concentrations of NO_2, SO_2, and PM_{10} (Figures 23, 23, & 24) exceed their respective ambient air quality standards. Long Beach area currently exceeds air quality standards for PM_{10}. The concentrations of the air pollutants appear to return to more acceptable levels about 3 km from the source of emissions. If there is any type of population within three kilometers of the onshore project, it is likely that the project will need to invest in better air pollutant control technology.

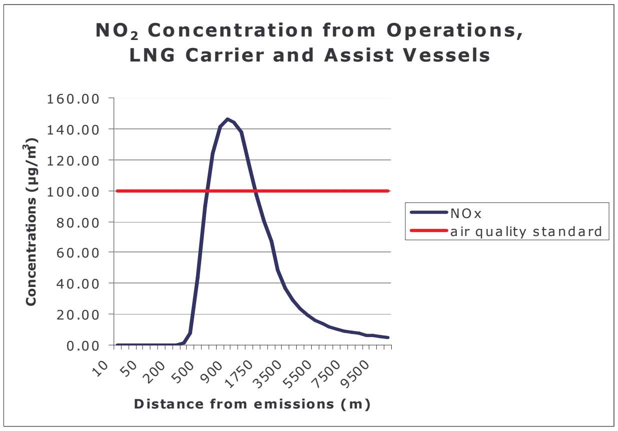

Figure 22 – NO_2 Concentrations

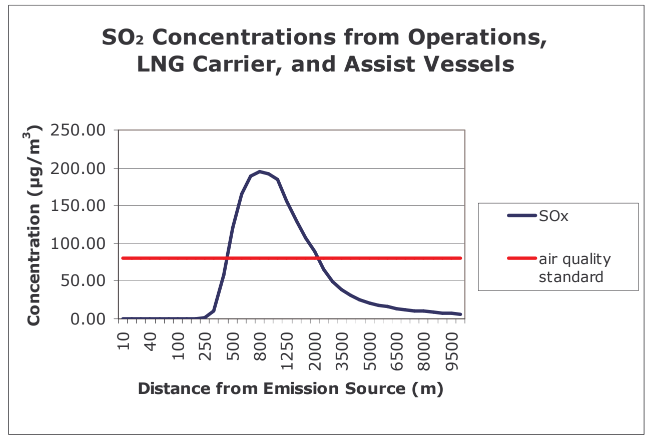

Figure 23 – SO_2 Concentrations

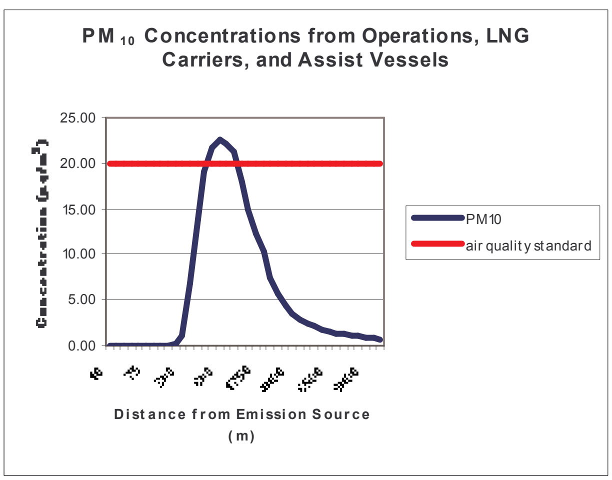

Figure 25 - PM_{10} Concentrations

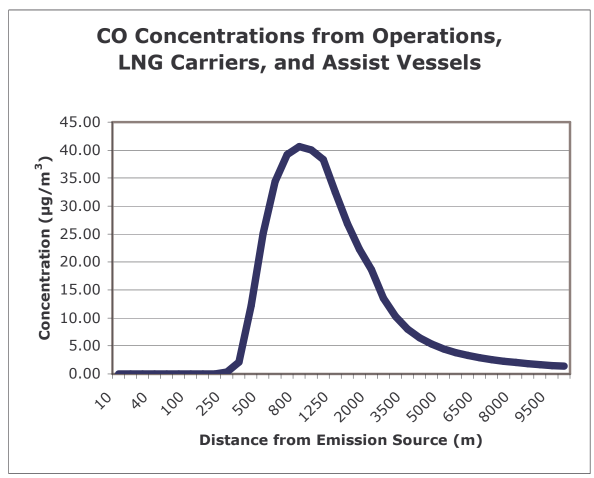

Figure 24 - CO Concentrations

5.3.5 Terrestrial and Freshwater Biology

Los Angeles and Long Beach Harbors cover an area that was once an estuary where the Los Angeles River and San Gabriel River emptied to the Pacific Ocean. Construction of the harbors began in 1908 (SES Resource Report 2, 2003). Since that time, an area that was once comprised of extensive sandbars, mudflats, and salt marsh habitats has become an area of concrete and steel. The highly developed nature of the POLB has eliminated much of the biological resources in the area.

The vegetation in the project area consists of ornamental plants and weeds. There is no Habitat Conservation Plan or Natural Community Conservation Plan designated for the biological resources within the project area (SES Resource Report 3, 2003). However, eelgrass and pickleweed, both species of concern, are located 1 mile northwest of the project site. In the Port of Los Angeles, there are eelgrass beds that range from 20 hectares (50 acres) in the spring to 40 hectares (100 acres) in the fall (MEC Analytical Systems, 2002).

Also found in the Port of Long Beach and the Port of Los Angeles are California brown pelicans. The Ports of Long Beach and Los Angeles Year 2000 Biological Baseline Study found that the California brown pelican accounted for 9.5% of the total bird observations. The peregrine falcon is also known to nest within the vicinity of the two ports. The baseline study also reports at least 500 nesting pairs of California least terns within the ports (MEC Analytical Systems, 2002).

There are no wetlands, private or public wells, or springs located in the project area (SES Resource Report 2, 2003). The project overlays the West Coast Sub-basin, which is part of the Los Angeles-Orange County Coastal Plain Aquifer System. The LA-Orange Co. Aquifer system extends approximately 2,200 square kilometers (860 square miles). The West Coast sub-Basin supplies Long Beach with 44% of its water and extends over an area of approximately 370 square kilometers (142 square miles). The project area, approximately 10 hectares (25 acres), covers only a small fraction of the total area of the West Coast sub-Basin. There are eight principle aquifers present in this sub-basin. Aquifers that underlie the project area include the Gaspur, Gardena/Gage, and Lynnwood/Silverado. There is a significant amount of seawater intrusion into the aquifers in the project area, because the area borders a marine interface. The shallowest of these aquifers is saline and is located 6.1 meters (20 feet) below ground surface (bgs) (SES Resource Report 2, 2003). The Gaspur aquifer, located between 18 – 24 meters (60 – 80 feet) bgs, is separated from the shallow aquifer by a dense layer of clay. Water from the Gaspur aquifer is used to pump into Wilmington oil field at depths of over 1200 meters (SES Resource Report 2, 2003).

Impacts from Construction

Construction of the project may require ground dewatering. Ground dewatering involves pumping ground water that could interfere with or be contaminated by construction activities. However, most of the project is constructed above the ground water table, so ground dewatering activities are expected to be limited. Any extracted groundwater is hauled to a municipal water treatment plant for treatment. All construction (except the tank foundations) is not expected to be deeper than 4.6 meters (15 feet) below ground surface (bgs) and should not require ground dewatering. Planned construction of the LNG tank takes place at a depth of 30 meters (100 feet bgs). It is expected that driven piles will be used to prevent cross contamination between the shallow saline aquifer and the Gaspur Aquifer. The project is expected to have no impact on the groundwater supply.

Avian species, including species of concern found in the project area, may be impacted through disruption of foraging habitat and by disruptive noise caused by the project. The disruption of foraging is expected to be temporary. Construction activities should not threaten the recovery of the brown pelican or the American peregrine falcon (SES Resource Report 3, 2003).

Because of the lack of biological resources in the highly developed area of the POLB, project construction is expected to have a less than significant impact on terrestrial vegetation or other terrestrial or freshwater biological resources. The magnitude of these impacts is considered minimally important.

Impacts from Operations

As proposed, the project directs storm water to existing drainage systems within the POLB. The operations of this project are not expected to have a significant impact on the terrestrial and freshwater biological resources in the area. A magnitude designation of minimally important is given to impacts from operations.

Impacts from Decommissioning

It is difficult to predict what POLB decommission requirements will be at the end of the project's lifespan. However, if current biological resources exist, it is likely that the impact will be minimally important unless decommissioning involves the permanent alteration of foraging habitats for listed species of concern.

Impacts from Accidents

A small accident, as defined by this analysis, is one that would be contained within the facility. As no sensitive terrestrial or freshwater biological resources are located within the immediate project vicinity, it is unlikely that a small accident will have any impact.

A moderate accident, as defined by this analysis, has impacts outside the POLB boundary. Within the POLB, nesting habitats and a significant population of brown pelicans and American peregrine falcons are found. If a moderate accident that included an LNG release and fire were to occur, it is likely that these birds would be burned or killed and their nesting habitats severely disrupted. Such a disruption is considered a significant impact to special status species located within the project area and therefore constitutes a magnitude ranking of severe.

A major accident, as defined by this analysis, has impacts that extend beyond the Port of Long Beach. As mentioned above, special status bird species located in the POLB and POLA would be significantly affected. The eelgrass, also considered special status, may also be significantly affected by fire. A magnitude ranking of severe is given, due to the significant effect on important terrestrial biological resources that may be expected from a major accident scenario.

5.3.6 Conclusions

Environmental analysis of the proposed onshore project is derived from resource reports generated by Sound Energy Solutions and the 2000 baseline study for the Ports of Long Beach and Los Angeles. Moderate and major accident scenarios, while not very likely, may have severe impacts on terrestrial biology. Construction activities are expected to severely impact localized benthic communities. However, anticipated impacts to biological resources including terrestrial, freshwater, and marine biology should be considered site specific, and results explored by this study should not be generalized to other onshore projects.

Air quality, as modeled by the simple Gaussian-plume model, appears to exceed air quality standards for SO_2 and NO_2, and PM_{10}. The results from the air quality analysis are probably the most important environmental impacts anticipated from the onshore project. Plumes return to less than significant levels approximately 3km from the source of emissions. The onshore project proposes to use grid power for its electricity needs; therefore peak air pollutant concentrations for the onshore project are lower than expected for both the platform and FSRU projects. However, the air quality impact is considered significant due to its proximity to shore.

5.4 Socioeconomic Analysis

5.4.1 Introduction

This section considers the impact of the onshore receiving terminal project on socioeconomic aspects. Six categories are evaluated throughout the life cycle of the project (construction, operations and maintenance, and decommissioning). Results of the collective socioeconomic rankings are illustrated within the matrix shown below (Table 38). A detailed explanation of these results follows.

Table 38 - Onshore Socioeconomic Matrix

	ONSHORE	construction	operation & maintenance	accidents			decommission
				minor - within facility	moderate - within exclusion zone	major - outside exclusion zone	
Socioeconomic Effects	population affected	b-1	b-3	not evaluated	not evaluated	not evaluated	b-2
	economy & employment	g-1	f-2	e-1	e-3	f-4	g-1
	property value	c-2	c-3	e-1	b-3	a-4	c-2
	housing	d-2	e-3	e-1	e-3	b-4	d-2
	public services	e-3	e-3	e-3	d-3	c-3	e-3
	traffic	b-1	c-2	c-1	b-3	a-4	b-2

5.4.2 Population Affected

State Analysis

The proposed onshore LNG terminal project is located within the City of Long Beach, within Los Angeles County. The population of California on April 1, 2000 was 33,871,648**.** The population of the County of Los Angeles was 9,519,338 and the City of Long Beach was 461,522 in 2000. California is the most populous state and ranks number twelve based on population density. It is assumed that any project proposed in California will affect more than the average population density nation wide (Table 39).

Table 39 - State Population Summary. *Source: U.S. Census Bureau 2000*

Average State Population	Average State Population Density	California Population	California Population Density
5,616,997	70.3 (182.2)	**33,871,648**	**83.9 (217.2)**

Population Density in persons/square kilometer or (persons/square mile)

County Analysis

Los Angeles County ranks number one in California based on total population, and third in population density. Los Angeles County exceeds the average county population by sixteen fold and average population density by nearly four fold. Los Angeles County has approximately 1,718 more people per square mile than the average county. Therefore, locating an LNG terminal in Los Angeles County will affect more than the average population, based on derived data.

Table 40 – County Population Summary. *Source: U.S. Census Bureau 2000*

Within California			
Average County Population	Average County Population Density	Los Angeles County Population	Los Angeles County Population Density
583,994	241.8 (626.2)	**9,519,338**	**905.1 (2,344.2)**

Population Density in persons/square kilometer or (persons/square mile)

City Analysis

City population data were analyzed for two hundred and seventeen of the states' most populated cities. Cities with less than 25,000 persons based on 2000 U.S. Census data are excluded.

Long Beach has the highest population density in Los Angeles County. The city is ranked twenty in overall population and fifty-five based on population density when compared to all other cities in the state. A project proposed within the City of Long Beach exceeds the average city total population by more than 312 percent and population density in excess of 63 percent.

Table 41 - City Population Summary. *Source: U.S. Census Bureau 2000*

Within California			
Average City Population	Average City Population Density	City of Long Beach Population	City of Long Beach Population Density
111,915	2,166.6 (5,611.5)	**461,522**	**3,535.6 (9,157.2)**

Population Density in persons/square kilometer or (persons/square mile)

Ranking Population

Based on aggregate population data, it is expected that the population surrounding a proposed project within the City of Long Beach will exceed state, county and city averages.

According to matrix ranking criteria, a project that is proposed in a moderately populated area that exceeds the state, county, or city average is assigned a severe rating with regard to population exposure. The onshore project is proposed in a state (California) that exceeds the average population density, a county (Los Angeles) that exceeds the average population density, and a city (Long Beach) that exceeds the average city population density by nearly 40 percent. The onshore project exceeds the average population density in all three of the categories examined, thus is rated as severe throughout the life cycle of the project.

Based on the proposed onshore project description, it is highly likely that the general population will experience some impacts due to the initial construction phase, yet significantly less likely during normal operation and decommissioning. It is assumed that upon the end of its useful life, the onshore project will require a moderate increase in activity due to the additional personnel and equipment necessary to remove the facility. For this reason, a slightly less significant rating of likely is used during decommissioning and neutral is assigned for normal operations.

5.4.3 Economy and Employment

The Long Beach receiving terminal is expected to employ an average of 669 workers during the 47-month construction phase. After construction, 60 employees are required for normal operations. According to the Resource Report submitted by Sound Energy Solutions, approximately 90 percent of the required workers will be local community members. Employment estimates are summarized in Table 42

Total immigration estimates are derived assuming a migration of 0.80 family members per non-local worker. Much like the initial construction phase, it is assumed that decommissioning entails a temporary increase in employment necessary for removal of the terminal. According to Sound Energy Solutions, the onshore terminal estimated annual labor cost during normal operations is expected to be $3.6 million. The project will generate a total payroll of $77.3 million during the 47-month construction phase. The project also contributes to the local revenue through purchases of construction goods and materials. The significance of this economic benefit has been determined by analyzing potential state, county, and local data.

Table 42 – Onshore Employment Estimates. *Source: Environmental Analysis, Sound Energy Solutions*

Activity	Total Estimate	Estimated Local Workers	Estimated Non-Local Workers	Estimated Family Members of Non-Local Workers*	Total Immigration (Non-Local + Family)
Pipeline & Construction	669	602	67	54	121
Operations and Maintenance	60	54	6	5	11
Total	**729**	**656**	**73**	**59**	**132**

California Analysis
According to the U.S. Department of Commerce, Bureau of Census (2000), the largest economic sectors in California are: (1) Education, health, and social services; (2) Manufacturing; (3) Professional, scientific, management, administrative, and waste management services. Management, professional, and related occupations are the largest employers in the state followed by, sales, office, and service occupations. Unemployment in the state during 2003 was 6.4 percent (State of California, 2003).

Los Angeles County Analysis
According to the U.S. Department of Commerce, Bureau of Census (2000) the largest economic sectors in LA County are the same as the states: (1) Education, health, and social services, (2) Manufacturing, (3) Professional, scientific, management, administrative, and waste management services. Occupational data for Los Angeles County is as follows: management, professional, and related occupations are the largest employers in the county followed by sales, office, production, transportation, and material moving.

Unemployment in Los Angeles County in December of 2003 was 6.1 percent (State of California, 2003).

City of Long Beach Analysis
The largest economic sectors in the City of Long Beach are the same as both California and Los Angeles County: (1) Education, health, and social services, (2) Manufacturing, (3) Professional, scientific, management, administrative, and waste management services. Management, professional, and related occupations are the largest employers with sales and office occupations second and service occupations third.

Unemployment in the City of Long Beach during 2002 was 6.3 percent (State of California, 2003).

City of Los Angeles Analysis
Our analysis includes data for the City of Los Angles due to its close proximity to the onshore LNG terminal. The population of the City of Los Angeles, in 2000, was 3,694,820. The largest economic sectors in the City of Los Angeles are the same as for California, Los Angeles County and the City of Long Beach: (1) Education, health, and social services, (2) Manufacturing, (3) Professional, scientific, management, administrative, and waste management services. Top

occupations in the City of Los Angeles match California and Long Beach. Management, professional, and related occupations are the largest employers with sales and office occupations second and service occupations third.

Unemployment in the City of Los Angeles during 2002 was 7.7 percent (State of California, 2003).

Ranking Economy and Employment

Economic and employment benefits are rated according to significance to local population. Projects that create a noticeable impact on the local unemployment rates and/or economic community receive a beneficial ranking (higher than neutral). According to 2000 census data, there are an estimated 306,450 workers employed in construction/extraction and maintenance occupations in Los Angeles County which represents about 3.1 percent of the total employment in the County (Table 43). In 2000, there were an estimated 202,829 jobs within the construction economic sector of the County (Table 44). During the construction phase, the proposed onshore project adds an estimated 602 jobs to the local workforce, which accounts for roughly 0.3 percent of the county employment and 6 percent of the Long Beach City employment. Based on this information, the County of Los Angeles will not realize a significant boost to the economy or employment due to the construction phase of the project. However, a 6 percent increase in overall employment for the City of Long Beach construction sector is significant. Normal operations employ 60 people, of which 54 are assumed to come from the local residence. Normal operations as a result of the onshore terminal will only contribute 0.5 percent to the local work force. Based on this analysis, the onshore terminal proves beneficial to the local economy and employment during the construction/decommissioning phase and is rated beneficial. Although economic and employment benefits are expected during normal operations they appear to be of minimal benefit to the community, thus raked accordingly.

Table 43 – Occupational Employment Summary. *Source: U.S. Department of Commerce, Bureau of Census (2000)*

Occupation	California		Los Angeles County		City of Los Angeles		City of Long Beach	
	Employed	%	Employed	%	Employed	%	Employed	%
Management, professional, and related occupations	5,295,069	36.0	1,355,973	34.3	524,440	34.2	65,060	34.3
Service occupations	2,173,874	14.8	580,809	14.7	245,498	16	30,019	15.8
Sales and office occupations	3,939,383	26.8	1,090,059	27.6	409,696	26.7	51,516	27.2
Farming, fishing, and forestry occupations	196,695	1.3	6,650	0.2	2,511	0.2	276	0.1
Construction, extraction, and maintenance occupations	1,239,160	8.4	306,450	7.8	117,561	7.7	14,649	7.7
Production, transportation, and material moving occupations	1,874,747	12.7	613,474	15.5	232,368	15.2	27,967	14.8
Total	**14,718,928**	**100**	**3,953,415**	**100.1**	**1,532,074**	**100**	**189,487**	**100**

Table 44 - Industry Employment Summary. *Source: U.S. Department of Commerce, Bureau of Census (2000)*

Economic Sector	California		Los Angeles County		City of Los Angeles		City of Long Beach	
	Employed	%	Employed	%	Employed	%	Employed	%
Agriculture, forestry, fishing & hunting, & mining	282,717	1.9	10,180	0.3	3,158	0.2	748	0.4
Construction	915,023	6.2	202,829	5.1	81,032	5.3	9,627	5.1
Manufacturing	1,930,141	13.1	586,627	14.8	202,277	13.2	27,248	14.4
Wholesale trade	596,309	4.1	184,369	4.7	60,691	4	8,675	4.6
Retail trade	1,641,243	11.2	416,390	10.5	158,118	10.3	19,445	10.3
Transportation & warehousing, & utilities	689,387	4.7	198,375	5	60,867	4	12,578	6.6
Information	577,463	3.9	213,589	5.4	107,285	7	6,173	3.3
Finance, insurance real estate & leasing	1,016,916	6.9	272,304	6.9	108,032	7.1	11,246	5.9
Professional, scientific, management, administrative, & waste management services	1,711,625	11.6	455,069	11.5	197,876	12.9	20,240	10.7
Educational, health & social services	2,723,928	18.5	722,792	18.3	265,613	17.3	39,982	21.1
Arts, entertainment, recreation, accommodation & food services	1,204,211	8.2	332,753	8.4	147,462	9.6	16,272	8.6
Other services (except public administration)	761,154	5.2	233,193	5.9	105,037	6.9	10,192	5.4
Public administration	668,811	4.5	124,937	3.2	34,626	2.3	7,061	3.7
Total	14,718,928	100	3,953,407	100	1,532,074	100	189,487	100

Economic and employment numbers can be dramatically different in the event of an accident. It is anticipated that a minor LNG accident, defined as one that occurs within the boundaries of the facility, will have no noticeable impact to economy and employment, or a magnitude of neutral. A moderate accident within the perimeter of the exclusion zone (approximately 10.92 hectares or 27 acres) is assumed to have slightly more significance but is still rated neutral. A major accident beyond the perimeter of the exclusion zone could theoretically cause a temporary but significant boost in economy and employment if a large influx of non-local personnel were to respond. For this reason, a major event, as it relates to economy and employment, is also ranked minimally beneficial.

5.4.4 Property Value

The proposed Long Beach LNG receiving terminal is located in Los Angeles County. The LNG terminal site is located within the boundaries of the City of Long Beach. This facility is also within the jurisdiction of the Port of Long Beach (POLB), a department within the City of Long Beach. The POLB has its own master plan for the city port under its jurisdiction, as required by the California Coastal Act (CCA). The CCA established the California Coastal Commission (CCC) by voter initiative in 1972 (Proposition 20) and was made permanent by the Legislature in

1976. The Commission is one of California's two designated coastal management agencies for the purpose of administering the federal Coastal Zone Management Act (CZMA) in California.

Proposed Property Use

The proposed onshore project is located on a 27-acre site on the eastern portion of Pier T (Pier T East) of the former naval shipyard property that was transferred to the POLB. The onshore LNG receiving terminal includes: an offloading dock, two 160,000m^3 (1 million barrel) capacity LNG storage tanks, vaporization facilities, a natural gas liquids recovery unit, and a truck loading facility. Associate facilities include approximately 4 km (2.3 miles) of 91 cm (36 inch) pipeline that will deliver natural gas to an existing pipeline system of Southern California Gas Company (SoCalGas) and 1.28 km (0.8 mile) of electrical distribution lines to connect the LNG terminal to the existing Southern California Edison (SoCal Edison) system. The pipeline and associate electrical distribution is not part of our analysis (SES Resource Report 1, 2003).

Adherence to the General Plan

Chapter 3 of the CCA lists the six coastal resources planning and management policies that are used to evaluate a proposed project's consistency with the CCA: 1) maximizing access to California's coast, 2) protecting water-oriented recreational activities, 3) maintaining, enhancing, and restoring California's marine environment, 4) protecting sensitive habitats and agricultural uses, 5) minimizing environmental and aesthetic impacts of new development, and 6) locating coastal-dependant industrial facilities within existing sites whenever possible. Chapter 8 of the CCA recognizes ports, including the port of Long Beach, as primary economic and coastal resource and as essential elements of the national maritime industry. However, the POLB was required to prepare a port management plan (PMP), for approval by the Coastal Commission that outlined how the port planned to comply with the general policies of the CCA.

The POLB submitted its PMP in June 1978. The Coastal Commission certified the PMP in October 1978, subject to submission of a revised plan for re-certification within 5 years, and a risk management plan for assessing hazardous risks. Since that time, there have been a total of 18 amendments to the PMP that have been submitted to and approved by the Coastal Commission. Projects that are approved by the POLB under its PMP are explicitly considered to be consistent with the CCA (Article 3 Implementation; Master Plan) for federal permitting purposes under Section 30719 of the California Code (§30719) (SES Resource Report 1, 2003).

The Project is located within the POLB's Terminal Island Planning District 4 . The POLB's PMP addresses environmental, recreational, economic, and cargo-related concerns within the port, and has been certified by the Coastal Commission. Permitted uses within the POLB District 4 include hazardous cargo facilities that are defined as" operations and terminals engaged in the loading/unloading, storage and transfer of crude and bulk refined petroleum products and chemicals with a National Fire Protection Association (NFPA) rating of 2 or greater" (SES Resource Report 1, 2003). The NFPA rating is a system for indicating the health, flammability, and reactivity hazards of chemicals, also known as the NFPA Diamond.

Hazards are classified by NFPA ratings, ranging from 0 to 4. NFPA flammability rating of 0 is defined as not combustible and NFPA 4 is defined as flammable gas or extremely flammable liquid as defined in Table 45. LNG has an NFPA flammability rating of 4, and is not classified as a bulk refined petroleum product. Accordingly, the POLB will submit a PMP amendment for the proposed project to the Coastal Commission for review and certification (SES Resource Report 1, 2003).

Table 45 - NFPA Flammability Definition. *Source: Office of Radiation, Chemical & Biological Safety*

Flammability (Red)		
4	**Danger**	Flammable gas or extremely flammable liquid
3	**Warning**	Flammable liquid flash point below 100° F
2	**Caution**	Combustible liquid flash point of 100° to 200° F
1		Combustible if heated
0		Not combustible

Ranking Property Value

According to the POLB management plan, the onshore project is zoned industrial yet will require amendments to the PMP. Based on this fact, some impact to land use plan consistency is expected. For this reason, the onshore project's effect on property value will be ranked important throughout the life cycle of the project.

It is anticipated that a minor LNG accident, defined as a spill that occurs within the boundaries of the facility, will have no noticeable impact to property value, or a magnitude of neutral. A moderate LNG release, which stays within the perimeter of the exclusion zone (approximately 10.92 ha - 27 acres), is assumed to have more significance based on the proximity to port operations and passing vessels, thus will be rated severe. A major LNG release, assuming impacts beyond the perimeter of the exclusion zone, is classified as catastrophic.

5.4.5 Housing

The onshore receiving terminal is expected to employ an average of 669 workers during the construction phase and 60 during normal operations. It is estimated that 90 percent of the employed will come from the local community. This represents approximately 67 non-local workers who are expected to migrate to the area temporarily during the construction phase and 6 permanent workers during normal operations. Including family members, total migration estimates are expected to be 121 workers during construction and 11 workers during normal operations (SES Resource Report 5, 2003). All of these workers will require housing.

Local Vacancy Rates

Housing Occupancy data is obtained from the U.S. Census Bureau (2000). Vacancy rate calculations are made based on occupied housing and vacant housing units available for Los Angeles County, the City of Los Angeles and Long Beach. For comparison, California homeowner vacancy rates are included in the analysis.

Results show Los Angeles County and the City of Los Angeles to have near equivalent vacancy rates when compared to California averages (Table 46). Homeowner vacancy rates are slightly more than the state average while rental vacancy rates are slightly less. Both homeowner and rental vacancy rates within the City of Long Beach are significantly greater than the county and state average.

Table 46 - Housing Occupancy. *Source: U.S. Census Bureau 2000*

HOUSING OCCUPANCY	California	Los Angels County	City of Long Beach	City of Los Angeles
Occupied housing units	11,502,870	3,133,774	163,088	1,275,412
Vacant housing units	711,679	137,135	8,544	62,294
For seasonal, recreational, or occasional use	236,857	13,565	761	4,876
Total housing units	**12,214,549**	**3,284,474**	**172,393**	**1,342,582**
Homeowner vacancy rate (percent)	1.4	1.6	2.2	1.8
Rental vacancy rate (percent)	**3.7**	**3.3**	**4.2**	**3.5**

Ranking Housing

Although the City of Long Beach exhibits a greater availability of public housing compared to the average state, county, and city levels, rates are significantly lower than 10 percent, which is normally considered sufficient to accommodate housing for tourists, non-local workers, and other visitors. In accordance with our matrix ranking criteria housing availability is ranked minimally important (a minor detriment to society) through the construction and abandonment phases of the project life cycle with a neutral rank given during normal operations. This is the same housing magnitude ranking assigned to the FSRU project. However, the onshore project will need to accommodate a larger migrant work force during all phases of the project.

A total of 8,544 vacant housing units are available in the City of Long Beach (2000). If 67 additional families were to migrate to the area during construction of the onshore terminal they would absorb less than 1 percent of the available housing, which is not considered significant. Additionally, only 6 non-local workers are expected to migrate to the area during normal operations, which represents less than 0.1 percent of available housing.

Based on this analysis, it is assumed local housing availability will experience a slight strain during initial construction and decommissioning phase, yet significantly less during normal operation. Magnitude ranking with regard to construction and decommissioning is minimally important with a likely occurrence. A rating of neutral is used during normal operations with a neutral likelihood.

Housing availability could change in the event of an accident. It is anticipated that a minor LNG accident, defined as one that occurs within the boundaries of the facility, will have no noticeable impact to local housing, or a magnitude of neutral. A moderate accident within the perimeter of the exclusion zone (approximately 10.92 ha - 27 acres) is assumed to have slightly more significance but is still rated neutral. In the event of a major LNG accident, which affects areas outside the exclusion zone, a potential influx of response personnel and news crews are expected, which could cause a temporary drain on housing availability. Given this scenario, a major accident is ranked as severe.

Ranking Public Services

Long Beach has a well-developed infrastructure to provide health, police, fire, emergency, and social services near the proposed onshore site. The workforce is expected to be small relative to the current population of the area. Construction, operations, and maintenance of the terminal and piping are expected to have minor, temporary, or no impact on local community facilities and services.

During the normal life cycle of the onshore project, local emergency medical services may be necessary to treat injuries as a result of work site accidents. This demand is not expected to strain public services, thus magnitude and likelihood ranking is neutral for all phases of the project. However, public services may experience additional demand in the event of an accident. For this purpose the proposed onshore project receives a progressively increased magnitude of significance based on severity of the LNG accident. In the case of a minor LNG accident, contained within the facility, no drain on public services is expected, thus a neutral ranking is assigned. A moderate LNG accident, within the facility exclusion zone, is defined as minimally important and a major LNG accident outside the exclusion zone is important.

5.4.6 Traffic

Building and operating an onshore terminal is expected to increase both congestion on access roads in route to the onshore receiving terminal and traffic within the port. Most of this increase is expected to occur during initial construction activities. The influx of construction equipment, materials, and personnel to the project area can result in traffic congestion, roadside-parking hazards, and less capacity at the project site.

Roadway Traffic

A network of freeway and surface streets provide access to the LNG terminal site. Personnel, supplies, and equipment will most likely take the San Diego Freeway (I-405), the main thoroughfare on the west coast, to the Long Beach Freeway (I-710). Typical directions are as follows:

To Port of Long Beach from North or South

- On San Diego Freeway (I-405)
- Exit I-405 at Long Beach Freeway (I-710) and go south to West Ocean Blvd.
- West Ocean Blvd to West Seaside Blvd.
- West Seaside Blvd becomes Pier T Avenue

Table 47 – Annual Average Daily Traffic (AADT) volumes related to the onshore project. *Source: CalTrans http://www.ventura.org/vcpwa/transportation/traffic.htm#volume*

	AADT	A.M. Peak LOS	P.M. Peak LOS
Hwy 405 jct with route I-710 (s/b)	283,000	N/A	N/A
Hwy 405 jct with route I-710 (n/b)	279,000	N/A	N/A
Hwy 710 jct with West Ocean Blvd. (e/b)	66,000	D	D
Hwy 710 jct with West Ocean Blvd. (w/b)	54,000	E	E
West Ocean with Henry Ford Ave (w/b)	1,807	F	F
West Ocean with Henry Ford Ave (e/b)	2,618	F	F

Significant, short-term traffic increases are expected during the initial construction of the onshore receiving terminal. Passenger and semi-truck traffic is expected to increase, due to the delivery of personnel, supplies, and construction materials. Based on the 669 estimated workers needed for the construction phase, approximately 515 additional passenger vehicles (1.3 persons/vehicle) are expected to access the Port of Long Beach during the 47-month period.

This figure is conservative, and does not account for the increase in semi-truck traffic required to support the construction.

Additionally, once the receiving terminal is built, approximately 60 full time workers will access the port during normal operations. Using the same criteria, approximately 46 additional passenger cars are expected to access the area. An undetermined increase in semi-truck traffic is expected due to additional sales of LNG, natural gas, propane, and ethane, which will be trucked from the onshore facility. Similarly, it is anticipated that supplies of nitrogen, diesel fuel, and mercaptans (which is the odorant added to gas as a safety precaution) will be delivered into the port during normal operations. According to the Level of Service (LOS) ratings of the main intersections in route to the POLB, the proposed onshore project will have a significant impact on vehicular traffic. Nearly all of the main thoroughfares have LOS ratings of D (defined as FAIR and having delays) or below, which indicate the port traffic already experiences significant delays and congestion. An LOS rating of C or better is considered an acceptable level of service.

Marine Traffic

Marine traffic is analyzed by determining the estimated vessel traffic necessary during the construction, normal operations, and abandonment phase of an LNG terminal project. This data is compared to the normal port traffic and rated according to significance. In part, ranking criteria for port traffic is derived from personal interviews with the POLB Authority.

In 2002, there were an estimated 3,000 ship entries into the Port of Long Beach. Annual ship movements within the port during that time exceed 6,300. This equates to an average of 8 ship entries, and 16 in port movements each day. According to John Strong with Jacobs Pilot Service, which services the Port of Long Beach, the majority of movements are completed in less than 2 hours. The POLB has plans to expand ship entries from 5,200 to 7,600 by 2020 (SES Resource Report 1, 2003).

The project is estimated to increase ship entries by 70 LNG carrier entries per year, or approximately one carrier every 5 days. In port movements are expected to be 140 each year or less than one movement every 3 days. Minor delays within the port may occur as a result of a United States Coast Guard (USCG) required security zone, 100 yards ahead and 500 yards astern of arriving LNG carriers. According to this analysis, the POLB will experience a 2 percent increase in port entries, and a 4 percent increase of in port movements as a result of the proposed terminal. Given the port expansion plan to increase ship entries by 2,400, the increase of entries as a result of the onshore project accounts for less than 1 percent of the total port traffic.

Ranking Traffic

Results indicate that LNG carrier traffic will have little effect during the life cycle of the onshore project. Thus magnitude rating for these criteria reflects vehicular traffic only. Due to the low LOS ratings of the primary routes heading into the Port, vehicle traffic is expected to be significant. For this reason, magnitude ranking during the construction and decommissioning phase will be severe and during normal operations important. Similarly, the construction phase is highly likely to impact traffic conditions while normal operations and decommissioning are likely to cause an impact. The rationale for reducing the magnitude during normal operations is due to the current plans for a new interchange at Ocean Boulevard and Terminal Island Freeway. The new interchange is expected to improve the LOS for about 10 years.

Traffic congestion both onshore and in the port may experience additional demand in the event of an accident. Therefore the proposed onshore project will receive a progressively increased magnitude of significance based on severity of the LNG accident. In the case of a minor LNG accident contained within the facility, no additional drain is expected on traffic capacity beyond normal operations, and is assigned an important ranking. A moderate LNG accident within the exclusion zone is defined as severe and a major LNG accident outside the exclusion zone is catastrophic.

5.4.7 Conclusions

Like the FSRU project, economy and employment sectors represent the only socioeconomic category that appears to benefit as a result of building the terminal. Due to its large scale and use of local work force, the onshore project should significantly benefit the local economy.

The proposed onshore project has the potential to affect a much larger population than projects located away from population centers. As a result, the population affected category receives severe rankings throughout the life cycle of the project.

Similarly, vehicular traffic flows in and around the Long Beach terminal are already experiencing very low levels of service. A project that adds to the congestion of access roads heading in and out of the terminal will certainly create detrimental effects on existing traffic flow.

Although less likely and temporary in nature, it is expected that a moderate to major accident could compound existing traffic problems due to the influx of media and emergency response personnel.

5.5 General Onshore Terminal Conclusions

Community safety analysis shows that the proposed onshore facility’s location (near dense populations and other port operations) may compound safety risks to the community. Significant impacts to the environment may occur in the form of decreased air quality. Air quality modeling shows ambient air quality standards were exceeded for three criteria pollutants. In addition, terrestrial and freshwater biology may be seriously impacted in the case of a moderate or major accident. Analysis shows that the local economy/employment sectors should significantly benefit from the proposed terminal. However, the facility could adversely impact local traffic.

6 PLATFORM TERMINAL

6.1 Terminal Description

The proposed conversion of Platform Grace will be the first LNG receiving terminal of its kind.

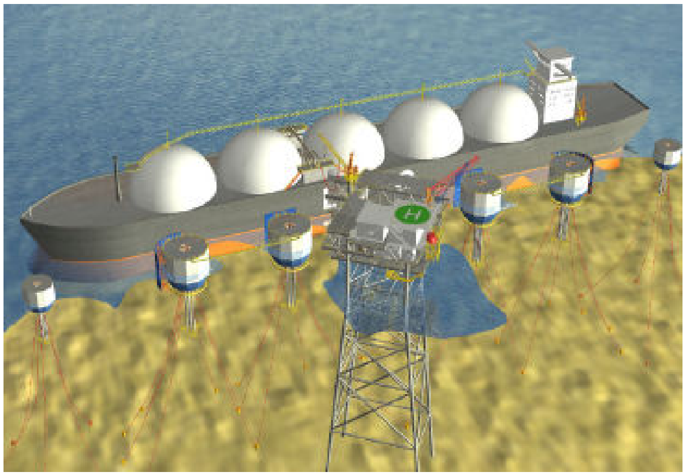

Figure 26 - Artist Rendition of Platform Facility. *Source: Crystal Energy CSLC Application Supplement*

Platform Grace is located in the Santa Barbara Channel at 34° 10' 47" N, 119° 28' 05" W, approximately 20 km (13 miles) west of Oxnard and 18 km (11 miles) off the coast of Ventura, CA (Figure 28). The Clearwater Port Deepwater Port application has recently been submitted by Crystal Energy, so all assumptions are based on information gained from various application documents and preliminary project descriptions.

Initial platform conversion costs are estimated at $200 million. Construction of the proposed facility is anticipated to take approximately one year to construct the mooring system, an additional 6-11 months for equipment upgrades and regasification equipment installation, and approximately 30 days for pipeline construction. The proposed throughput capacity of the facility is 800,000 mmcfd. Offshore platforms historically have an exclusion zone of 500 meters, but this analysis will assume a 1 nautical mile (1852 meters) exclusion zone to account for the presence of LNG carriers. Additional specifics of the proposed terminal are listed in Table 48.

Figure 27 - Platform Grace. *Source: Minerals Management Service*

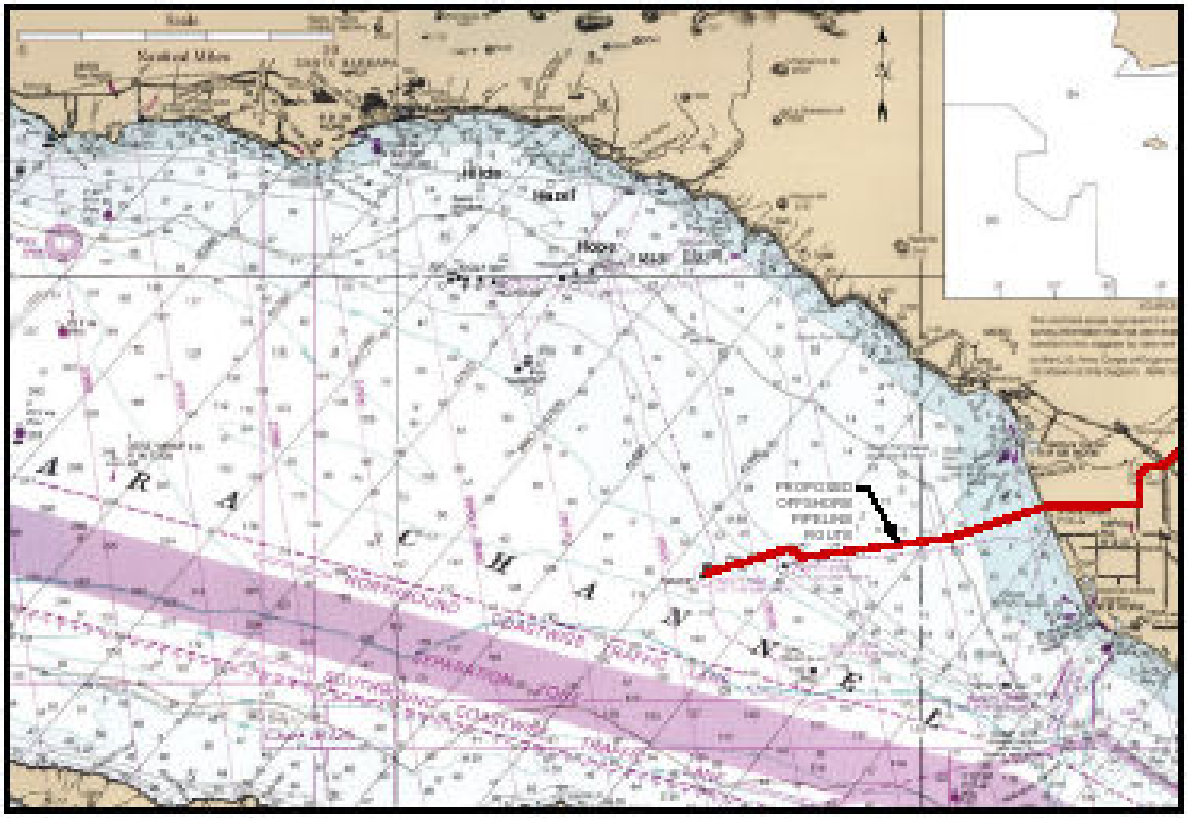

Figure 28 - Proposed Platform Project Site. *Source: Crystal Energy CSLC Application Supplement*

Table 48 - Platform Terminal Description. *Source: Crystal Energy*

Terminal Description – Converted Platform Facility	
Location	34° 10' 47" N, 119° 28' 05" W; Platform Grace in the Santa Barbara Channel; 18 km (11 miles) off the coast of Ventura & 20.9 km (13 miles) west of Oxnard.
Facility design life	50-100 years
Construction	Conversion of an existing platform Retrofitting the existing crane with LNG transfer system; SSP Floating Dock & Mooring system
Carrier berthing	Maximum of 80 per year; 2.5-3.5 days to regasify one tanker load.
Carrier size range	70,000-160,000 m^3 capacity
Transfer rate	26,498 liters (7000 gallons) LNG per minute.
Tank type	No LNG storage tank; One tank for onboard fuel use
# of storage tanks	None.
Storage capacity	None.
# of loading arms	1, no vapor return system.
Throughput capacity	Six gas sendout pumps; annual average of 800,000 million cubic feet per day. Facility can only regas when an LNG vessel is docked to supply LNG. Five pumps required for design rate of 1.05 billion cubic feet per day, max of 1.2 billion cubic feet per day.
Regasification method	SCV; Regassified gas enters pipeline directly without any gas conditioning. Regas method produces up to 151 million liters (40 million gallons) of water per year.
Fire protection system	Seawater pumps for firefighting; Foam and carbon dioxide fire protection systems.
Pipeline	58 km(36 miles) of a 82 cm (32 inch) diameter steel pipeline for gas sendout; 21 km (13 miles) subsea & 21 km terrestrial to tie-in. 29 km (18 miles) of a 15 cm (6 inch) diameter HDPE pipe for water to city of Oxnard.
Personnel	12 man crew.
Exclusion Zone	Not specified. Assumed to be 1 nautical mile
Flare System	Used for hydrocarbon disposal during normal operations, maintenance, startup and shutdown.

6.2 Community Safety Analysis

6.2.1 Introduction

As stated previously, the proposed converted platform LNG terminal is the first of its kind. An application was recently submitted to the State Lands Commission and included supplemental information about the proposed terminal. This preliminary project description is used to set evaluation boundaries for this analysis. It should be emphasized that this is an incomplete description of the terminal and the final project specifications will address important aspects that are not currently covered in the project description. Like the onshore terminal, safety modeling results have not yet been produced by project developers. Evaluations are based on data extrapolated from other sources. For the purposes of this evaluation, the exclusion zone is assumed to be 1 nautical mile (1852 meters).

Table 49 - Platform Community Safety Matrix

Community Safety Effects	PLATFORM	construction	operation & maintenance	accidents			decommission
				minor - within facility	moderate - within exclusion zone	major - outside exclusion zone	
	operational failure	not evaluated	not evaluated	c-1	c-2	c-4	not evaluated
	maritime accidents	not evaluated	not evaluated	e-2	c-3	b-4	not evaluated
	natural phenomena	not evaluated	not evaluated	e-2	c-2	b-3	not evaluated
	terrorism/sabotage	not evaluated	not evaluated	c-4	b-4	a-4	not evaluated

6.2.2 Operational Failure

For cargo unloading, LNG carriers are required to remain hooked up to the platform until the cargo tanks are nearly empty. This requirement is based on a lack of storage capacity on the facility as well as wave forces that can damage partially filled vessel cargo holds. The project developers estimate a time of 2.5-3.5 days to unload a vessel. Chances of operational failure increase the longer the vessel is docked and transferring LNG.

According to the project application, an existing platform crane is used to transfer LNG from carriers to the platform for regasification. Specific plans for the loading system are not yet outlined, but only one transfer pump is proposed. Even though injuries are not expected, a small malfunction during operations will interrupt operations while the system is inspected and repaired. Because there is a single transfer arm, there will be no vapor return arm to keep the pressure inside the cargo tank constant. The pressure is controlled solely by the unloading rate.

The same mid-size leak considered in the FSRU analysis would have similar spread size at this facility, forming a 1.2 meter (3.9 feet) diameter pool with impacts remaining within the exclusion zone. However, once again, an operational disruption is anticipated.

Using Koopman's worst case estimate (Koopman, 2002), a full tank rupture would form a plume reaching 0.4 miles, still within the exclusion area, before dissipating below flammable levels. The only steady ignition source is a flare system on the platform that is used to dispose of excess pressure or hydrocarbons by burning (Crystal Energy, 2004). It is assumed that this flare will be extinguished in case of a spill and any gas causing excess pressure will be vented instead of flared. If ignited, the resulting pool fire will have farther-reaching effects. Platform Grace is located approximately 8 km (5 miles) from Platform Gail (Crystal Energy, 2004) and the northbound shipping traffic lane, which are the most likely subjects of thermal radiation from a pool fire. The facility is far enough from the main coastline, Channel Islands, and the general public that they should not feel any effect.

6.2.3 Maritime Accidents

Being located away from high traffic areas helps prevent maritime collisions, and the water depth at the facility reduces chances of grounding. The exclusion zone decreases the chance of ships alliding into the platform, however, if a small ship were to hit the facility, there is no damage expected.

A larger ship with more mass could cause some damage to the platform, and temporarily stop operations until the facility can be inspected. A moderate accident may cause spillage of LNG onto water from a damaged LNG loading arm.

The proposed project applicants estimate that a vessel will be docked at the facility a maximum of 280 days out of the year (Table 50). A longer berthing time is intrinsic for a facility without storage capabilities, increasing the risk of an accident involving an LNG carrier. However the absence of storage tanks also decreases the possible magnitudes of injury.

Table 50 - Comparison of vessel berthing duration. Derived from Cabrillo Port EA, SES Draft Research Report No. 1, Crystal Energy Clearwater Port Deepwater Port Application Supplement.

Facility	Vessel berthing duration*
FSRU	130 days/year average (3x a week at 20 hrs each to berth, unload and de-berth)
Onshore	35 days/year average (70 vessels at 12 hrs each to unload)
Platform	280 days/ year maximum** (80 vessels at 2.5-3.5 days each to unload)
* Figures are approximate. ** No average given in project description.	

If a marine accident resulted in the full release of an LNG carrier tank, the resulting impact could be devastating. Collision sparks would act as an ignition source, starting a pool fire that has the potential to envelop the entire tanker and create a situation of a drifting tanker (Raines and Finch, 2003). Both offshore facilities, the FSRU and platform, are susceptible to this kind of event but the platform's lack of storage tanks eliminates the likelihood that additional LNG tanks could fail, enlarging the pool fire. Aside from alliding with the facility, the drifting tanker can collide with other vessels. Moving vessels in the shipping lane near the offshore facilities can avoid accidents. However, that is not a viable option for tenants of the Port of Long Beach or the oil platforms near the converted platform facility.

An additional concern of the converted platform is the presence of an oil pipeline. During oil production, Platform Grace received oil from Platform Gail (8 km or 5 miles away) and the combined production was sent via subsea pipeline to shore. Platform Grace still performs a "pigging" function for Platform Gail that cleans the pipeline by using pressure to force a specialized object from one end of the pipeline to another. A fire could compromise the integrity of this pipeline and cause an oil spill and possible explosion, in addition to LNG spill and pool fire. The events following a mixed accident like this are unknown, but consequences will undoubtedly be complex.

6.2.4 Natural Phenomena

There are two active faults near the proposed facility, the Oak Ridge and Santa Cruz Island Faults. The 6.7 magnitude 1994 Northridge earthquake was attributed to a fault in the Oak Ridge fault system, south east of the segment shown in the Fault Map (Figure 29). This quake had the strongest instrument readings on ground movements ever seen in urban North America, resulting in collapsed freeways and buildings. Platform Grace was in operation at the time, located far from (86 km (54 miles)) the epicenter. Whether the earthquake had any effect on the platform is unknown, but the distance makes significant impact unlikely. The interval between major earthquakes is unknown for the Oak Ridge fault, but is estimated at 4000 years for the Santa Cruz Island fault (SCEDC).

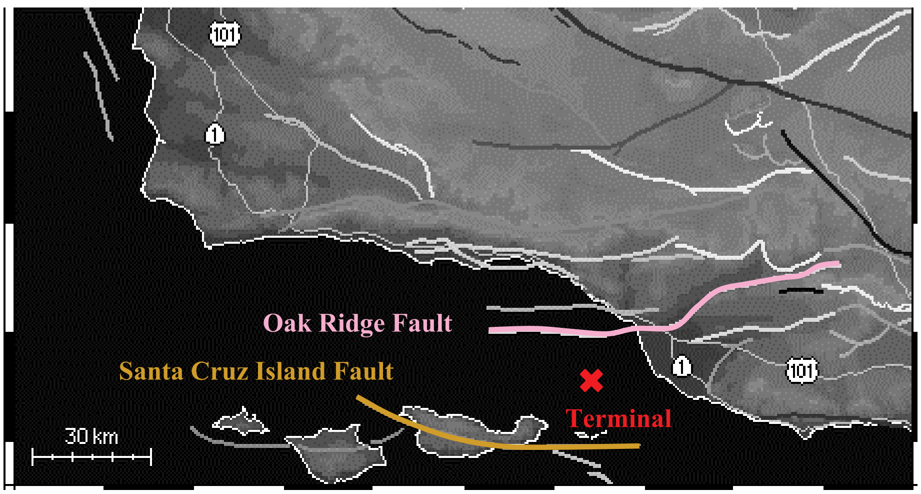

Figure 29 - Fault Map. *Derived from: Southern California Earthquake Data Center Website*

Small earthquakes are not expected to cause any injuries or operational disruptions. After a mid-size earthquake, operations should be ceased for a thorough inspection of the platform's structural integrity. The artificially extended lifespan of the facility, as well as its location over a depleted oil field, should be considered. There are nearby platforms that are and will continue to extract oil, which can trigger ground subsidence with potential to damage the platform foundation and pipelines (Entrix, 2003).

A large earthquake closer to the planned terminal could have adverse impacts on facility stability and prevent operations until the facility and mooring system can be inspected. Active faults and sediment types in the area should be considered when deciding pipeline routes. If the pipeline were to break, the gas will bubble to the surface. The total amount released depends on an emergency valve system that can stop the flow of gas within the pipeline. This type of system is not mentioned in the project description, but is something that should be included in future, more detailed descriptions. The location of the pipeline break also makes a large difference in impact magnitude. If the break is assumed to be in the middle of the pipeline route, as in the FSRU evaluation, the break will occur between the 6 and 7-mile stretch. This puts the released gas near Platform Gina, an active oil extraction platform. If the leak is not detected in time to contact operators on nearby platforms, flare systems on those platforms could ignite the gas rising from the broken pipe. It should be noted that in the current project description, the gas is to be regasified and sent directly into the distribution grid without any processing. The FSRU and onshore terminals are planning to add an odorizing agent to the gas during regasification, as well as separate out additional hydrocarbons such as propane or butane that may be in the LNG. The odor makes leak detection easier and the separation of compounds with higher energy outputs and explosive properties makes distribution safer.

The developer has not yet addressed tsunami hazards, but like the FSRU, the platform is located in deep water and should not be affected.

6.2.5 Terrorism Sabotage

Terrorism acts are not likely but must be prepared for. A minor and moderate terrorism accident would have similar impacts as moderate and major maritime accidents, respectively. A larger incident, such as Dr. Koopman's 747-crash scenario (Table 51), would be similar to the FSRU, only without the additional storage tank capacity. Actual distances that could result in an attack on an LNG carrier have not be addressed, but Koopman's study indicates a 4 mile radius of skin blister impact from the plane collision, plane fuel, and 250 m^3 of LNG. The smallest vessel accommodated by this facility is 70,000 m^3. Impacts could undoubtedly reach other platforms in the area, as well as shipping lane traffic. Impacts are not expected to reach either the main coast (17.7 km or 11 miles) nor the Channel Islands (15.8 km or 11 miles) (Koopman, 2004).

Table 51 – Effect of 747 crashing into LNG storage tank. *Ref: LNG Release Hazards*

	Distance to:		
	Skin Blister	2nd Degree Burn	3rd Degree Burn
747 Plane + Fuel	3600 meters (~2 miles)	2000 meters (~1 mile)	1500 meters (~1 mile)
747 Plane + Fuel + LNG	6400 meters (~4 miles)	3400 meters (~2 miles)	2600 meters (~1.5 miles)
* Numbers are only estimates of impact zone and should not be considered firm.			

6.2.6 Conclusions

Platform Grace was installed in 1979 with a projected 32-year life expectancy. The validity of an extension of another 50-100 years is questionable. The proposed project design has no storage tanks, but mentions that one can be added in the future. The addition of storage tanks makes the question of the adequate support and safety an important issue.

The presence of other active platforms nearby, oil pipelines, and heightened risk of ground subsidence all increase impact magnitude and must be addressed in future proposals to convert oil platforms to accommodate LNG.

6.3 Environmental Analysis

6.3.1 Introduction

This section focuses on the proposed platform terminal's impacts to the surrounding environment. Possible impacts to the subcategories mentioned previously are considered. Environmental impact rankings for the proposed project are outlined below (Table 52). The matrix is followed by detailed explanations of rankings.

Table 52 - Platform Environmental Matrix

Environmental Effects	PLATFORM	construction	operation & maintenance	accidents			decommission
				minor - within facility	moderate - within exclusion zone	major - outside exclusion zone	
	benthic community	d-1	d-1	e-2	e-3	e-4	not evaluated
	pelagic community	d-2	c-2	e-2	d-3	d-4	not evaluated
	air quality	not evalutated	d-3	not evaluated	not evaluated	not evaluated	not evaluated
	terrestrial/freshwater biology	d-1	d-2	e-1	e-3	e-4	not evaluated

6.3.2 Benthic Community

The benthic communities in the proposed platform project area are expected to be very similar to those that exist in the FSRU project area. As of yet, there is not an environmental analysis for the platform project. Therefore, most of the information concerning the benthic communities of the platform project area is derived from Environmental Assessments for Platform Gail and the Cabrillo Port Environmental Analysis.

The LNG platform project proposes to lay a 21 km (13 mile) pipeline that extends from Platform Grace, past Platform Gilda, to Mandalay Beach. The portions of the platform project likely to have an impact on the benthic communities include pipeline construction, and the installation of the anchoring system for the Satellite Service Platform Arrangement Floating Dock (SSP). The platform application frequently mentions hard bottom strata that may exist in the project area. Hard bottom substrata are important marine habitats and typically support diverse communities of organisms. The project proposes to use a detailed seafloor side scan sonar survey of the corridor and potential anchor locations to choose a pipeline route and anchor positions that avoid all hard substrata (Crystal Energy, 2004).

Impacts from Construction

It is proposed that a 21-km (13 mile) subsea pipeline be installed extending from Platform Grace to Mandalay Beach Generating Station. If possible, a pipeline route will be chosen that has no hard substrate. If no hard substrate are present, the impact to benthic communities from pipeline installation is likely to be similar to that expected by the proposed FSRU. The benthic organisms that are in the direct path of the proposed pipeline would likely be crushed by pipeline installation. However, this is a small fraction of the total benthic population, so the impact to benthic communities from subsea pipeline installation is considered minimally important.

The platform project also proposes the use of horizontal directional drilling to avoid impacts to sensitive intertidal communities. Accompanying the use of HDD is the possibility that a fracture will occur, which may result in the release of drilling fluids that may bury surrounding benthic organisms. Please refer to Chapter 4 (FSRU) for a complete description of effects from a fracture. The probability that a fracture will occur is low.

The SSP serves as the mooring system for LNG carriers. The project proposes to anchor the SSP to the sea floor using conventional steel pilings. Placement of the steel pilings will crush or displace benthic organisms in the immediate area. If no rocky bottom/hard substrata are in the project vicinity, the impact to the benthic community is minimally important.

Impacts from Operations
Natural gas will travel from the platform, through the subsea pipeline to shore. There is no expected impact to the benthic communities from this activity. If the pipeline were to rupture, the natural gas, which has a low solubility in water, will bubble to the surface. If the rupture were large, it would displace organisms in the immediate vicinity of the pipeline. If no hard bottom substrata exist in the area, the magnitude of this impact is minimally important.

Impacts from Decommissioning
As mentioned in the project description, there is political debate about decommissioning requirements for platforms that have reached the end of their productive lives. It is outside the scope of this analysis to determine which decommissioning option will be chosen when the LNG platform project is abandoned. Therefore, future impacts from decommissioning are not analyzed.

Impacts from Accidents
There are no accident scenarios from a spill of LNG that will result in an impact to benthic communities in or near the project vicinity.

6.3.3 Pelagic Communities

The marine environment surrounding the platform is similar to the environment surrounding the proposed FSRU. However, the environment created by the platform structure has been known to support an abundance of biomass including species of rockfish and other marine animals (McGinnis and al, 2001). The marine life around a platform is typically adapted to normal operations of the facility. This analysis assumes that normal LNG operations will affect these organisms similarly to oil platform operations. Therefore, impacts to pelagic communities are expected to be the same for both the FSRU and platform projects for construction, operations, and various accident scenarios. Refer to Chapter 4 for information about expected impacts to pelagic communities.

Impacts from Decommissioning

When the original leases were written for construction of oil platforms, they stated that once a facility ceased oil production, there was to be a complete removal of the facility. However, now that many of these facilities have come to the end of their productive lives, there are unanticipated issues concerning decommissioning. These issues include the high cost of platform removal, the platform structure as part of the marine environment, and the release of buried contaminants during removal. The hard substrate provided by the platform, in some cases, is habitat for important fish species including the rockfish, an important commercial fish, and the bocaccio, a candidate species for listing under the federal ESA. There is political debate about the various platform decommissioning options. Platform decommissioning today could involve one of three options: leave in place, complete removal, or partial removal (McGinnis and al, 2001). It is not the subject of this analysis to determine what type of decommissioning solution will be chosen for the LNG platform project. Different environmental impacts are associated with each decommissioning option. Complete removal of the platform is typically done with explosives. Environmental communities that have developed around the platform structure are heavily impacted by platform removal. Therefore, the option that has the most severe impact on the environment is the complete removal of the platform. Leaving the platform in place has the least severe impact on the existing environment (DOI/MMS, 1997).

6.3.4 Air Quality

The platform project proposal has a throughput capacity that is similar to the FSRU project. However, the platform project is not as far along in the proposal process as is the FSRU project. At the time of this analysis, the platform project has submitted its initial application for the Crystal Clearwater Port. No air quality data is yet available for this specific project. Therefore, since the capacities are similar between the platform project and the FSRU project, and both the platform and FSRU projects propose to use "state of the art" equipment, this analysis has assumed that similar emissions quantities of the criteria pollutants are emitted from the platform as are emitted from the FSRU. It is assumed that the only difference between the two projects in the effects to air quality is related to each project's distance to shore. There is a degree of uncertainty associated with this analysis, but assumptions are based on the best available data.

Impacts from Operations

As described in the air quality methodologies, a Gaussian-plume model was used to determine the concentration of each criteria pollutant at the designated receptor. The distance between the platform and the shoreline WSW of the platform is 20 km (12.5 miles) (NOAA, 2003). Similar parameters are used in the platform analysis as are stated in the FSRU analysis. The results obtained from air quality modeling are reported in Table 53.

Table 53 - Concentration of Criteria Pollutants on Shore WSW of Platform

Pollutant	Concentration 20 km from Source	Ambient Air Quality Standard	Magnitude of Impact
NO_2	9 $\mu g/m^3$	100 $\mu g/m^3$	Minimally important
CO	2 $\mu g/m^3$	10,000 $\mu g/m^3$	Neutral
PM_{10}	.1 $\mu g/m^3$	20 $\mu g/m^3$	Neutral
SO_2	0 $\mu g/m^3$	80 $\mu g/m^3$	Neutral

The data for the prevailing wind direction was obtained from the annual average reported by LAX. If the wind were to shift slightly, perhaps SW, then the air pollutant plume may reach landfall sooner than the above model estimation. The shore that is closest to the platform is 17.5 km (11miles) away from the platform. As the pollutant plume would have less time to disperse in this shorter distance, the pollutant would be more concentrated at this point.

Table 54 - Peak Pollutant Concentrations

Pollutant	Concentration 17.5 km from Source	Peak Concentration (600 m)
NO_2	11 $\mu g/m^3$	1500 $\mu g/m^3$
CO	3 $\mu g/m^3$	375.8 $\mu g/m^3$
PM_{10}	.2 $\mu g/m^3$	24.8 $\mu g/m^3$
SO_2	0 $\mu g/m^3$	0.3 $\mu g/m^3$

As the plume moves away from the emission source, the concentration of the air pollutant initially increases, peaks, and then declines as it disperses. Reported in Table 54 are the peak concentrations of each criteria pollutant. Because the same parameters are used for the platform analysis as the FSRU analysis, the peak is the same concentration reported by the FSRU and is located 600 meters from the emission source. Peak concentrations of CO and SO_2, remaining far below ambient air quality standards, have only a neutral magnitude. The concentrations of NO_2 and PM_{10} are higher than ambient air quality standards. Peak concentrations occur 600 meters away from the emission source, which may affect people in the Santa Barbara Channel. However, exposure to elevated pollutant levels are expected to be short term for anyone in the channel.

The increase in ozone concentration caused by platform emissions, which is not modeled in this analysis, is assumed to be the same as the FSRU.

6.3.5 Terrestrial and Freshwater Biology

Platform Grace is approximately 18 km (11 miles) offshore. Due to its distance from shore, the platform project is expected to have only a small impact on the terrestrial and freshwater biology. Any impact to terrestrial and freshwater biology is likely to come from the 82 cm (32 inch) pipeline that will be used to pipe the natural gas to shore.

The platform pipeline is proposed to come ashore just south of McGrath Lake and McGrath State Beach and north of Mandalay Beach, near the Reliant Mandalay Generating Station. The onshore environment where the platform pipeline will come ashore is similar to that described in the FSRU Terrestrial and Freshwater Biology analysis. The same special status species that are mentioned in the Chapter 4 and the same habitats are also sources of concern for the platform project. Additional biological resources of McGrath Lake may also need to be considered.

Very few details exist about the platform pipeline. Horizontal directional drilling (HDD) will be used for the approximately 1 km (3000 feet) of the project, and will begin 550 meters (1800 feet) offshore. HDD is used to avoid impacts to the sensitive intertidal communities and to avoid beach disturbance. The distance is not known for the pipeline between the end of HDD and the Mandalay Generating Station. It is assumed that this length of pipe will be installed using traditional trench methods.

Impacts from Construction
Assuming that the same care is taken in the construction of the platform pipeline as is proposed with the FSRU, the impacts from construction to terrestrial and freshwater biology are assumed to be the same. In addition, the proposed platform project will need to specifically consider the biological resources of McGrath Lake.

Impacts from Operations
Impacts to freshwater and terrestrial biology from operations are expected to be similar to those reported in the FSRU.

Impacts from Decommissioning
Since the proposed platform project is located 18 km (11 miles) offshore, decommissioning the platform, whether it is completely removed, partially removed, or left in place, is not likely to have much impact on terrestrial and freshwater biological resources. If the pipeline is left in place, then the impacts are expected to be minimal, much like those reported in the FSRU chapter.

Impacts from Accidents
There is not an impact scenario that would cause an effect large enough to reach terrestrial and freshwater biology.

6.3.6 Conclusions

Most environmental impacts expected from the proposed platform LNG facility are similar to those expected from the proposed FSRU project. This similarity can be explained by the following: the projects are in close proximity to each other (so the existing biological resources are similar) and the projects have similar pipeline systems. Both projects propose a subsea pipeline that comes ashore using horizontal directional drilling, which avoids impacts to the sensitive intertidal communities. While the proposed platform pipeline is considerably shorter than the proposed FSRU pipeline, the impacts of both are considered less than significant due to the small impact area relative to total benthic communities.

6.4 Socioeconomic Analysis

6.4.1 Introduction

This section considers the impact of the proposed platform conversion project on socioeconomic aspects. Six categories are evaluated throughout the life cycle of the project (construction, operations and maintenance, and decommissioning). Results of the collective socioeconomic rankings are illustrated within the matrix below (Table 55). A detailed explanation of these results follows.

Table 55 - Platform Socioeconomic Matrix

	PLATFORM	construction	operation & maintenance	accidents			decommission
				minor - within facility	moderate - within exclusion zone	major - outside exclusion zone	
Socioeconomic Effects	population affected	c-1	c-3	not evaluated	not evaluated	not evaluated	c-2
	economy & employment	f-1	f-2	e-1	e-3	f-4	f-2
	property value	e-1	e-1	e-1	e-3	d-4	e-1
	housing	c-2	d-3	c-1	c-3	b-4	c-2
	public services	e-3	e-3	e-3	d-3	c-3	e-3
	traffic	c-2	d-1	e-2	d-3	c-4	d-2

Due to the close proximity of the proposed converted platform terminal to the FSRU site, much of the socioeconomic data is similar. Although both projects are located offshore, from Ventura County, differences exist regarding storage and throughput capacity, employment estimates, proximity to land, and traffic volumes. Most of these differences are not of enough significance to be reflected within the matrix ranking, yet may be of significance when compared to other projects.

6.4.2 Population Affected

The proposed platform is located 17.7km (11 miles) offshore. Both the platform and FSRU are located within the Pacific Outer Continental Shelf (POCS), defined as 5.6 km (3 nautical miles) seaward of the baseline from the breadth of the territorial sea (MMS, 2004). In both cases, the perimeter of the proposed exclusion zone is more than 10 miles from shore. For this reason, population ranking regarding the offshore receiving terminal is expected to be the same as the FSRU.

6.4.3 Economy and Employment

Precise economic and employment data with regard to the offshore platform conversion is limited. Therefore FSRU economic and employment data is extrapolated to reflect the scale of the platform project. Crystal Energy estimates the cost of the platform conversion to be approximately $200 million. As stated within chapter 4, BHP Billiton anticipates spending in excess of $400 million to complete the FSRU. Employment estimates for both projects are of similar scale. The platform conversion is designed to handle 12 workers. Workers are expected to live aboard the facility for seven days (one hitch), which requires a rotation of 12 workers per hitch. In other words, 24 persons are needed to cover both shifts.

Although different in size and storage capacity, the FSRU and platform conversion project affect the local economy and employment similarly. In fact, there are little differences during normal operations, pipeline construction, and accident scenarios. Both projects will employ approximately the same number of people and are of significant distance from any local population center.

The distinct differences within the construction and decommissioning phase depend on the manner with which the projects are executed. The proposed platform conversion project requires approximately half the length of subsea pipeline when compared to the FSRU (35.2 km (21.9 miles) versus 17.7 km (11 miles)) yet will utilize a larger diameter 81 cm (32 inch) pipe and will include the installation of a 15 cm (6 inch) high density polyethylene (HDPE) water pipeline. Although the pipeline installation is comparable, the construction phase of the platform conversion is expected to provide more local employment because the installation of the regasification equipment needed on Platform Grace must occur locally. Similarly, decommissioning an offshore platform requires additional expenditures and significantly more personnel during removal. Decommissioning of an oil platform is a lengthy, labor intensive, and costly process.

Based on this analysis there are distinct differences between the economic and employment benefits realized when comparing the two projects, however not of enough significance to warrant changing the results derived from the FSRU data. For this reason, ranking economy and employment data for the platform conversion is the same as the FSRU.

6.4.4 Property Value

The gas and water pipeline required for the platform conversion project is proposed to reach landfall within the existing Mandalay Generating Station in the City of Oxnard. Much like the FSRU project, property value ranking criteria are determined by evaluating general plans for the City of Oxnard 2020, Ventura County 2000, and the City of Oxnard Coast Land Use Plan (2000). Like the FSRU, the platform conversion project is reviewed for compatibility with the Channel Island National Marine Sanctuary (CINMS).

Adherence to the General Plan

The onshore portion of the proposed platform conversion project is located within the City of Oxnard. According to Ventura County's General Plan, the onshore portion of the project, near the Mandalay Beach power plant, is located in an area designated for industrial use. The Oxnard 2020 General Plan and Land Use Plan designates the area within the immediate Coastal Zone as industrial, with priority to coastal-dependent uses, coastal recreation, resource protection, and public utility/energy facilities (City of Oxnard, 1990).

Offshore Analysis

As discussed within the FSRU section of this analysis, the CINMS is an area of national significance. It encompasses the waters that surround Anacapa, Santa Cruz, Santa Rosa, San Miguel, and Santa Barbara Islands, extending from mean high tide to 11.1 km (six nautical miles or 7 miles) offshore around each of the five islands. The sanctuary's primary goal is the protection of the natural and cultural resources contained within its boundaries (CINMS, 2004). The platform conversion project, Platform Grace, is located approximately 15.8 km (11 miles) from the tip of Santa Cruz Island, which is outside the CINMS boundary.

After careful review of the applicable general plan(s) associated with the offshore platform conversion, the analysis shows that the project will not conflict with the community vision of the area. In addition, it is still compatible with the sanctuary's primary goal of protecting natural and cultural resources. The converted platform receiving terminal does not appear to have any incompatible land use issues nor have conflicts with existing County and City General Plan(s). For this reason, the converted platform terminal is ranked the same as the FSRU project with regard to effects on property value.

6.4.5 Housing

Although the exact number of workers required for offshore conversion project has not been disclosed, it is not anticipated to exceed that of the FSRU. With that said, the relatively small number of vacant housing units available at the state, county, and city level within proximity to the project could be impacted in the same manner, or less, as that of the FSRU. For this reason, the offshore conversion project is ranked the same as the FSRU.

6.4.6 Public Services

Ventura County has a well-developed infrastructure to provide health, police, fire, emergency, and social services near the proposed offshore platform conversion. Like the FSRU project, the workforce is expected to be small relative to the current population of the area. There are minor differences between the public service demands required for either project. However, not enough to warrant changing the results derived from the FSRU data. For this reason, ranking public service demand for the platform conversion project is the same as the FSRU.

6.4.7 Traffic

Minor marine and vehicular traffic differences exist between the FSRU and the converted platform project. Traffic as a result of the platform project is expected to be of slightly more significance given that much of the construction would be performed locally. During normal operations, traffic flows are expected to be slightly less significant due to an estimated 50 percent fewer operation personnel (as compared to the FSRU) needed to operate the converted platform once in service

Roadway Traffic

Most of the road traffic required for the converted platform project is anticipated to use the Port of Hueneme. As discussed within the FSRU section of this paper, the City of Oxnard in cooperation with the California Department of Transportation (Caltrans) is proposing to improve the Rice Avenue/U.S. 101 interchange that will provide a direct route to the Port (City of Oxnard, 2003). It is anticipated that the majority of vehicular traffic relating to the terminal projects will utilize the expanded Rice Avenue route.

According to the FSRU environmental assessment, an increase of 15 semi-trucks during construction, and approximately 60 auto trips per week during normal operations, is expected. Semi-trucks will deliver construction materials to port and onshore staging areas and autos will deliver employees to the port where they will be transported to the offshore facility for a seven-day work period.

Although traffic data with regard to the platform conversion project is not available at this time, estimates can be derived by doubling the FSRU data during the construction phase and taking one half the data during normal operations. Utilizing this method, an estimated 30 semi-trucks can be expected during the construction phase of the platform conversion, including 30 auto trips per week to the port for employees to access the crew boat that takes them to the offshore facility. This estimate assumes personnel will work a seven day hitch, i.e. not returning to port on a daily basis.

Marine Traffic

A similar method to estimate marine traffic with regard to the platform conversion project is used by doubling the FSRU data during construction and taking half the estimates during normal operation.

The platform conversion project will require a 20.9 km (13 miles), 81 cm (32 inch) steel gas and 15 cm (6 inch) high-density polyethylene water line to reach the tie-in point at the Mandalay Power Station.

During the construction phase, both the FSRU and converted platform require extensive use of marine equipment that will include a pipeline barge, supply vessels, and a pipe lay vessel. To estimate the differences in marine traffic flow, estimated construction times are utilized. For the proposed FSRU, an estimated 45 days will be required for pipeline construction and an additional 45 days for installation of the mooring system (Entrix, 2003). Similarly, the converted platform is estimated to take 30 days for pipeline construction, 335-365 days (11-12 months) for the mooring system, and an additional 180-330 days (6-11 months) for equipment removal, structural upgrades, and installation of regasification equipment on the platform (Crystal Energy, 2004). These estimates do not account for the onshore portion of the pipeline, which is similar in nature with regard to each project. Averaging the high and low estimates with regard to the converted platform results in a construction phase of 505 days, which is about 5.6 times more than the 90 days estimated for the FSRU project.

Port traffic is expected to experience similar impacts for the two projects (FSRU and platform) during pipeline construction. Both projects will involve extensive pipeline construction activities. However, based on the estimated construction time, the pipeline portion of the platform conversion project (including the water pipeline) is roughly 75 percent the scale of the FSRU (30 days versus 45 days). The large discrepancy in construction time is mostly due to the 11-12 month span required for fabrication of the mooring system and partly due to the additional 6-11 months needed to upgrade the platform. Based on this analysis it is possible for the converted platform project to increase port traffic, during the construction phase, significantly more than the FSRU. This is primarily due to having the bulk of the work performed locally rather than utilizing imported regasification equipment, such as with the FSRU project. Likewise, during the decommissioning phase of the project, a similar increase in port traffic is expected. Unlike the FSRU, where upon completion of its operating life it will be towed away, the platform will entail a local workforce to remove the structure.

Normal operations require the periodic use of crew and supply vessels to deliver operations personnel, supplies, and collect waste. Estimated port traffic increases due to normal operations of the converted platform are estimated to be half of the FSRU, i.e. 5 trips weekly, or less than 1 trip per day. In this case, a neutral rating is assigned.

Aggregate traffic data as a result of the converted platform project illustrate a slightly larger impact to overall traffic flow during the construction and decommissioning phase of the project. For this reason, the converted platform project is ranked important during construction and minimally important during decommissioning.

6.4.8 Conclusions

Much of the socioeconomic data with regard to the converted platform project is either the same or similar to the data provided for the FSRU project. Ranking criteria between the two projects are determined by extrapolating the differences based on storage, throughput capacity, employment estimates, and proximity to land and traffic volumes. Results of the converted platform socioeconomic analysis indicate little differences amongst each category. The only dissimilarity that warranted a change to the previously calculated FSRU rankings is with regard to the perceived traffic impact.

Heavier traffic volumes, both at Port Hueneme and on local roads, are expected during the construction and decommissioning phase of the converted platform. Similarly, in comparison to the FSRU project, a slightly less significant volume of traffic is expected during normal operations of the converted platform. Accident scenarios for both projects remain the same.

6.5 General Platform Terminal Conclusions

Community safety analysis reveals that consideration should be given to surrounding operational oil platforms and pipelines when proposing a platform conversion terminal. In addition, ground subsidence risks should be considered. Environmental impacts are expected to occur primarily during pipeline construction, but will impact a small portion of the marine community. Socioeconomic impacts will be felt primarily in the form of increased traffic to the nearest port (Port Hueneme) during construction and decommissioning.

7 DISCUSSION

7.1 Conclusions & Recommendations

After reviewing the three different proposed terminals, it is clear that each have strengths and weaknesses, both particular to the specific proposal and also as generic facility types. For each impact category, three matrices, one for each terminal type, summarize our findings. The matrices are followed by general conclusions and recommendations for each category of analysis.

7.1.1 Community Safety Conclusions

Potential impacts of different accident events for each terminal type are presented below. A discussion of the findings as well as general community safety conclusions and recommendations follow the matrices.

Magnitude Definitions

a	Catastrophic	irreversible injuries or damage to facility requiring closure
b	Severe	irreversible injuries or temporary disruption of operations
c	Important	reversible injuries or temporary disruption of operations
d	Minimally important	reversible injuries or no disruption of operations
e	Neutral	no injury, no disruption of operations
f	Minimally Beneficial	not applicable (n/a)
g	Beneficial	n/a

Likelihood Definitions

1	highly likely	expected to happen at least once a year
2	likely	expected to happen once in a ten year period
3	possible	expected to happen once during lifetime of facility
4	unlikely	not expected to happen during lifetime of facility

Community Safety	FSRU	construction	operation & maintenance	accidents			decommission
				minor - within facility	moderate - within exclusion zone	major - outside exclusion zone	
	operational failure	not evaluated	not evaluated	e-1	e-3	c-4	not evaluated
	maritime accidents	not evaluated	not evaluated	e-2	c-3	c-4	not evaluated
	natural phenomena	not evaluated	not evaluated	e-2	e-2	c-3	not evaluated
	terrorism/sabotage	not evaluated	not evaluated	c-4	c-4	b-4	not evaluated

Community Safety	ONSHORE	construction	operation & maintenance	accidents			decommission
				minor - within facility	moderate - within exclusion zone	major - outside exclusion zone	
	operational failure	not evaluated	not evaluated	e-1	c-2	a-4	not evaluated
	maritime accidents	not evaluated	not evaluated	e-1	b-2	a-3	not evaluated
	natural phenomena	not evaluated	not evaluated	e-2	b-2	a-3	not evaluated
	terrorism/sabotage	not evaluated	not evaluated	b-4	a-4	a-4	not evaluated

Community Safety	PLATFORM	construction	operation & maintenance	accidents			decommission
				minor - within facility	moderate - within exclusion zone	major - outside exclusion zone	
	operational failure	not evaluated	not evaluated	c-1	c-2	c-4	not evaluated
	maritime accidents	not evaluated	not evaluated	e-2	c-3	b-4	not evaluated
	natural phenomena	not evaluated	not evaluated	e-2	c-2	b-3	not evaluated
	terrorism/sabotage	not evaluated	not evaluated	c-4	b-4	a-4	not evaluated

The single most important factor in community safety is the location of the terminal relative to the population. Remote citing of facilities can help mitigate possible impacts to the community.

The platform facility is expected to be more vulnerable to operational failure due to the long unloading time and the lack of redundancy in the unloading system. The addition of storage to a platform facility would require an additional review of structural integrity as well as a new evaluation of spill impacts. The absence of storage tanks is also better for preventing large releases of LNG into the water, however the possible presence of active oil pipelines, such as in the proposed platform project, complicates emergency response and cleanup efforts for extreme accidents.

Onshore facilities have a higher likelihood of marine accidents because of the higher amount of traffic in the vicinity. They also have a slightly higher risk of damage from natural phenomenon because of the additional risk of tsunamis. This additional risk was not considered enough to differentiate the likelihood rating.

Onshore facilities are more attractive as a terrorist target in comparison to the other facilities. This conclusion is based solely on the safety impact magnitudes of the different facilities evaluated. Impact magnitudes were greater across the board for an onshore facility due to the dense population around the facility. The most noticeable difference in impact magnitude between the terminal types evaluated is between moderate and major accident scenarios (Onshore > Platform > FSRU). The proposed onshore facility would be closest to a dense population, and it is assumed this will be the case for all onshore facilities in Southern California. However if a port can be found that is suitable for tanker traffic and is in a remote location, the safety risk of the facility will vary substantially.

Community Safety Recommendations

To address community safety impacts discussed above, the following should be considered:

- Remote siting is the most important factor in determining safety impacts. Population density surrounding the facility is the single most significant factor in community safety risk. A larger population at risk demands more resources from emergency response crews. Remote citing does not automatically mean offshore, however locating an LNG terminal offshore lowers safety risk, given the densely populated coastline in Southern California.
- Studies give short burn times (minutes) for LNG fires from a single large release. Fire from a smaller release could cause storage or cargo tanks to rupture, releasing additional LNG and extending the burn period. Offshore facilities are farther from emergency response. Each facility should have their own emergency response protocol and not rely solely on government authorities. There is limited action that emergency crews can take once an LNG pool fire starts burning.
- Onshore facilities are closer to medical and law enforcement, but it is unclear if a shorter distance equates to better response capabilities due to differences in transportation and traffic. Offshore facilities will probably rely on helicopters and ships as emergency response vehicles. Onshore facilities will probably rely on automobiles and possibly helicopters. Emergency crews may have to deal with traffic and have a larger affected population to care for.
- When evaluating three very different projects that essentially perform the same function, it is essential to include low probability catastrophic events. These large magnitude events can highlight differences in the risk of each facility.

7.1.2 Environmental Conclusions

The terminals' potential impacts to the environmental community are summarized below. Matrices are followed by general conclusions and recommendations for mitigating environmental impacts.

Magnitude Definitions

a	**Catastrophic**	**not applicable (n/a)**
b	**Severe**	**a significant impact (per CEQA guidelines)**
c	**Important**	**an impact but not significant *with* mitigation (per CEQA guidelines)**
d	**Minimally important**	**an impact but not significant (per CEQA guidelines)**
e	**Neutral**	**no impact on the environment**
f	**Minimally beneficial**	**n/a**
g	**Beneficial**	**n/a**

Likelihood Definitions

1	**highly likely**	**expected to happen at least once a year**
2	**likely**	**expected to happen once in a ten year period**
3	**possible**	**expected to happen once during lifetime of facility**
4	**unlikely**	**not expected to happen during lifetime of facility**

Environmental Effects	FSRU	construction	operation & maintenance	accidents			decommission
				minor - within facility	moderate - within exclusion zone	major - outside exclusion zone	
	benthic community	d-1	d-1	e-2	e-3	e-4	d-2
	pelagic community	d-2	c-2	e-2	d-3	d-4	e-1
	air quality	not evaluated	d-1	not evaluated	not evaluated	not evaluated	not evaluated
	terrestrial/freshwater biology	d-1	d-2	e-1	e-3	e-4	c-2

Environmental Effects	ONSHORE	construction	operation & maintenance	accidents			decommission
				minor - within facility	moderate – within exclusion zone	major - outside exclusion zone	
	benthic community	b-1	e-2	e-2	d-3	d-4	d-3
	pelagic community	c-3	d-2	e-4	d-3	d-4	e-3
	air quality	not evaluated	b-1	not evaluated	not evaluated	not evaluated	not evaluated
	terrestrial/freshwater biology	d-1	d-1	e-2	b-4	b-4	d-3

Environmental Effects	PLATFORM	construction	operation & maintenance	accidents			decommission
				minor - within facility	moderate – within exclusion zone	major - outside exclusion zone	
	benthic community	d-1	d-1	e-2	e-3	e-4	not evaluated
	pelagic community	d-2	c-2	e-2	d-3	d-4	not evaluated
	air quality	not evaluated	d-3	not evaluated	not evaluated	not evaluated	not evaluated
	terrestrial/freshwater biology	d-1	d-2	e-1	e-3	e-4	not evaluated

The potential for each of these projects to cause environmental impacts is very site specific, and it is difficult to generalize between different terminal types without consideration of detailed location information. However, the main differences between terminal types are highlighted below.

Air quality is the environmental impact that has the most noticeable difference between the terminal types. There appears to be significant air quality concerns with the onshore project as both concentrations of NO_2 and SO_2 exceed ambient air quality standards and the concentration of PM_{10} closely approaches air quality standards. Due to onshore reliance on electricity provided by the grid (whose emissions are not included in the analysis), peak concentrations reached by the onshore project are actually lower than concentrations generated by the offshore projects. However, the air quality impacts from both offshore projects, the FSRU and the platform, have impacts that are, at most, minimally important. The reason for this difference in air quality impacts is because the projects that are offshore allow for significant dissipation before the plume reaches shore. The peak of both of these offshore projects exceeds ambient air quality standards, but in both cases, is far removed from shore. In the case of the onshore facility, as the plume reaches its peak concentration, it has already reached the population.

The conversion of a platform to accept LNG makes use of an existing structure, so much of the initial construction impact has already occurred. However, platforms add to the hard substrate of the marine environment and can provide habitat for different benthic and pelagic marine communities. These communities may be impacted by this conversion.

Both platform and FSRU projects require subsea pipelines from the terminals to a natural gas tie-in facility, the construction of which could cause a significant impact if they cross over rocky bottom/hard substrata or through nursery areas. These pipelines have to breach the potentially sensitive shoreline area to reach the onshore tie-ins. Horizontal directional drilling (HDD) can be used to minimize the impacts to sensitive intertidal and shoreline communities.

The FSRU facility is constructed abroad, and then towed to its final destination where it is moored to the sea floor. The chief environmental impacts are short-term and come from the installation of the pipeline and mooring system and modifications to the tie-in facility. Therefore, the FSRU may have relatively small impacts to its surrounding environment. The onshore project requires dredging. In onshore proposal for the POLB, it is proposed that 57,000m^3 to 96,000m^3 (75,000 to 125,000 cubic yards) of sediment will be dredged. This type of activity has a much more substantial impact on the marine communities in the project area. In the case of the POLB, the few number of significant impacts experienced during construction is because of limited biological resources in the area. If important biological resources were present, then construction and operation of the project would likely have a more significant impact on the environment.

All of the projects will increase marine traffic. The marine vessels associated with a project may strike marine mammals or reptiles and therefore have a significant impact on pelagic marine communities.

An onshore facility has the option to rely on locally supplied electricity for its power generation, where the offshore terminals will onsite generators for power generation. Additional environmental consequences may be present from installing substations and power lines used to deliver power to an onshore facility.

Decommissioning may be another important activity when considering impacts of each project to the environment. The FSRU can basically be untethered and hauled away for decommissioning, while the pipeline may be left in place. Conflicting politics surround the issue of platform decommissioning, so it is difficult to predict the how the platform will be decommissioned, or the impacts of that action. The platform may have created additional hard substrata where important benthic and pelagic organisms may dwell. A complete removal of the platform is likely to have an important impact on the surrounding environment. Most decommissioning of the onshore project is expected to take place onshore. Due to the lack of biological resources in the POLB, decommissioning is expected to have minimally important impacts, which are dependant on the extent of structure removal.

Additional pipelines will be constructed for each project that will deliver the natural gas to a distribution center. The construction of each pipeline has the potential to impact the surrounding environment. However, assessing this impact was outside the scope of this analysis.

When considering environmental impacts of any terminal type, siting is the most important factor. Environmental impacts of any project action are dependent on the biological resources in the area as well as the potential that the action has to impact those resources.

Environmental Recommendations

To mitigate environmental impacts associated with all LNG terminal types, the following should be considered:

- **Construction**- Construction may cause destruction of habitat and may also disrupt feeding, breeding, and migration areas. Care should be taken to avoid sensitive habitats .
- **Air pollution**- Technology may be required that reduces emissions of NO_2, PM_{10}, and SO_2, especially for facilities close to a population.
- **Noise**- Noise may impact marine mammals; so timing of construction and LNG offloading may be important factors, especially for offshore facilities.

7.1.3 Socioeconomic Conclusions

Potential beneficial and detrimental impacts to socioeconomic aspects as a result of the three receiving terminal projects are summarized in the matrices below. Matrices are followed by justifications of rankings as well as general socioeconomic conclusions and recommendations.

Magnitude Definitions

a	Catastrophic	catastrophic impact to society
b	Severe	detrimental to society
c	Important	minor detriment to society, significant
d	Minimally important	minor detriment to society, not significant
e	Neutral	no noticeable impact either positive or negative to society
f	Minimally beneficial	minor beneficial impact to society
g	Beneficial	significant benefit to society

Likelihood Definitions

1	highly likely	expected to happen at least once a year
2	likely	expected to happen once in a ten year period
3	possible	expected to happen once during lifetime of facility
4	unlikely	not expected to happen during lifetime of facility

Socioeconomic Effects: FSRU	construction	operation & maintenance	accidents: minor - within facility	accidents: moderate - within exclusion zone	accidents: major - outside exclusion zone	decommission
population affected	c-1	c-3	not evaluated	not evaluated	not evaluated	c-2
economy & employment	f-1	f-2	e-1	e-3	f-4	f-2
property value	e-1	e-1	e-1	e-3	d-4	e-1
housing	c-2	d-3	c-1	c-3	b-4	c-2
public services	e-3	e-3	e-3	d-3	c-3	e-3
traffic	d-2	d-1	e-2	d-3	c-4	d-2

Socioeconomic Effects: ONSHORE	construction	operation & maintenance	accidents: minor - within facility	accidents: moderate - within exclusion zone	accidents: major - outside exclusion zone	decommission
population affected	b-1	b-3	not evaluated	not evaluated	not evaluated	b-2
economy & employment	g-1	f-2	e-1	e-3	f-4	g-1
property value	c-2	c-3	e-1	b-3	a-4	c-2
housing	d-2	e-3	e-1	e-3	b-4	d-2
public services	e-3	e-3	e-3	d-3	c-3	e-3
traffic	b-1	c-2	c-1	b-3	a-4	b-2

Socioeconomic Effects: PLATFORM	construction	operation & maintenance	accidents: minor - within facility	accidents: moderate - within exclusion zone	accidents: major - outside exclusion zone	decommission
population affected	c-1	c-3	not evaluated	not evaluated	not evaluated	c-2
economy & employment	f-1	f-2	e-1	e-3	f-4	f-2
property value	e-1	e-1	e-1	e-3	d-4	e-1
housing	c-2	d-3	c-1	c-3	b-4	c-2
public services	e-3	e-3	e-3	d-3	c-3	e-3
traffic	c-2	d-1	e-2	d-3	c-4	d-2

Minor differences exist between the FSRU and converted platform. This analysis only identified one category within the socioeconomic section of the matrix that was of enough significance to warrant a different ranking. Due to the locale of the proposed platform project, road traffic is expected to be significantly greater during the construction and decommissioning phase, and slightly less during normal operations.

There are distinct differences between both the FSRU and platform projects when compared to the onshore terminal. The onshore project has a much wider range of socioeconomic effects, and it was the only project to receive a beneficial ranking. Due to the size, overall cost, and expected duration of the construction and decommissioning phases of the onshore project, economic and employment sectors should benefit. On the other hand, the onshore terminal was the only project to receive a catastrophic ranking, of which both were given under the major accident scenario.

Socioeconomic Recommendations

- Prior to issuing a permit to build or decommission an LNG receiving terminal, provisions should be made to accommodate housing for construction workers. Temporary workers should utilize hotels, campgrounds, and RV parks, to offset negative impacts to housing availability.
- Traffic impacts as a result of a building an LNG receiving terminal can be significant. Regulators should consider the potential increases to vehicular traffic patterns carefully.
- Consideration should be given to expected increases in hazardous cargo shipments by truck as a result of delivering LNG and related hydrocarbon products to market.

7.2 Limitations and Boundaries to Analysis

The following limitations apply to our evaluation:

- In some instances, we extrapolated or reinterpreted results from previous studies and we are aware than these may not apply exactly to the proposed terminals. These conclusions are only meant to provide a framework to exhibit how some concerns may be more pertinent to a particular terminal type. The goal of this analysis is to highlight the major differences between the different terminal types.
- Possible impacts to air traffic, in the case of a large LNG fire, were not included in the evaluation.
- Models estimating results from large fires often concentrate on distance to thermal impact or gas dispersion. Such a large LNG fire also changes the vulnerability of the facility or vessel to additional releases (Havens, 2003). The effect of a large fire on the facility or tanker should be the next area of safety studies.
- The current estimations of large-scale accidents are projections. Extrapolation from smaller actual release studies to large-scale events is challenging. Continuing work in this area is necessary for improved accuracy of safety forecasting.
- Due to limited and conflicting data, tax revenue generated as a result of building an LNG terminal was not considered within this analysis. It can be assumed federal, state and local governments can benefit by receiving additional sales, payroll, and property taxes as a result of building an LNG receiving terminal.

- Environmental analyses were based primarily on information provided by the project applicants. These documents have not gone through the peer-review process. Much of the certainty of this analysis is bound by the accuracy of these documents.
- Future requirements for decommissioning platforms are a subject of political debate. Decommissioning impacts of the proposed platform project were not analyzed due to uncertainty regarding the future decommissioning method.
- Regulatory requirements, in terms of permitting or monitoring costs, were not considered in ranking the terminal types.

8 APPENDICES

APPENDIX A: Safety History of International LNG Operations. *Source: CH-IV International, Revision 2, November 2002*

Chronological Summary of Incidents Involving Land-Based LNG Facilities

1. October, 1944 Cleveland, Ohio, USA ~ *"The Cleveland Disaster"*
LNG Peakshaving Facility
Any time the topic of LNG is introduced to a new audience the *"Cleveland Disaster"* is bound to surface. It was indeed tragic, but a candid review will show just how far the industry has come from that horrific incident. The East Ohio Gas Company built the first "commercial" LNG peakshaving facility in Cleveland in 1941. The facility was run without incident until 1944, when a larger new tank was added. As stainless steel alloys were scarce because of World War II, the new tank was built with a low-nickel content (3.5%). Shortly after going into service, the tank failed. LNG spilled into the street and storm sewer system. The resultant fire killed 128 people, setting back the embryonic LNG industry substantially. The following information is extracted from the U.S. Bureau of Mines report[4] on the incident:

On October 20, 1944, the tanks had been filled to capacity in readiness for the coming winter months. About 2:15 PM, the cylindrical tank suddenly failed releasing all of its contents into the nearby streets and sewers of Cleveland. The cloud promptly ignited and a fire ensued which engulfed the nearby tanks, residences and commercial establishments. After about 20 minutes, when the initial fire had nearly died down, the sphere nearest to the cylindrical tank toppled over and released its contents. 9,400 gallons of LNG immediately evaporated and ignited. In all, 128 people were killed and 225 injured. The area directly involved was about three-quarters of a square mile (475 acres) of which an area of about 30 acres was completely devastated.

The Bureau of Mines investigation showed that the accident was due to the low temperature embrittlement of the inner shell of the cylindrical tank. The inner tank was made of 3.5% nickel steel, a material now known to be susceptible to brittle fracture at LNG storage temperature (minus 260°F). In addition, the tanks were located close to a heavily traveled railroad station and a bombshell stamping plant. Excessive vibration from the railroad engines and stamping presses probably accelerated crack propagation in the inner shell. Once the inner shell ruptured, the outer carbon steel wall would have easily fractured upon contact with LNG. The accident was aggravated by the absence of adequate diking around the tanks, and the proximity of the facility to the residential area. The cause of the second release from the spherical tank was the fact that the legs of the sphere were not insulated against fire so that they eventually buckled after being exposed to direct flame contact.

[4] *"Report on the Investigation of the Fire at the Liquefaction, Storage, and Regasification Plant of the East Ohio Gas Co., Cleveland, Ohio, October 20, 1944,"* U.S. Bureau of Mines, February, 1946.

Further, it should be noted that the ignition of the two unconfined vapor clouds of LNG in Cleveland did not result in explosions. There was no evidence of any explosion overpressures after the ignition of the spill from either the cylindrical tank or the sphere. The only explosions that took place in Cleveland were limited to the sewers where LNG ran and vaporized before the vapor-air mixture ignited in a relatively confined volume. The U.S. Bureau of Mines, concluded that the concept of liquefying and storing LNG was valid if "proper precautions are observed."

The Cleveland Disaster put an end to any further LNG development in the United States for many years. It was not until the early sixties that LNG began to be taken seriously through construction of LNG peakshaving facilities. A number of elements came together to bring LNG back; these included:

- The advent of the space program and its associated cryogenic technologies
- Successful large-scale fire and vapor cloud dispersion demonstrations
- Extensive cryogenic material compatibility studies
- Construction and operation of liquefaction plants in Algeria and receiving terminals in France and England.

2. May, 1965 Canvey Island, Essex, United Kingdom
LNG Import Terminal
A small amount of LNG spilled from a tank during maintenance. The spill ignited and one worker was seriously burned. No other details have been made available.

3. March, 1968 Portland, Oregon, USA
LNG Peakshaving Facility - *Construction Accident, no LNG present*
Four workers inside an unfinished LNG storage tank were killed when natural gas from a pipeline being pressure tested inadvertently entered the tank as a result of improper isolation, and then ignited causing an explosion. The LNG tank was 120 feet in diameter with a 100-foot shell height and a capacity of 176,000 barrels and damaged beyond repair. Neither the tank nor the process facility had been commissioned at the time the accident occurred. The LNG tank involved in this accident had never been commissioned; thus, it had never contained any LNG.

4. 1971 La Spezia, Italy
LNG Import Terminal - *First documented LNG Rollover incident*
The LNG carrier *Esso Brega* had been in the harbor for about a month before unloading its load of "heavy" LNG into the storage tank. Eighteen hours after the tank was filled, the tank developed a sudden increase in pressure causing LNG vapor to discharge from the tank safety valves and vents over a period of a few hours. The roof of the tank was also slightly damaged. It is estimated that about 100 mmscf of LNG vapor flowed out of the tank. No ignition took place. This accident was caused by a phenomenon called "rollover,"[5] where two layers of LNG having different densities and heat content are allowed to form. The sudden mixing of these two layers results in the release of large volumes of vapor.

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[5] See Section 3.1 of CH·IV's ***"Introduction to LNG Safety,"*** *Short Course on LNG Rollover.*

5. January, 1972 Montreal, Canada
LNG Peakshaving Facility - *Although an LNG facility, LNG was not involved*
On January 27, 1972 an explosion occurred in the LNG liquefaction and peak shaving plant of Gaz Métropolitain in Montreal East, Quebec. The accident occurred in the control room due to a back flow of natural gas from the compressor to the nitrogen line. Nitrogen was supplied to the recycle compressor as a seal gas during defrosting operations. The valves on the nitrogen line that were kept open during defrosting operation were not closed after completing the operation. This resulted in the over-pressurization of the compressor with up to 250 - 350 psig of natural gas. Natural gas entered the nitrogen header, which was at 75 psig. The pneumatically controlled instruments were being operated with nitrogen due to the failure of the instrument-air compressor. The instruments vented their contents into the atmosphere at the control panel. Natural gas entered the control room through the nitrogen header and accumulated in the control room, where operators were allowed to smoke. The explosion occurred while an operator was trying to light a cigarette.

6. February, 1973 Staten Island, New York, USA
LNG Peakshaving Facility - *Construction Accident, no LNG present*
Proper precautions have been common place in all of the LNG facilities built and placed in service ever since Cleveland. Between the mid-1960s and mid-1970s more than 60 LNG facilities were built in the United States. These peak-shaving plants have had an excellent safety record. This construction accident has consistently been used by opponents of LNG as a case-in-point to depict the danger of LNG, after all, "37 persons lost their lives at an LNG facility."

One of Texas Eastern Transmission Corporation's (TETCO) LNG storage tanks on Staten Island had been in service for over three years when it was taken out of service for internal repairs. The tank was warmed, purged of the remaining combustible gases with inert nitrogen, and then filled with fresh recirculating air. A construction crew entered the tank to begin repair work in April of 1972. Ten months later, in February of 1973, an unknown cause ignited the Mylar liner and polyurethane foam insulation inside the tank. Initial standard operating procedures called for the use of explosion-proof equipment within the tank, however nonexplosion proof irons and vacuum cleaners were being used for sealing the liner and cleaning insulation debris. It is assumed that an electrical spark in one of the irons or vacuum cleaners ignited the Mylar liner. The rapid rise in temperature caused a corresponding raise in pressure. The pressure increase lifted the tank's concrete dome. The dome then collapsed killing the 37 construction workers inside.

The subsequent New York City Fire Department investigation[6] concluded that the accident was clearly a construction accident and not an LNG accident. This has not prevented LNG's opponents from claiming that since there may have been latent vapors from the heavy components of the LNG that was stored in the tank, then it was in fact an LNG incident.

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[6] ***"Report of Texas Eastern LNG Tank Fatal Fire and Roof Collapse, February 10, 1973,"*** Fire Department ofthe City of New York, July, 1973

7. March, 1977 Arzew, Algeria
LNG Export Terminal
A worker at the CAMEL plant was frozen to death when he was sprayed with LNG, which was escaping from a ruptured valve body on top of an in-ground storage tank. Approximately 1,500 to 2,000 m^3 of LNG were released, but the resulting vapor cloud did not ignite. The valve body that ruptured was constructed of cast aluminum. The current practice is to fabricate large valves in LNG service with stainless steel.

8. March, 1978 Das Island, United Arab Emirates
LNG Export Terminal
A bottom pipe connection of an LNG tank failed resulting in an LNG spill inside the LNG tank containment. The liquid flow was stopped by closing the internal valve designed for just such service. A large vapor cloud resulted and dissipated without ignition. No injuries or fatalities were reported.

9. October, 1979 Cove Point, Maryland, USA
LNG Import Terminal
The Cove Point LNG Receiving Terminal in Maryland began operations in the spring of 1978. By the fall of 1979, Cove Point had unloaded over 80 LNG ships. In 1979, a tragic accident occurred at Cove Point that took the life of one operator and seriously burned another.

Around 3:00 AM on October 6, 1979, an explosion occurred within an electrical substation at Cove Point. LNG had leaked through an inadequately tightened LNG pump electrical penetration seal, vaporized, passed through 200 feet of underground electrical conduit, and entered the substation. Since natural gas was never expected in this substation, no gas detectors had been installed in the building. The natural gas-air mixture was ignited by the normal arcing contacts of a circuit breaker, resulting in an explosion. The explosion killed one operator in the building, seriously injured a second and caused about $3 million in damages.

The National Transportation Safety Board (NTSB) found[7] that the Cove Point Terminal was designed and constructed in conformance with all appropriate regulations and codes. It further concluded that this was an isolated incident, not likely to recur elsewhere. The NTSB concluded that it is unlikely that any pump seal, regardless of the liquid being pumped, could be designed, fabricated, or installed to completely preclude the possibility of leakage. With that conclusion in mind, building codes pertaining to the equipment and systems downstream of the pump seal were changed. Before the Cove Point Terminal was restarted, all pump seal systems were modified to meet the new codes and gas detection systems were added to all buildings.

[7] "Columbia LNG Corporation Explosion and Fire; Cove Point, MD; October 6, 1979" National Transportation Safety Board Report NTSB-PAR-80-2, April 16, 1980

10. April, 1983 Bontang, Indonesia

LNG Export Terminal - *Maintenance Accident, no LNG present*

A major incident occurred on April 14, 1983 in Bontang, Indonesia. The main liquefaction column (large vertical shell-and-tube heat exchanger) in Train B ruptured due to overpressurization of the heat exchanger caused by a blind[8] left in a flare line during start-up. All the pressure relief systems were connected to this line. The exchanger was designed to operate at 60 psig on the shell side. The gas pressure reached 180 psig causing the failure of the exchanger. Debris and coil sections were projected some 50 meters away. Shrapnel from the column killed three workers. The ensuing fire was extinguished in about 30 minutes.

11. 1987 Mercury, Nevada, USA

Department of Energy Test Facility

An accidental ignition of an LNG vapor cloud occurred at the DOE, Nevada Test Site on August 29, 1987. The large-scale tests involving spills of LNG on water were sponsored by the Department of Energy and Gas Research Institute to study the effectiveness of vapor fences in reducing the extent of downwind dispersion of LNG vapor clouds. The cloud accidentally ignited during Test #5 just after a sequence of relatively strong rapid phase transitions (RPTs) which damaged and propelled polyurethane pipe insulation outside the fence.

The official explanation was that a spark generated by static electricity approximately 76 seconds after the spill was the most likely source of ignition. An independent investigation on behalf of Gas Research Institute showed that a more likely source of ignition was oxygen enrichment between the surface of the LNG pipe and the combustible polyurethane foam insulation. Oxygen enrichment occurred during the long cool-down period with liquid nitrogen that preceded the LNG test. Such enrichment had been previously observed during tests carried out by an LNG tank design and manufacturing company. Impacts during the RPTs may have ignited the insulation but not the nearby fuel-rich vapor cloud. However, when a smoldering insulation fragment was propelled outside the fence by an RPT, it ignited the portion of the cloud that was within the flammable limits. The duration of the fire was 30 seconds. The flame length was about 20 feet above the ground.

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[8] A flat plate temporarily installed between flanges during construction and/or maintenance to isolate equipment.

There have been other accidental ignitions involving LNG during large-scale tests.

- One occurred in England during large-scale fire tests being carried out by British Gas Corporation. Stray currents from a nearby radar station were blamed for prematurely igniting the primer that was eventually to be used to ignite the LNG cloud.
- Another occurred in Japan during similar large-scale tests carried out by Japan Gas Association. The ignition mechanism was not explained.
- During a test at a research facility near San Clemente, California, a sudden change in wind direction caused the vapor cloud to encounter a tractor that was moving some of the test equipment. The tractor ignited the vapor cloud, badly burning the driver. A researcher was also in the vapor cloud at the time of ignition. He was able to get out of the vapor cloud before the flame front reached him by running crosswind and was not injured.

12. August, 1985 Pinson, Alabama, USA
LNG Peakshaving Facility
The welds on an 8 1/ 4-inch by 12-inch "patch plate" on a small aluminum vessel (3 ft in diameter by 7 ft tall) failed as the vessel was receiving LNG which was being drained from the liquefaction cold box. The plate was propelled into a building that contained the control room, boiler room, and offices. Some of the windows in the control room were blown inward and natural gas escaping from the failed vessel entered the building and ignited. Six employees were injured.

13. 1988 Everett, Massachusetts, USA
LNG Import Terminal
Approximately 30,000 gallons of LNG were spilled through "blown" flange gaskets during an interruption in LNG transfer at Distrigas. The cause was later determined to be "condensation induced water hammer."[9] The spill was contained in a small area, as designed. The still night prevented the movement of the vapor cloud from the immediate area. No one was injured and no damage occurred beyond the blown gasket. Operating procedures, both manual and automatic, were modified as a result.

14. 1989 Thurley, United Kingdom
LNG Peakshaving Facility
While cooling down the vaporizers in preparation for sending out natural gas, lowpoint drain valves were opened on each vaporizer. One of these drain valves had not been closed when the pumps were started and LNG entered the vaporizers. As a result, LNG was released into the atmosphere as a high-pressure jet. The resulting vapor cloud ignited about thirty seconds after the release began. The flash fire covered an area approximately 40 by 25 m. Two operators received burns to their hands and faces. The source of ignition was believed to be the pilot light on one of the other submerged combustion vaporizers.

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[9] See description in Section 3.1 of CH·IV's ***"Introduction to LNG Safety"***

15. September, 2000 Savannah, Georgia, USA
LNG Import Terminal
In September 2000, a 580-foot ship, the Sun Sapphire, lost control in the Savannah River and crashed into the LNG unloading pier at Elba Island. The Elba Island facility was undergoing reactivation but had no LNG in the plant. The Sun Sapphire, carrying almost 20 tons of palm and coconut oil, suffered a 40-foot gash in her hull. The point of impact at the terminal was the LNG unloading platform. Although the LNG facility experienced significant damage, including the need to replace five 16" unloading arms, there was no indication that had LNG been present in the piping that there would have been a release. Given the geometry of the Savannah River at Elba Island, it is doubtful that had an LNG ship been present that a similar ramming could have penetrated the double hull and released any LNG.

16. January, 2004 Skikda, Algeria *(Source: New York Times, February 12, 2004)*
LNG Export Terminal
On January 19, 2004 an explosion killed 30 people and injured over 70 in the Algerian port of Skikda. The port is responsible for approximately 25% of LNG exports from Algeria. The Algerian national oil and gas company, Sonatrach, attributes the explosion to a malfunction in a steam boiler, the type of which are not used in U.S. facilities. An official investigation is currently underway.

Appendix B: Average Abundance of Benthic Species in Proposed FSRU Project Vicinity (with Frequency of Occurrence Greater than 60 Percent and Average Abundance of at least $20/m^2$ in Each Group) All Values are Area Weighted.
Source: Cabrillo Port EA

Species	Taxonomic Group	Deep Coarse	Deep Fine	Mid-Depth	Shallow
Spiophanes missionensis	Annelids	386.0	195.0	563.2	132.2
Amphiodia digitata	Ophiuroidea	236.0			
Euphilomedes producta	Arthropoda	215.0			
Mediomastus spp.	Annelida	168.0	71.6	117.8	76.2
Chloeia pinnata	Annelida	100.0			
Amphiodia urtica	Ophiuroidea	83.0	263.2	422.0	
Spiophanes firnbriata	Annelida	82.0	149.7		
Ampelisca careyi	Arthropoda	69.0	21.0		
Photis lacia	Arthropoda	69.0			
Rhepoxynius bicuspidatus	Arthropoda	59.0		43.0	
Maldanidae*	Annelida	51.0	91.5	105.0	127.9
Pectinaria califomiensis	Annelida	50.0	91.1	85.3	
Eudorella pacifica	Arthropoda	35.0			
Lumbrineris spp.	Annelida	35.0	94.0	50.8	57.5
Paraprionospio pinnata	Annelida	33.0	47.8	45.4	108.9
Euclymeninae sp. A	Annelida	31.0		28.2	
Decamastus gracilis	Annelida	21.0			
Terebellides califomica	Annelida		23.0	20.2	
Maldane sarsi	Annelida		34.0		
Levinsenia spp.	Annelida		30.3		
Cossura spp.	Annelida		26.9		
Laonice appelloefi	Annelida		21.8		
Sthenelanella uniformis	Annelida			84.2	
Phoronis sp.	Phoronida			77.9	
Prionospio sp. A	Annelida			76.4	
Ampelisca brevisimulata	Arthropoda			50.2	31.6
Euphilomedes carcharodonta	Arthropoda			47.5	
Paramage scutata	Annelida			46.4	
Parvilucina tenuisculpta	Mollusca			44.0	
Leptochelia dubia	Arthropoda			42.3	
Heterophoxus oculatus	Arthropoda			37.6	
Pholoe glabra	Annelida			28.0	
Glycera nana	Annelida			26.7	

Species	**Taxonomic Group**	**Deep Coarse**	**Deep Fine**	**Mid-Depth**	**Shallow**
Tellina carpenteri	Mollusca			24.4	
Gnathia crenulatifrons	Arthropoda			24.2	
Tubulanus polymorphus	Nemertea			23.2	
Ampelisca pugetica	Arthropoda			22.2	
Amphideutopus oculatus	Arthropoda				132.9
Glottidia albida	Brachiopoda				90.3
Spiophanes bombyx	Annelida				82.6
Ampelisca cristata	Arthropoda				65.1
Macoma yoldiformis	Mollusca				54.8
Tellina modesta	Mollusca				50.8
Apoprionospio pygmaea	Annelida				50.0
Owenia collaris	Annelida				44.7
Amphicteis scaphobranchiata	Annelida				24.8
Carinoma mutabilis	Nemertea				24.3
Ampharete labrops	Annelida				23.4
Rhepoxynius menziesi	Arthropoda				22.2
Lineidae	Nemertea				20.3

*All Maldanids except 11 identified species.

Appendix C: Common Fish of the Proposed FSRU Project Vicinity with Associated Habitats and Water Depths source. *Source: Cabrillo Port EA*

Common Names	Soft Bottom 0 To 25m	Soft Bottom > 25m	Hard Bottom 0 To 25m	Hard Bottom > 25m
Bass, barred sand	X	X		
Bass, kelp			X	X
Bass, spotted bay	X	X	X	X
California corbina[1]	X			
Cowcod		X		X
Croaker, yellowfin[1]	X	X		
Croaker, white	X	X		
Garibaldi			X	
Grunion, California[1]	X			
Guitarfish, shovelnose[1]	X			
Halibut, California	X	X		
Halfmoon			X	X
Opaleye			X	X
Ray, bat	X	X		
Rockfish, black	X	X	X	X
Rockfish, blue			X	X
Rockfish, bocaccio	X	X	X	X
Rockfish, calico		X		X
Rockfish, kelp			X	X
Sanddab, Pacific		X		
Sanddab, speckled	X	X		
Scorpionfish, California	X	X	X	X
Seabass, white	X	X	X	X
Shark, leopard	X			
Sheephead, California			X	X
Sole, Dover		X		
Sole, petrale		X		
Surfperch spp.[1]	X			
Thornyhead spp.		X		X

[1]Commonly found in intertidal and surf zones

Appendix D: Special-Status Plant Species Potentially Occurring in the Ormond Beach Area. *Source: Cabrillo Port EA*

Scientific Name **Common Name**	**Status**	**Growth Form**	**Flowering Period**	**Habitat**	**Potential To Occur in Project Area**
Astragalus pycnostachyus var. *lanosissimus* Ventura marsh milk-vetch	FE, CE, CNPS 1B	perennial herb	Jun-Oct	Coastal salt marsh. Within reach of high tide or protected by barrier beaches, more rarely near seeps on sandy bluffs. 1-35m.	Suitable habitat is present in the Project area.
Chaenactis glabriuscula var. *orcuttiana* Orcutt's pincushion	CNPS 1B	annual herb	Jan-Aug	Coastal bluff scrub, coastal dunes. Sandy sites. 3-100m.	Suitable habitat is present in the Project area.
Cordylanthus maritimus ssp. *maritimus* salt marsh bird's-beak	FE, CE, CNPS 1B	annual herb, hemiparasitic	May-Oct	Coastal salt marsh, coastal dunes. Limited to the higher zones of the salt marsh habitat. 0-30m.	Suitable habitat is present near the Project area.
Lasthenia glabrata ssp. *Coulteri* Coulter's goldfields	CNPS 1B	annual herb	Feb-Jun	Coastal salt marshes, playas, valley & foothill grassland, vernal pools. Usually on alkaline soils in playas, sinks & grasslands. 1-1400m.	Suitable habitat is present in the Project area.

Codes:
FE = federally listed as endangered
CE = listed by California as endangered
CNPS 1B = California Native Plant Society designated as rare, threatened or endangered in California and elsewhere.
Status codes derived from CNDDB (CDFG 2002a), CDFG 2003a, 2003b), CNPS (2001).

Appendix E: Special Status Wildlife Species Potentially Occurring in the Offshore Project Areas. *Source: Cabrillo Port EA.*

Wildlife Species	Status Fed/State/CNPS	Habitat and Occurrence in Project Area
Freshwater Fish		
Eucyclogobius newberryi Tidewater goby	FE/CSC	Brackish water habitats along the California coast, in shallow lagoons and lower stream reaches. Need fairly still but not stagnant water and high oxygen levels. Reported from Calleguas Creek, the Santa Clara River estuary, and the Oxnard Drain ("J" Street Canal) at Ormond Beach in the Project vicinity.
Gila orcutti Arroyo chub	CSC	Slow water stream sections with mud or sand bottoms. Feed heavily on aquatic vegetation and associated invertebrates. Reported from the freshwater sections of Calleguas Creek and Revolon Slough, tributaries of Mugu Lagoon.
Mollusks		
Tryonia imitator Mimic tryonia (California brackishwater snails)		Coastal lagoons, estuaries and salt marshes from Sonoma County to San Diego County. Found only in permanently submerged areas in a variety of sediment types. Reported from Mugu Lagoon.
Insects		
Coelus globosus Globose dune beetle	FSC	Coastal sand dune habitat from Sonoma County to Ensenada, Mexico. Inhabits foredunes and sand hummocks. Burrows beneath the sand surface and is most common beneath dune vegetation. Reported from the sand dunes of the barrier beach along the entire length of the Point Mugu Naval Air Station.
Cincindela hirticollis gravida Sandy beach tiger beetle	FSC	Adjacent to non-brackish water along the coast of California from San Francisco Bay to northern Mexico. Clean, dry, light-colored sand in the upper intertidal zone. Subterranean larvae prefer moist sand not affected by wave action. Reported from depressions in the dunes at Point Mugu Naval Air Station.
Cicindela senilis frosti Tiger beetle		Estuaries and mudflats along the coast of Southern California. Generally on dark-colored mud in the lower zone; occasionally on dry saline flats of estuaries and in salt marshes. This subspecies has been reported from Mugu Lagoon.
Danaus plexippus Monarch butterfly		Winter roost sites extend along the coast from Northern Mendocino to Baja California, Mexico. Roosts located in wind-protected groves of eucalyptus, Monterey pine and cypress. Nectar and water sources nearby. Reported from Point Mugu State Park and the "Blue Gum Grove" site just east of Pleasant Valley Road in the Project vicinity. No roost trees are present in the Project area.
Panoquina errans		Southern California coastal salt marshes. Adults are

Wildlife Species	Status Fed/State/CNPS	Habitat and Occurrence in Project Area
Wandering skipper		occasionally seen feeding on flowers on the barrier beach sand dunes or in upland areas. Found in close association with salt grass. Reported from the Project area.
Reptiles		
Clemmys marmorata pallida Southwestern pond turtle	FSC/CSC	Permanent or nearly permanent bodies of water in many habitat types; below 6,000 ft. elevation. Require basking sites such as partially submerged logs, vegetation mats, or open mud banks.
Phrynosoma coronatum blainvillei San Diego horned lizard	CSC	Inhabits coastal sage scrub and chaparral in arid and semi-arid climate conditions. Reported from the river side of an existing levee, south of the Santa Clara River, in the Project vicinity.
Birds		
Athene cunicularia hypugaea Western burrowing owl	FSC/CSC	Open, dry annual or perennial grasslands, deserts and scrublands characterized by low growing vegetation. Subterranean nester dependent upon burrowing mammals to provide nesting burrows. Reported from south of McGrath State Beach campgrounds, in the Project vicinity.
Buteo regalis Ferruginous Hawk	FSC/CSC	Winters in open grasslands, sagebrush flats, desert scrub, low foothills, coastal salt marsh, and fringes of pinyon-juniper habitats. Eats rabbits, hares, ground squirrels, and mice. Reported from the salt marshes at Mugu Lagoon.
Charadrius alexandrinus nivosus Western snowy plover	FT/CSC	Sandy beaches, salt pond levees and shores of large alkali lakes. Winters and breeds along beaches of the eastern Pacific to British Columbia. Needs sandy, gravelly, or friable soils for nesting. Reported as nesting in a dune-backed beach in Project vicinity.
Coccyzus americanus occidentalis Western yellow-billed cuckoo	CE	Riparian forest nester. Riparian jungles of willow, often mixed with cottonwoods, with lower story of blackberry, nettles, or wild grape. Reported from the mouth of the Santa Clara River in a sandy floodplain between levees, but not expected to occur in the Project area because no woody riparian vegetation is present.
Falco peregrinus anatum American peregrine falcon	FD, FSC/CE, CFP	Nests near wetlands, lakes, rivers, or other water; on cliffs, banks, dunes, mounds; also, human-made structures. Nest consists of a scrape on a depression or ledge in an open site. Migrants occur along the coast, and in the western Sierra Nevada in spring and fall.
Larus californicus California gull	CSC	Colonial nester on islets in large interior lakes, either fresh or strongly alkaline. An abundant visitor to coastal and interior lowlands in nonbreeding season. In late summer, migrates westward across the Sierra Nevada from interior nesting grounds to winter in California and the Pacific Northwest. Preferred habitats along the coast are sandy beaches, mudflats,

Wildlife Species	Status Fed/State/CNPS	Habitat and Occurrence in Project Area
		rocky intertidal, and pelagic areas of marine and estuarine habitats, as well as fresh and saline emergent wetlands.
Laterallus jamaicensis coturniculus California black rail	FSC/CT, CFP	Mainly inhabits salt-marshes bordering larger bays. Occurs in tidal salt marsh heavily grown to pickleweed; also in fresh-water and brackish marshes, all at low elevation. Reported from the Project vicinity.
Passerculus sandwichensis beldingi Belding's savannah sparrow	CE	Common but local permanent residents associated with pickleweed habitat, restricted to coastal salt marshes from southern Santa Barbara County to San Diego County. Reported from east, central and west portions of Point Mugu Lagoon. Also reported from Ormond Beach wetlands in a small patch of marsh between the power plant and the northwest fenceline.
Pelecanus occidentalis californicus California brown pelican	FE/CE	Common along the California coast. Observed year-round near the Santa Ynez River mouth. Largest flocks (several hundred individuals) occur in summer. Forages in estuary and offshore waters. Reported from the vicinity of the generating plant.
Phalacrocorax auritus Double-crested cormorant	CSC	Colonial nester on coastal cliffs, offshore islands, & along lake margins in the interior of the state. Nests along coast on sequestered islets, usually on ground with sloping surface, or in tall trees along lake margins. A yearlong resident along the entire coast of California and on inland lakes, in fresh, salt and estuarine waters. Reported from the Project vicinity.
Rallus longirostris levipes Light-footed clapper rail	FE/CE	Found in salt marshes traversed by tidal sloughs, where cordgrass and pickleweed are the dominant vegetation. Reported from the salt marshes at Mugu Lagoon.
Riparia riparia Bank swallow	FSC/CT	Nests primarily in riparian and other lowland habitats west of the desert. Requires vertical banks/cliffs with fine-textured/sandy soils near streams, rivers, lakes, or ocean to dig nesting hole. Reported from the Santa Clara River estuary in the Project vicinity, but not expected to occur in the Project area due to lack of habitat.
Sterna antillarum browni California least tern	FE/CE	Nests at isolated beaches near bays and lagoons, San Francisco Bay to Northern Baja California. Present in Project area from May to September. Colonial breeder on bare or sparsely vegetated flat substrates, sand beaches, alkali flats, land fills, or paved areas. Has nested in the Project vicinity at Ormond Beach since 1931. Also reported from just north of inlet to Channel Island Harbor.
Sterna elegans (=Thalasseus e.) Elegant tern	FSC/CSC	Formerly a rare and irregular post-nesting visitor to coastal California. Large flocks now can be seen in most years off the southern California coast. Preferred habitats are inshore coastal waters, bays, estuaries, and harbors; rarely occurs far offshore, and never inland.

Wildlife Species	Status Fed/State/CNPS	Habitat and Occurrence in Project Area
		Reported from the Project vicinity.
Vireo bellii pusillus Least Bell's vireo	FE/CE	Nests in Southern California, during summer, in low riparian areas in vicinity of water or in dry river bottoms; below 2000 ft. Nests placed along margins of bushes or on twigs projecting into pathways, usually willow, baccharis, mesquite. Reported from Project vicinity in a streambed supporting sycamores and other shrubs, but no willows. Not expected to occur in the Project area, because no woody riparian vegetation is present.

Sources: CDFG 2002a,CDFG 2003a, 2003b, 2003c, 2003d, CNPS 2000, Zeiner, et al. 1988, 1990a, 1990b
FE – federally listed as endangered
FT = federally listed as threatened
FD = federally de-listed
FSC = federal species of concern
CE = state listed as endangered
CT = state listed as threatened
CSC = California species of concern
CFP = California Fully Protected
CNPS 1B = California Native Plant Society designated as rare, threatened or endangered in California and elsewhere.

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