



LNG Facilities in Urban Areas

A SECURITY RISK MANAGEMENT ANALYSIS FOR
ATTORNEY GENERAL PATRICK LYNCH

RHODE ISLAND

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Key Judgments

This analysis focuses on Security Risk Management involving intentional damage by a determined group. It does not address Safety Risk Management.

1. **METHODOLOGY:** Traditional risk management calculation methodologies are insufficient to deal effectively with the security risk now posed by terrorist groups. Traditional risk management methodologies would have determined that the probability of terrorists employing hijacked commercial passenger aircraft to destroy the World Trade Center was zero. The probability of a terrorist attack occurring can not be effectively measured, but it is now "a foreseeable risk" in the United States. Instead of calculations involving probability of attack, we suggest an alternative five part methodology for determining security risks and cost calculations.

2. **SECURITY RISK MANAGEMENT:** An appropriate security risk management methodology examines five factors:

INTENT, whether and to what extent terrorist groups have expressed interest in attacking a particular type of target or whether their overall ends and priorities would be served by such attacks;

CAPABILITIES, whether and to what extent terrorist groups have or could easily obtain the means necessary to conduct a significant attack against a class of facilities;

VULNERABILITIES, whether and to what extent a class of facilities have inherent weaknesses to certain vectors of attack, with and without mitigation efforts;

CONSEQUENCES, what the range of damage from an attack on a certain class of facilities could be and to what extent the facilities and the communities in which they reside have the capability to respond adequately to such circumstances; what the costs would be of creating missing capabilities and on whom the financial burden would be placed;

RECOVERY, what the timing and costs of various kinds would be to restore essential services and infrastructure and to otherwise compensate for damages after an attack, and on whom the financial burden would be placed.

3. INTENT: The Jihadist Terrorist network of al Qaeda and similar groups have articulated goals including a) killing large numbers of Americans, b) conducting attacks in the US, c) damaging the US economy and infrastructure, and d) damaging oil and gas infrastructure.

The al Qaeda network has demonstrated the use of parts of the US civilian infrastructure as weapons to be used against US facilities.

As to intent to attack shipping, the al Qaeda network has used explosive laden small craft to attack a US destroyer in port and a double hulled French tanker at sea. They have planned or discussed attacks on shipping in other locations around the world. The FBI has warned that the al Qaeda network is interested in scuba gear for underwater attacks in the US.

Other terrorist groups, specifically homegrown American groups, have also planned to destroy infrastructure in this country, such as the attack in Oklahoma in 1995 and the attempted attack on a gas storage facility in California in 1998.

4. CAPABILITY: Al Qaeda and related groups have demonstrated an ability to operate in the US. Even since 9-11, terrorist groups have maintained a presence in the US. A recent report indicated that the FBI has over 1000 Full Field Investigations underway against al Qaeda alone. Illegal crossing into the United States is a commonplace activity.

Weapons and other capabilities needed to conduct an attack on an urban LNG off loading facility or an LNG tanker can be readily obtained in the US, according to US Government reports. A variety of boats and scuba gear can be easily procured. General Aviation aircraft can easily be rented or stolen at numerous small airports throughout the US. Explosives are readily available, both fertilizer based weapons, which can be procured without a license, and commercial explosives, which are frequently stolen and sold on the black market. Fifty caliber rifles with anti-armor shells are readily available in the US. Rocket propelled grenades (RPGs), light anti-tank weapons, mortars, and bazooka styled weapons are very easily and cheaply obtainable on the international gray arms market. Few containers entering the United States are inspected by US Customs.

5. VULNERABILITIES: Both the proposed urban LNG off loading facility and the proposed LNG tanker transit through 29 miles of Rhode Island have security vulnerabilities that are unlikely to be successfully remediated.

The creation of permanent or temporary restricted flight areas around the urban LNG facility and the tanker will not prevent hijacked or stolen aircraft (commercial passenger, commercial freight, or general aviation) from successfully penetrating the restricted airspace and crashing into the facility and/or ship. No air defense system is planned, nor is it easy to imagine a system which would authorize the use of deadly force against an aircraft that might appear to have unintentionally strayed into the restricted air space.

As to the LNG ship, the creation of restricted waterways around the LNG tanker and the use of armed Coast Guard (USCG) patrol craft provides little assurance that a determined terrorist group would be stopped before attacking the tanker with an explosives laden vessel. Narraganset Bay is home to thousands of small craft. The USCG and other law enforcement agencies would be reluctant to use lethal force against an apparently misguided pleasure craft. Moreover, the escorting patrol boats could themselves be attacked in a multi-boat terrorist operation. Counter-SCUBA operations in the Bay would also not offer high assurance of success.

Attacks involving stand off weapons could be mounted from boats or from numerous land locations along the route. To prevent the entry of weapons for land based, stand-off attacks, all vehicles entering the littoral would have to be searched not just during the tanker's transit, but at all times.

As to the urban LNG facility, it currently appears to have inadequate security to prevent unauthorized penetration. Upgrades to the facility would be unlikely to prevent the two wave attack technique demonstrated by al Qaeda in Saudi Arabia, Iraq, Kenya, Pakistan and elsewhere. The two wave attack involves an initial explosion or small arms attack directed at security gates and guards, followed by a second attacking vehicle carrying a large explosive.

We are unaware of any analysis performed by counter-terrorism experts in the US Government, such as the US Special Operation Command, that would demonstrate the ability of the Coast Guard and the Rhode Island police to prevent attacks by determined and skilled terrorists on either the urban off loading facility and/or the LNG tanker during its 29 mile inland waterway transit.

6. CONSEQUENCES: There is a spectrum of expert opinion on the precise extent of damage that would result from various levels of attack on an urban LNG facility and on an LNG tanker. There appears, however, to be a high risk that catastrophic damage could occur if a large breach were made in the urban LNG facility's tank, if three of five containers aboard the LNG tanker were breached, or if an attack occurred involving both the facility and the tanker during unloading.

The consequences of a major attack could include fires that would damage homes, hospitals, a chemical plant, and other infrastructure, depending upon where the attack occurred. Many fires could exceed the 2000 BTU limit for the employment of fire fighters, necessitating a "let it burn" approach to many structures. There would be both prompt and delayed fatalities.

The delayed fatalities and the wounded could place a burden on the Rhode Island and South Eastern Massachusetts trauma, burn, and overall emergency medical response capability that the system would be unable to handle. It is unclear where the funding would come from to upgrade the region's consequence management capabilities to be able to deal with a possible catastrophic attack on the urban LNG facility and/or tanker. Governments could, however, place that burden on the facility owners and operators, similar to the Nuclear Regulatory Commission's approach to commercial nuclear reactors.

7. RECOVERY: The financial cost of compensating victims and rebuilding damaged or destroyed facilities following a catastrophic attack on the urban LNG facility and/or LNG tanker would likely exceed any insurance carried by the owners and operators of the LNG facility and tanker.

8. HIDDEN COSTS: In the absence of adequate insurance to pay victims and rebuild damaged or destroyed facilities, the LNG operators would be transferring the financial cost of

the risk they would be creating either to the victims or to governments, or to some combination of both. Governments would also bear costs for greatly enhanced security and consequence management, including mass trauma and burn capabilities.

9. RISK JUDGMENT: We judge that terrorist groups now have the intent to attack facilities in the US such as the urban LNG off loading facility proposed. We judge that they could relatively easily both obtain the needed capability and conduct an attack on the urban LNG facility and/or the LNG tanker during its transit of 29 miles of inland waterway. We judge that such attacks run a high risk of generating catastrophic damage, with which the region could not adequately cope during the consequence management or recovery phases.

10. RISK REDUCTION AND AVOIDANCE: We doubt that deterrence or prevention measures could be designed and implemented for the proposed facility and ship routing that would be adequate against a determined and skilled terrorist group of the type that exists today. Possibilities for further investigation, however, include:

--armor plating the gas storage containers aboard the LNG tankers which transit inland waterways near populated areas,

--transporting gas along inland waterways near populated areas only in tankers that do not freeze and condense the gas, thereby significantly reducing the force and radius of an explosion

--constructing structures around LNG facilities in urban areas similar to those buildings required by the Nuclear Regulatory Commission around commercial nuclear reactors (an NRC design criterion is that a direct hit by a general aviation aircraft would not breach the reactor).

All of those measures would significantly increase the cost

of building or operating the LNG facility or LNG tanker.

Alternatively, the LNG off loading facility could be sited in a location that did not involve either an urban environment for the facility or an inland waterway transit for the LNG tanker. Locating the facility in a non-urban environment and eliminating the inland waterway transit would significantly reduce both the attractiveness to terrorists of an attack (because the attack would not generate large scale casualties) and the consequence management and recovery burdens on governments should an attack occur. We note that GAO, the investigatory arm of the Congress, recommended in 1979 that the Congress or Administration prohibit any additional large scale LNG facilities in or LNG tanker transit through urban areas.

NET ASSESSMENT: While there is no adequate way in which to determine the probability of a terrorist attack on the proposed urban LNG facility and inland waterway transit routing, there is adequate grounds to judge that such an attack would be consistent with terrorists demonstrated intent and capability. There is also a basis to judge that likely enhanced security measures would not significantly reduce the risk. While there are some differences among experts about the conditions needed to generate a catastrophic explosion and about the precise extent of the resulting damage, there is significant grounds to conclude that a high risk exists of catastrophic damage from the types of attacks terrorists are capable of mounting. Those damage levels would overwhelm regional trauma, burn, and emergency medical capabilities. The LNG facility's insurance is likely to be inadequate to fully compensate victims and to rebuild facilities.

Siting the LNG off loading facility in a non-urban setting would reduce the terrorists' incentives to attack it.

Non-urban locations may possibly increase costs to the LNG operator and consumers.

If all alternative sites do cost more and governments decide to proceed with the proposed urban location because of that cost differential, then the cost trade off can be precisely measured. Governments would be deciding that avoiding the possible additional financial cost to the LNG operator and/or consumers of a more secure location is more important public policy than avoiding the additional risk of a catastrophic attack involving mass trauma and burn injuries which does accompany a decision to permit an urban LNG facility.

TABLE OF CONTENTS

SECTION ONE: BACKGROUND & THREAT ANALYSIS..... 13

I. SUMMARY 13

II. BACKGROUND AND THREAT ANALYSIS 15

 A. The Nexus of Terrorist Groups and LNG..... 15

 1. Philosophical Context 15

 2. History of Terrorist Acts..... 27

 B. The Threat 32

 1. The Future of Maritime Terrorism 32

 2. Safety Record of the LNG Industry 38

 3. The Potential Threats 41

 4. Properties of LNG..... 46

 5. Extant Threat Analyses 51

 6. FERC’s Risk Assessment of the Threat 52

 7. Conclusions 58

SECTION TWO: THREAT SCENARIOS INVOLVING AN LNG TANKER IN NARRAGANSETT BAY 60

I. INTRODUCTION..... 60

 A. Purpose 60

 B. Summary of Analysis 60

II. CONSTRUCTION METHODS FOR THE STORAGE AND TRANSPORT OF LNG..... 64

 A. Methods of Construction 64

 1. Figure 2.1: LNG Tank Construction Cross Cut Diagram Moss Tanker 65

 2. Figure 2.2: LNG Tank Construction Cross Cut Diagram Prismatic Tanker..... 67

III. RISK ASSESSMENT OF THE NARRAGANSETT BAY AND PROVIDENCE RIVER 68

 A. Narragansett Bay and Providence River..... 68

 B. Threat Sectors..... 69

 C. Threat Sector Descriptions 70

 D. Scenario Driven Risk Assessment Matrix 75

 E. TARGET SELECTION METHOD 76

 1. CARVER Threat Assessment Process 76

 2. CARVER Matrix 77

IV. LNG TANKER ATTACK SCENARIOS 79

 A. AIRCRAFT ATTACK SCENARIO 79

 1. Assumptions 80

 2. Airfields within 33 nautical miles 81

 3. Attack Profiles 82

 4. General Protection Against an Aircraft Attack 82

 5. Summary..... 83

 B. Stand-Off Weapons Attack Scenario..... 84

 1. Weapons Categories 84

 C. Mortars 94

 D. Shaped Charges 96

 E. Small Boat Attack Scenario 98

- F. Limpet Attack Scenario..... 103
- G. Mines or Mine-Like Devices..... 106
- V. CONCLUSION 109
- SECTION THREE: CONSEQUENCE MANAGEMENT..... 111**
- I. SUMMARY 111
- II. BACKGROUND: SCOPE AND SCENARIO..... 115
 - A. Effects of Thermal Radiation 116
 - 1. Predominant Injuries Expected 118
 - B. Distances to Thermal Hazards..... 120
- III. SECTOR 8: PROVIDENCE HARBOR 121
 - A. Death & Injury 121
 - 1. The Port of Providence (Red Ring)..... 122
 - 2. Overview: Providence, East Providence & Cranston (Orange Ring)..... 123
 - B. Damage to Critical Infrastructure 134
 - 1. Infrastructure, Facilities & Places at Risk within 630 Meters (Red Ring) 137
 - 2. Infrastructure, Facilities & Places at Risk between 630 & 2,118 Meters (Orange Ring) 139
 - C. Sympathetic Detonation Potential 148
 - D. LONG-TERM EFFECTS 149
- IV. CONSEQUENCE MANAGEMENT 150
 - A. Incident Command and Control 150
 - B. Emergency Alert Notification 151
 - C. Fire Control 152
 - 1. Response Plan..... 152
 - 2. Capacity Required vs. Capacity Available..... 152
 - D. Emergency Medical Response 153
 - 1. Response Plan..... 153
 - 2. Capacity Required vs. Capacity Available..... 154
 - 3. Trauma Centers/Morgue 155
 - 4. Police Response..... 156
- V. EXHIBITS..... 157
 - A. Exhibit One: Fire Stations in Providence 157
 - B. Exhibit Two: EMT Qualifications..... 158

SECTION ONE: Background & Threat Analysis

I. Summary

The terrorist attacks of September 11, 2001 illustrated, perhaps for the first time, the potentially devastating results of terrorist attacks on U.S. soil. Relative to the rest of the world, the U.S. enjoyed peaceful living removed from terrorist threat, until we witnessed a grand scale of destruction as our financial and government centers were attacked. Over the past four years, this rising terrorist threat has shaped the way we live, revealing dangers we face both domestically and internationally. Prior to 9/11, adequately protecting our homeland, including critical infrastructure, financial and banking sectors, private and commercial property, and our citizens, was something we gave too little thought. Now we understand the importance of securing our homeland and our people - and the potential results if we fail in doing so.

But the challenge in creating true homeland security is to understand *what* we need to protect and *how* to do so. Determining risk is essential in appropriately allocating security resources to ensure a safer country. And making sound decisions about how critical infrastructure is secured through preventive measures rather than reactive consequence management is essential.

For that reason, the Attorney General of The State of Rhode Island requested a terrorist threat analysis for KeySpan's proposed liquefied natural gas facility to be built along the Providence River in Providence, Rhode Island. In determining the risk of terrorist attack on the target, potential damage and consequence management, we have:

- Examined historical and philosophical aspects of existing terrorist organizations and their statements about intended targets to achieve their goal of creating terror.
- Examined previous LNG safety incidents.
- Examined potential areas of risk in Providence.
- Examined existing research on LNG spills.
- Examined legal and regulatory codes affecting LNG safety.

In our examination, we have come to a number of conclusions that should affect decision-making about the placement of such a facility:

- The United States will continue to face the risk of domestic terrorist attack over the foreseeable future.
- Critical infrastructure, including gas and oil facilities, are primary targets for terrorist attack.
- Although the LNG industry has enjoyed a history of relatively few safety incidents, there is no reason to believe that the LNG industry would be a less attractive target to terrorist organizations than other infrastructure.
- Although intentionally creating the "perfect storm" of events necessary to cause a significant LNG incident would be challenging, it is not impossible.
- The placement of such an LNG facility could either increase or decrease the level of risk and the resulting consequence management demands.

II. Background and Threat Analysis

A. The Nexus of Terrorist Groups and LNG

1. Philosophical Context

It is difficult to understand the potential threat to domestic critical infrastructure without understanding the context for why terrorists act as they do, their motivations and goals, their actions in the past and their articulated targets for the future. With this mind, we turn to an analysis of terrorist activity as related to their overall mission.

a. Goal of Terrorist Attacks

In the announcement of the World Islamic Front on February 22, 1998, Osama bin Laden provided the context for what would be a new period of terrorist acts carried out by al Qaeda.¹ In his announcement, bin Laden denounced the presence of U.S. troops in the Arabian Peninsula and pronounced a *fatwa* (an Islamic religious decree) against all Americans and Arab countries supporting U.S. interests.²

As such, the goal of al Qaeda and other jihadist organizations has since been dedicated to the removal of non-Muslims from the Arabian Peninsula and the overthrow of non-Islamic fundamentalist governments in the Arab world. To achieve this ultimate goal, al Qaeda has employed the use

¹ The World Islamic Front for Jihad against Jews and Crusaders brought Bin Laden together with Ayman al-Zawahiri of Egypt's Jihad Group, Rifia Ahmed Taha of Egypt's Islamic Group, and other key jihadists from Pakistan and Bangladesh.

² Bernard Lewis. "License to Kill," *Foreign Affairs*. November/December 1999

of terrorism to achieve a range of organizational objectives:

Short-Term Objectives	Medium-Term Objectives	Long-Term Objectives
<ul style="list-style-type: none"> • Convince the Muslim world that United States military strength can be defeated through terrorist activity. • Raise financial donations. 	<ul style="list-style-type: none"> • Recruit and train the next generation of jihadists. • Invoke a perpetual sense of fear in Americans through terrorist acts or the threat terrorist acts. 	<ul style="list-style-type: none"> • Influence opinion to demand the end of U.S. presence in the Muslim world. • End U.S. support for non-fundamental Islamic regimes.

Figure 1.1: Al Qaeda Organizational Objects³

A necessary issue to consider when analyzing the goal of terrorist attacks is the motivation behind terrorist organizations. Some argue that organization leaders are chiefly concerned with combating the United States to oppose policy. Others argue that terrorist leaders are chiefly concerned with establishing fundamentalist Islamic states throughout the Arab world.⁴ Their vision of a fundamentalist Islamic state is grand and would require tremendous efforts over the long term to achieve, as evidenced by al Qaeda's

³ Chart adapted from *Defeating the Jihadists: A Blueprint for Action*. Richard Clarke et al.

⁴ Clarke et al. *Defeating the Jihadists: A Blueprint for Action*. New York, NY: The Century Foundation Press. 2004. pg.12.

indication that the former Taliban regime in Afghanistan had gotten close to their ideal but was not quite there.⁵

Regardless of al Qaeda's true motivation, the United States can expect continued conflicts with Islamic terrorist organizations as the jihadist movement seeks to increase numbers and gain influence throughout the Muslim world. Bin Laden has stated that inciting young Muslims to the jihadist movement is his chief priority and that continued terrorist actions are a sure way of achieving this goal.⁶

b. Potential Groups

Numerous terrorist organizations currently threaten U.S. interests and home and abroad. Below is a selection of some of the groups that have the desire, intent, and are attempting to develop the capability to wage an attack against our energy infrastructure.

Al Qaeda

Nearly four years after the attack on September 11th and the subsequent invasion of Afghanistan, al Qaeda remains America's most immediate and serious terrorist threat.⁷ Although U.S. armed forces have captured or killed thousands of al Qaeda operatives, many still remain at large. Al Qaeda's top two leaders - bin Laden and Ayman al-Zawahiri - have evaded capture and continue to issue threats against the United States with impunity.⁸

⁵ Bergen, Peter. *Holy War, Inc.* New York, NY: Simon and Schuster. 2002 pg.13.

⁶ Anonymous. *Through our Enemies' Eyes: Osama bin Laden, Radical Islam, and the Future of America.* Washington, D.C. Brassey's Inc. 2002 pg. 61.

⁷ The White House. *National Strategy for Homeland Security.* Congressional Information Service, Inc. Policy Papers. Washington, DC: July 2002.

⁸ Bin Laden's most recent threat against the United States was released just days before the 2004 election. For a transcript of this statement see

<http://www.cnn.com/2004/WORLD/meast/10/29/bin.laden.transcript/index.html>

Nevertheless, a recent FBI report seemed to indicate that al Qaeda's current ability to attack within the United States is not currently understood because of the lack of current terrorist cells within the country. According to the report, al Qaeda is still actively recruiting and training terrorist to carry out attacks within the United States, but its success in establishing sleeper agents post 9/11 is unclear. The FBI assessment cites instances in which individuals have been identified as potential sleeper agents. More recently, a member of the Saudi Arabian Air Force training at Lackland Air Force Base in Texas was identified and dismissed after it was discovered he had been secretly supplying overseas al Qaeda leaders with information on U.S. landmarks. The classified document indicates that instead of employing the traditional sleeper cells, al Qaeda may decide to make use of disaffected Americans or other sympathizers who might pick easier, softer targets.⁹

Al Qaeda has already waged a successful attack on the oil and gas industry when it bombed the French oil tanker *Limburg* in 2002. Al Qaeda has also shown its ability to attack large, fortified ships, as illustrated by its attack on the *U.S.S. Cole* in 2000. See p. 31 for further discussion of the *Limburg* and the *Cole*.

Jemaah Islamiya

Jemaah Islamiya (JI) is a large and diverse Southeast Asian regional jihadi organization with numerous and well-documented ties to al Qaeda. JI was responsible for the 2002 nightclub bombing in Bali that killed 202 people, many of whom were Western tourists. There is evidence that shows that JI and al Qaeda planners were preparing to coordinate a September 11th "second strike" on the west coast of the U.S. with planes hijacked in Southeast Asia. And in December

⁹ "Secret FBI Report Questions al Qaeda's Capabilities." By Brian Ross for ABC News. March 9, 2005: <http://abcnews.go.com/WNT/print?id=566425>

2001, authorities in Singapore uncovered a JI plot to attack American, Israeli, British, and Australian diplomatic targets in Singapore. Indonesia claims to have 200 JI-related men in custody, but the group still boasts at least several thousand members. The "second generation" of JI leaders appears to be even more dedicated to the holy war than their predecessors and evidence shows they may be more sympathetic to bin Laden's call to increasingly use violence against western targets. Most disturbingly, JI seems bent on developing chemical and biological weapons capabilities.¹⁰ See section B I for further discussion of JI and the threat it poses to oil and gas targets.

Abu Sayyaf

The Abu Sayyaf Group (ASG) is a radical Islamic militia based in Malaysia and the Philippines now known more for its brutal kidnapping operation than its commitment to jihad. ASG is now highly fragmented, due in large part to the U.S.-backed Philippine government crackdown, and now claims between 300-1000 members. The group maintains very strong ties to al Qaeda; it likely received regular financial support from bin Laden in the 1990s and a number of its fighters likely trained at al Qaeda camps in Afghanistan. ASG began a lucrative kidnapping and ransom operation in the 1990s; many captives were Westerners, including Americans, and some were released after large ransom payments while others were beheaded. Since September 11th, the group has claimed responsibility for a bombing near a Philippine military base that killed an American serviceman and the bombing of a passenger ferry near Manila that killed 130 people. Several recent attacks on shopping malls, trains, and Western embassies have been thwarted.¹¹ See B I for further discussion of ASG and the threat it poses to oil and gas targets.

¹⁰ Defeating the Jihadists.

¹¹ Defeating the Jihadists.

Other Jihadist Groups

Having lost its headquarters in Afghanistan, al Qaeda (which literally means "The Base") is currently more of a support network for other terrorist groups than it is a base of operations. Linked together by the Internet and enabled by modern technologies, al Qaeda can operate in a highly decentralized manner and spread its message and activities across many countries.¹² As such, al Qaeda presents no clear "center of gravity" whose destruction would entail the defeat of the entire organization.¹³

Today, militant jihadist groups loosely affiliated with al Qaeda operate in no fewer than 68 countries (up from 40 in 2001) many of whom received training in Afghanistan.¹⁴ The following is a list of a few of the organizations, not including those mentioned above, with which al Qaeda is known to have cooperated worldwide:¹⁵

- Egyptian Islamic Jihad
- The Libyan Islamic Fighting Group
- Islamic Army of Aden (Yemen)
- Lashkar-e-Taiba and Jaish-e-Muhammad (Kashmir)
- Islamic Movement of Uzbekistan
- Salafist Group for Call and Combat and the Armed Islamic Group (Algeria)

These groups share al Qaeda's Sunni Muslim fundamentalist views. Some terror experts theorize that al Qaeda, after the loss of its Afghanistan sanctuary, may be increasingly reliant on sympathetic affiliates to carry out its agenda. Intelligence officials and terrorism experts also say that

¹² Bergen, Peter. *Holy War, Inc.* New York, NY: Simon and Schuster. 2002 pgs

¹³ The White House. *National Strategy for Homeland Security.* Congressional Information Service, Inc. Policy Papers. Washington, DC: July 2002.

¹⁴ "Amorphous but Alive." *The Economist*, June 3rd 2004.

¹⁵ Adapted from "Al Qaeda" Council on Foreign Relations Q&A in cooperation with the Markle Foundation: <http://www.terrorismsanswers.org/groups/alqaeda.html>.

al Qaeda has stepped up its cooperation on logistics and training with Hezbollah.¹⁶

Other Major Terrorist Groups

Other terrorist groups, from Hamas in the West Bank and the Gaza Strip to the Real Irish Republican Army in Northern Ireland, have supporters in the United States. To date, most of these groups have largely limited their activities in the United States to fundraising, recruiting, and low-level intelligence, but many are capable of carrying out terrorist acts within the United States. For example, Hezbollah, though primarily based in the Middle East, was responsible for more American deaths than all other terrorist groups combined until September 11th.

Hamas and Palestinian Islamic Jihad (PIJ) have not targeted the United States or Americans directly, although Americans have died in attacks by these groups, along with Israelis and often the bombers themselves. Five out of the 65 killed in a series of four Hamas/PIJ bombings in Israel during February-March 1996 were American citizens.¹⁷

c. Domestic Terrorism

Understandably, since the attacks on the World Trade Center Towers and the Pentagon in 2001, national attention on terrorism has been primarily directed at overseas Islamic terrorism. Therefore, much of current methods of analyzing terrorism involve looking at terrorists based on organizational definitions.

However, in any terrorist threat assessment it is important to examine the potential threat posed by domestic

¹⁶ Ibid.

¹⁷ Pipes, Daniel and Steven Emerson. Rolling Back the Forces of Terror. Wall Street Journal, August 13, 2001.

terrorists, specifically individual actors. Increasingly, lone individuals with no connection or formal ties to established or identifiable terrorist organizations are rising up to engage in violence. These individuals are often inspired or motivated by some larger political movement of which they are not actually a part, but nonetheless from which they draw spiritual and emotional sustenance and support.¹⁸ U.S. Marshals Service chief inspector Geoff Shank said, "Not a lot of attention is being paid to this, because everybody is concerned about the guy in a turban. But there are still plenty of angry, Midwestern white guys out there."¹⁹

With the noted exception of 9/11, all of the major terrorist attacks that have occurred in United States were the work of a sole domestic actor or a group of two or three co-conspirators. The "Unabomber," Theodore Kaczynski; Oklahoma City bomber Timothy McVeigh; Eric Rudolph, who bombed the 1996 Atlanta Olympics as well as gay bars and abortion clinics; the lone gunman of Palestinian extraction who opened fire on the observation deck of the Empire State Building in 1997; the two Palestinians who, later that year, plotted a suicide bombing attack on the New York City subway; the July 4 shooting at Los Angeles International Airport by a naturalized American who had emigrated from Egypt; the 2001 anthrax mailings (culprit still at large), and the D.C.-area snipers, John Muhammad and John Lee Malvo, demonstrate the power to inculcate fear and terrorize in a specific locality even by modest levels of death by terrorists standards.²⁰

In many respects, domestic terrorist groups (such as the National Alliance, the Aryan Nation, and the extremist Puerto Rican separatist group Los Macheteros) and special

¹⁸ Hoffman, Bruce. *Al Qaeda, Trends in Terrorism, and Future Potentialities: An Assessment*. Published by The Rand Corporation: Washington, D.C. 2003

¹⁹ Copeland, Larry. "Domestic Terrorism, New Terrorism at Home" *USA Today*: Atlanta, GA: 11/14/2004.

²⁰ *Ibid.*

interest extremist groups pose as much as a threat to the United States as international terrorists.

d. Disrupting America's Economy

In its early days of destructive planning, al Qaeda directed its energies at American military and political targets, namely the Khobar Towers, the U.S. Embassies in Kenya and Tanzania, and the *USS Cole*. September 11th marked a shift in al Qaeda's tactics to target economic as well as governmental targets.²¹ This interest in economic targets is in contrast to many terrorist organizations that use terrorist attacks to make political statements.²² A student of economics and public administration, bin Laden took a keen interest in the substantial economic cost imposed on the United States as result of the September 11th attacks.²³ Below is a brief excerpt of remarks by bin Laden in the days following the attacks:

According to their own administration, the share of the losses on the Wall Street Market reached 16%...This large collapse has never happened. The gross amount that is traded in the market reaches \$4 trillion. So if we multiply 16% by \$4 trillion to find out the loss that affected the stocks, it reaches \$640 billion of losses from stocks, by Allah's grace. So this amount, for example, is the budget of Sudan for 640 years.

The statement goes on to conclude, in bin Laden's estimate, that his single day of attacks would cost the American

²¹ Bergen, Peter. "Al Qaeda 2.0" Article for website: www.PeterBergen.com 10/2002: accessed at <http://www.peterbergen.com/clients/PeterBergen/pbergen.nsf/>

²² The most recent example being the assassination of former Lebanese Prime Minister Rafik Hariri who was killed in a car bomb in Beirut last February.

²³ Gunaratna, Rohan. *Inside Al Qaeda: Global Network of Terror*. New York: Columbia University Press. 2002 pg. 225.

economy \$1 trillion.²⁴ In a statement made later that year, bin Laden referred to future suicide attacks against American economic interests, suggesting, "The young men need to seek out the nodes of the American economy and strike the enemy's nodes."²⁵ In October of 2002, Bin Laden's top lieutenant, Ayman al Zawahiri, made remarks calling for, "the destruction of the American economy."²⁶ Not more than a week after al Zawahiri's made his remarks did the world feel the impact of two attacks on economic soft targets: the bombing of an oil tanker in Yemen (the *Limburg*) and a nightclub bombing in Indonesia.

e. Al Qaeda's MO

Central to al Qaeda's modus operandi in previous terrorist attacks is the desire to choose targets that cause high casualties with relatively low costs. As such, al Qaeda has deliberately chosen targets based on an observed weakness in America's defense and security preparations.²⁷

In any preventive homeland security assessment it is important to think of terrorists (specifically al Qaeda) as strategic actors. In the past, al Qaeda has proven adept at monitoring our media outlets and policy makers who openly remark on how America should protect itself. Al Qaeda has subsequently responded by making the appropriate adjustments in order to sidestep these protective measures. When the U.S. discovers and protects itself from one form of attack, al Qaeda immediately goes in search for another four. And most likely, al Qaeda has performed careful cost benefit

²⁴ Ibid.

²⁵ Presentation made by the British journalist Paul Eedle, "The Language of Jihad," at the Third Annual Conference of the Centre for the Study of Terrorism and Political Violence, St Andrews University, Scotland, 8 June 2002.

²⁶ Bergen, Peter. "Al Qaeda 2.0" Article for website: www.PeterBergent.com 10/2002: accessed at <http://www.peterbergen.com/clients/PeterBergen/pbergen.nsf/>

²⁷ The White House. *National Strategy for Homeland Security*. Congressional Information Service, Inc. Policy Papers. Washington, DC: July 2002.

analysis and is able to weigh the magnitude of success against the potential loss it might suffer.²⁸

According to bin Laden biographer Jonathan Randal, Osama bin Laden was chiefly concerned with executing terrorist attacks which produced fear in the eyes of everyday citizens and not just among counterterrorism professionals in Washington.²⁹ It is clear that bin Laden favors symbolic targets in high casualty areas as a method of presenting his message to the world. On the other hand, now that he has successfully pulled off a spectacular attack with high casualties, he may now opt for a series of smaller, more sustained attacks.³⁰

f. Al Qaeda's Interest in LNG

There are two reasons why a terrorist would be interested in attacking an LNG tanker or facility, both of which fit al Qaeda's MO: the potential for high civilian casualties and the potential to bring substantial damage the American economy. Although the United States acquires roughly 2% of its overall gas consumption from LNG sources, some analysts predict that this amount is likely to increase at a rate of 2% a year.³¹ As LNG imports become a more important sector of our economy, terrorist organizations like al Qaeda will become more interested in attacking them. In addition, LNG tankers, which often travel in close proximity to metropolitan seaports, are undoubtedly attractive high casualty targets for al Qaeda planners.³²

²⁸ Ibid.

²⁹ Randal, Jonathan. *Osama: The Making of a Terrorist*. Westminster, MD, USA: Knopf Publishing Group, 2004. p16.

³⁰ Ibid.

³¹ Candyce M Kelshall. *LNG Tanker Terrorism: A Case Study*. London 2004

³² Image details adapted from Mark Clayton, "LNG: A Prized Energy Source or a Potent Terrorist Target." *The Christian Science Monitor*: Apr 6, 2004. accessed at <http://www.csmonitor.com/2004/0406/p01s01-uspo.html> 5Apr04.

In a recently released document known simply as the National Planning Scenarios, DHS indicated that a potential terrorist attack on chemical or gas tanker is the number six ranked doomsday scenario for the United States government. As a result, DHS is expected to spend at least an additional one billion dollars to secure against this form of terrorist attack. However even those within DHS believe that the United States is a long way away from true preparedness.³³

Currently, over 80% of the United States natural gas imports are shipped in tankers from Trinidad and Tobago, which are attractive targets to terrorist organizations.³⁴ As natural gas demands increase in the United States, natural gas-producing countries will increase their export. Interestingly, the same countries that currently provide much of the US's current oil supply will mostly likely be the same increasing their production of LNG: namely countries in West Africa and the Persian Gulf - areas where al Qaeda has an already established a foothold.



Figure 1.2: LNG Tanker in Boston Harbor

- A typical LNG tanker holds more than 33 million gallons of LNG
- As tall as a 12-story building -- traveling at 20 knots
- LNG tankers require 5 miles to halt
- LNG tanker hull and containers Block forward view for 3/4 of a mile

³³ Lipton, Eric. U.S. Report Lists Possibilities for Terrorist Attacks and Likely Toll, *New York Times* March 16, 2005

³⁴ Candyce M Kelshall. *LNG Tanker Terrorism: A Case Study*. London 2004

In addition to its interests in attacking tankers, al Qaeda would have the motivation and could develop the capability to attack LNG facilities. MS-13, a Central American criminal organization with a large membership in East Boston, is feared to be targeting the LNG facility and tankers near Boston. MS-13 has a strong presence in harborside neighborhoods of East Boston alongside which LNG tankers pass on their way to the unloading facility in Everett. In January, these members were subject to a Homeland Security and Customs Department investigation after the Justice Department announced that al Qaeda operatives might be trying to get into the country through Mexico. MS-13 is believed to be involved in smuggling from Mexico to the U.S.³⁵ Though al Qaeda has yet to attempt an attack on the LNG facility in Boston, to most counterterrorism officials, the threat is clear and present.

2. History of Terrorist Acts

Although LNG tankers have not yet been the target of terrorist attack, there have been several notable events that illustrate the vulnerability of LNG tankers to accidents or attacks. Al Qaeda and other terrorist groups have shown intent to target the energy sector through previous actions and statements.³⁶ The rise in high seas piracy, discussed in further detail in section B I, particularly in Southeast Asia, is a disturbing trend. Additionally, al Qaeda was reported to have smuggled an operative into Boston on an LNG tanker from Algeria before September 11, 2001.³⁷

³⁵McPhee, Michele. "Flaherty" Eastie Gang Poses Threat to LNG's in the Harbor." *The Boston Herald*. January 13, 2005.

³⁶ See discussion of the *Limburg* below.

³⁷ Candyce M. Kelshall MSc BSc (Hons), *LNG Tanker Terrorism: A Case Study*, London 2004, p. 3.

a. *LNG Safety Incidents*³⁸

There has never been an accident involving a LNG tanker that has caused significant damage to the public or the environment,³⁹ and no fatalities have resulted from safety accidents involving LNG tankers.⁴⁰ Through 2002, there were 30 minor safety accidents, which include collisions, groundings, and leaks.⁴¹ Of those 30 accidents, 12 were leaks that caused some freezing damages, and two were leaks that resulted in small vent fires.⁴²

Although LNG tanker accidents have not resulted in any fatalities, there have been fatalities from accidents at LNG facilities. Two fatal LNG facility accidents have occurred in the United States and two in Algeria.

- East Ohio Gas Co. Plant, Cleveland, OH (1944): short cuts in the design of a cylindrical liquid gas tank caused a leak that wafted into a nearby residential area and ignited. The resulting fireball caused another tank to explode, sending two tanks worth of gas into streets and sewers, igniting the entire neighborhood from below.⁴³ The accident killed 128 people and injured 435,⁴⁴ and caused \$6 million worth of property damage.⁴⁵ The U.S. Bureau of Mines

³⁸ The following section catalogs the most noteworthy events. For a complete list of LNG safety incidents, see University of Houston Law Center, Institute for Energy, Law, and Enterprise, *LNG Safety and Security*, October 2003, p. 77-79, available at http://www.energy.uh.edu/LNG/documents/IELE_LNG_Safety_and_Security.pdf.

³⁹ Statement of Mr. Mark Robinson, Director of the Office of Energy Projects, Federal Energy Regulatory Commission, before Senate Committee on Energy and Natural Resources, Energy Subcommittee, Feb. 15, 2005.

⁴⁰ University of Houston Law Center, p. 73

⁴¹ CH-IV International, *Safety History of International LNG Operations, Revision 2*. TD-02109. Millersville, MD. November, 2002. p. 13-17.

⁴² *Ibid.*

⁴³ Michael Sangiacomo and James Ewinger, "East Ohio Gas Explosions – 60 years later," *Cleveland Plain Dealer*, Oct. 18, 2004, A1.

⁴⁴ Diane Lindquist, *Liquid Natural Gas is a hot-button issue*, Copley News Service, Feb. 16, 2004.

⁴⁵ Sangiacomo and Ewinger.

investigation that followed determined LNG storage to be safe as long as "proper precautions were observed."⁴⁶

- Cove Point LNG facility, Lusby, Maryland (1979): an inadequately tightened pump seal leaked gas that traveled through 200 feet of underground electrical conduit, and ignited when it reached an electrical substation.⁴⁷ One person was killed, another was injured, and the explosion resulted in \$3 million worth of property damage.⁴⁸ The explosion was the result of an unlikely chain of events, and the National Transportation and Safety Board found the plant to be constructed and designed appropriately.⁴⁹
- Arzew, Algeria (1977): an aluminum valve made of the wrong alloy failed, releasing gas. The gas did not ignite, but froze one worker to death.⁵⁰ Shock waves from rapid phase transition of the gas broke several windows.⁵¹
- Skikda, Algeria (2004): Initial investigations attributed the cause of the January 2004 explosions that that killed 27 workers and injured 72 to a defective steam boiler that was only superficially repaired, but later investigations determined that the blast could have been caused by a LNG leak.⁵²

⁴⁶ U.S. Bureau of Mines, *Report on the Investigation of the Fire at the Liquefaction, Storage, and Regasification Facility of the East Ohio Gas Co., Cleveland, Ohio, October 20, 1944*, February 1946.

⁴⁷ Staff, "LNG terminal's revival timed right," *Baltimore Sun*, Jun. 22, 2003, 1D.

⁴⁸ University of Houston, p. 75.

⁴⁹ National Transportation Safety Board Report, *Columbia LNG Corporation Explosion and Fire; Cove Point, MD; October 6, 1979*, NTSB-PAR-80-2, April 16, 1980.

⁵⁰ University of Houston, p. 78.

⁵¹ Karen Bybee, *Latest Developments in Rapid Phase Transition Modeling*, JPT Online, Apr. 2004.

Available at:

http://www.spe.org/spe/jpt/jsp/jptpapersynopsis/0,2439,1104_11038_2354946_2367904,00.html.

⁵² Nelson Antosh, "Vast Site Devastated," *Houston Chronicle*, Jan. 21, 2004, Business, p. 1.

b. Attacks on Energy Infrastructure

International terrorist organizations have named energy infrastructure as a target for attack, but it has been domestic groups that have perpetrated attacks on energy targets in North America to date.

- Suburban Propane plant, Elk Grove, CA (1999): two former members of the San Joaquin militia are currently in prison for a Y2K conspiracy to blow up a liquid propane storage facility near Sacramento. The attack was intended to provoke U.S. adoption of martial law. The FBI used information from a government informant to arrest the men before the attack was carried out. The informant also mentioned at least one of the men had additional targets in Northern California.⁵³ The attack, which targeted two giant steel propane tanks, would have resulted in a five-mile blast.⁵⁴
- Hydro-Quebec transmission towers, Quebec, Canada (1994 and 2004): dynamite explosions damaged two transmission towers in March, 1994.⁵⁵ A Canadian cult that performed a mass suicide later that year was suspected of the bombing.⁵⁶ In December, 2004, another tower was found with damage to its base from an explosion. A group called "Initiative de Resistance Internationaliste" (IRI) has claimed responsibility, voicing opposition to waste of resources and exploitation by Hydro-Quebec,

⁵³ Anti-Defamation League, *Would-be Militia Bombers Sentenced*, Sep. 25, 2002, available at: http://www.adl.org/learn/news/bombers_Sentenced.asp.

⁵⁴ Lance Williams, "Militia Planned Propane Attack Near Sacramento," *Pittsburgh Post-Gazette*, Dec. 29, 1999, A11.

⁵⁵ *Hydro-Quebec Posts \$10,000 Reward for Information on Sabotage of Lines*, *Electric Utility Week*, Mar. 24, 1994, p. 3.

⁵⁶ *Canadian Cult Commits Mass Suicide in Switzerland*, CNN live report, transcript #838-1, 4:18pm, Oct. 5, 1994.

but Canadian police, who had never heard of the group, have not confirmed the veracity of their claim.⁵⁷

Most attacks on oil and gas terminals or pipelines have been small in scale, and have occurred outside of North America. The most common form of attack is pipeline bombings. General sabotage and office bombings are the next most frequent form of attack. Violent attacks on oil and gas depots and refineries and hijacking of energy installations are rare. In areas with a significant guerilla presence, kidnappings, and direct armed attacks occur with some frequency.⁵⁸

c. Attacks on Tankers

The first significant incident of tankers under missile attack was the "tanker war" during the Iran-Iraq conflict in the 1980s. Missiles were fired against tankers going into port in each country. Small spills and fires resulted, but there were no explosions. The tanker war illustrated the durability of double-hulled tankers under certain types of attack.⁵⁹

The number of incidents of piracy, particularly in Southeast Asia, has been steadily rising in the past 15 years. Most of these episodes amount to little more than high seas robbery. However, there have been some reports of terrorist groups hijacking ships to practice steering them, and then leaving with only a few hostages. All types of ships have been targeted by pirates, including oil and gas tankers.^{60 61} This issue is discussed in further detail on p. 34.

⁵⁷ News Staff, *Group takes credit for Que. hydro tower bombing*, CTV.ca, Dec. 6, 2004, available at: http://www.ctv.ca/servlet/ArticleNews/story/CTVNews/1102370147386_11/?hub=TopStories.

⁵⁸ Tamara Makarenko, *Terrorist threat to energy infrastructure increases*, Jane's Intelligence Review, June 1, 2003.

⁵⁹ David Hughes, "So, is the world safer now with ISPS in force?" *The Business Times Singapore*, Jul. 7, 2004, Shipping Times, Strait Talk.

⁶⁰ Kelshall, p. 4-6.

Two major terrorist incidents in the past five years have involved large ships - the *USS Cole* and a French oil tanker, the *Limburg*.

- *USS Cole*, Yemen (2000): The attack on the *USS Cole* involved a small ship laden with explosives that was steered into the side of the *Cole* in a suicide attack. The event killed 17 people, and injured 39 others. Al Qaeda claimed responsibility for the attack.
- *Limburg*, Yemen (2002): The attack on the *Limburg*, an oil supertanker, was performed in a similar manner to the *USS Cole*. A small boat filled with explosives was driven into the side of the boat, although it is not certain whether it was steered via remote control, or in another suicide attack. Al Qaeda claimed responsibility for the attack, rejoicing in having "hit the umbilical cord and lifeline of the crusader community."⁶²

B. The Threat

1. The Future of Maritime Terrorism

The desire of terrorist organizations such as al Qaeda to disrupt our economy through attacks on maritime trade and infrastructure has been shown. The attacks on the *U.S.S. Cole* and the *Limburg* have proven al Qaeda's ability to inflict heavy damage on fortified ships, and the rising number of maritime attacks in other parts of the world must be taken into account in devising maritime security precautions in the United States. As was examined in the

⁶¹ Kelshall, p. 4-6.

⁶² Brian Whitaker, "Bali Bombing: Tanker blast was work of terrorists," *The Guardian* (London), Oct. 17, 2002, Home Pages, p. 6.

previous section, al Qaeda has released several statements expressing its intent to strike maritime commerce, specifically the transit of oil and gas.

The London-based Aegis Defense Service recently released its 2005 Terrorism Report, which stresses that the maritime industry remains extremely vulnerable to terrorism. Significantly, Aegis predicts an attempted attack on a significant maritime target sometime this year. Aegis' forecast is based on Osama bin Laden's recent statements about his desire to injure economic lifelines, as well as the fact that the new al Qaeda chief in Saudi Arabia, Saud Hamud al-Utaibi, is a maritime specialist linked to the *Cole* attack.⁶³ Al Qaeda's former chief of naval operations and a key organizer of the *Cole* and *Limburg* attacks, Abdul Rahim Mohammed Hussein Abda al-Nasheri (a.k.a. Mulla Ahmad Belal), was captured in Yemen in 2002 and has since provided information to American officials that further substantiate the credibility of the threat of a future maritime attack. Nicknamed the Prince of the Sea, al-Nasheri has allegedly confessed to planning attacks on U.S. and British warships as they traveled through the Straits of Gibraltar.⁶⁴

a. Piracy as Terrorist Act

In addition to the potential for *Cole*- and *Limburg*-style attacks on LNG tankers or other tankers transporting hazardous material, the sharp rise in piracy, especially in South Asian ports, is cause for alarm. There were 325 attacks by pirates in 2004, with the lion's share (93) occurring in Indonesian waters. The total number of attacks is down from the 445 attacks reported in 2003, which was a 51% increase from the number of attacks in 1999, according

⁶³ *Aegis 2005 Terrorism Report* (accessed March 17, 2005); available from <http://www.aegisdef.com/pdfs/2005Overview.pdf>.

⁶⁴ *Al Qaeda and Maritime Terrorism, Part I* (accessed March 18, 2005); available from http://www.jamestown.org/publications_details.php?volume_id=391&&issue_id=2873.

to the International Maritime Bureau.⁶⁵ The IMB warns that vessels are most vulnerable while anchored outside port facilities or while traversing navigation channels and coastal waterways at slow speeds. In addition, new trends in piracy have begun to appear which could have implications for U.S. homeland security. Recently, the seizure of ships has failed to conform to established patterns. Rather than overpowering a ship's crew and stealing the cargo or holding the crew for ransom, pirates now seem interested in learning to steer ships and navigate them through narrow channels, and then often release the crew unharmed with its cargo intact.

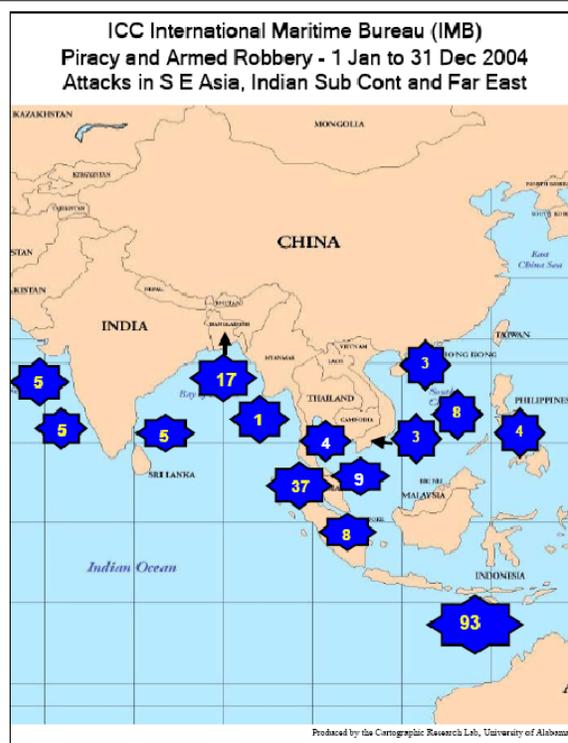


Figure 1.3: Locations of Piracy in Southeast Asia.
Source: Cartographic Research Lab, University of Alabama

⁶⁵ *International Chamber of Commerce Commercial Crime Services* (accessed March 17, 2005); available from <http://www.icc-ccs.org/main/news.php?newsid=42>.

Of particular concern was the nature of the attack on the Indonesian tanker *Dewi Madrim* in April 2003. The pirates boarded the tanker from a speedboat, and all were fully armed with automatic weapons - unusual for such attacks. The ten pirates went straight to the bridge of the tanker, rather than the safe room. The pirates then steered the fully loaded tanker for an hour at altering speeds through the narrow confines of the Malacca Straits. Afterwards, they released the crew but held on to the captain and first officer but made no ransom demands. It is believed the pirates kept these crew members in order to force them to teach them more about how to steer the tanker and use its instruments. An Aegis maritime specialist believes that the implication of such an attack is that the Malacca Straits are becoming "the equivalent of a flight training school for terrorists" - reference to the U.S. flight schools attended by the hijackers who piloted the commandeered airplanes on September 11th.⁶⁶

Equally ominous as the *Dewi Madrim* attack was the 1998 attack on the *Petro Ranger*, a Singaporean tanker loaded with over 1000 tons of diesel and jet fuel. Rather than stealing the cargo or demanding a ransom, the pirates repainted the ship and renamed it the *Wilby*, replaced the Singapore colors with a Honduran flag, and tied up the men below deck and posed as the ship's official crew. The *Wilby* then sailed nonchalantly into a Chinese port, and had it not been for the bravery of the hostages, several of whom managed to escape and alert the authorities, it would have been another in a series of successful merchant ships thefts. If al Qaeda copied this scenario, terrorists could conceivably enter any port in the world with a highly combustible cargo, the way the *Wilby* sailed unmolested into China. A U.S. Coast Guard

⁶⁶ Charles Glass, "The New Piracy," *London Review of Books* 25, no. 24 (2003).

official said, "If we have a vessel in our port that's a problem," such as the *Petro Ranger*, "it's too late."⁶⁷

Since 9/11, Southeast Asia has become a fertile recruiting ground for Islamic extremists, especially with the strong presence of Jemaah Islamiya, the regional terrorist network with well-documented ties to al Qaeda that was responsible for the Bali nightclub bombing in 2002 that killed 202 people. In 2003, armed pirates fired at two chemical tankers off the Indonesian coast in broad daylight, spraying the ships' bridges with automatic weapons.

b. Other Marine Threats

Additionally, there is evidence that shows that terrorists are learning about scuba diving with the aim of attacking a ship from below. Abu Sayyaf, a Philippine terrorist organization that likely received funding from Osama bin Laden in the 1990s and whose members trained in al Qaeda camps in Afghanistan, has been especially interested in scuba diving. In 2000, Abu Sayyaf kidnapped a diving instructor from a resort in the Philippines and held him captive for three years, during which time terrorists ordered him to teach them how to dive. A recently captured Abu Sayyaf guerrilla admitted to Philippine interrogators that Abu Sayyaf and Jemaah Islamiya have been training their members in scuba diving in preparation for a joint bomb attack on an unspecified target outside the Philippines. In a related event that caught the attention of law enforcement, the owner of a diving school in Kuala Lumpur reported a significant number of ethnic Malays wanting to learn about diving, but being suspiciously uninterested in decompression.⁶⁸

⁶⁷ Ibid.

⁶⁸ "Peril on the Sea," *Economist*, October 2, 2003.

The threat posed by scuba divers has been recognized by U.S. officials since September 11th. The FBI issued a statement in 2002 saying that terrorist groups were seeking to employ scuba divers in attacks on ships, power plants, bridges, depots and other waterfront targets. Soon after the attacks, the FBI asked the nation's largest scuba certification organizations to turn over records of every diver certified in the U.S. in the previous three years. Recent developments show that the threat continues to be taken very seriously. In February 2005, the Coast Guard unveiled a new sonar-based device that can distinguish humans from aquatic life and which will be used to respond to specific requests to monitor activity in relatively small areas near military ships, cruise ships or cargo ships. Underwater weapons have also been developed, such as an air gun that sends a non-lethal acoustic impulse to force divers to surface by causing them discomfort. Additionally, the Coast Guard has acquired an underwater speaker system to blast verbal warnings to errant divers. Coast Guard officials have previously spoken of an inability to detect threats underwater, which they call "a huge vulnerability." Special 75-member Coast Guard units specializing in underwater security are currently being posted in 13 ports across the country.⁶⁹

c. Islamic Fundamentalism in Trinidad and LNG

Natural gas shipments from Trinidad and Tobago account for more than 80% of all U.S. LNG imports, with that number expected to rise over the course of the next decade as the U.S. weans itself off of natural gas from Algeria and Qatar because of terrorism concerns. But there is a terrorism concern associated with Trinidadian natural gas as well. Jamaat al-Muslimeen is a radical Islamic Trinidadian opposition group that staged a failed coup against the national government in 1990 and has since built a lucrative

⁶⁹ Eric Lipton, "Coast Guard Turns Its Eyes Underwater," *New York Times*, February 1, 2005, A16.

criminal empire that includes arms smuggling, drug trafficking, and a disturbing kidnapping operation. Other radical Islamic groups in Trinidad include Waajihatul Islaamiyyah, an organization that openly supports Osama bin Laden, al Qaeda, and Jemaah Islamiya. Waajihatul Islaamiyyah has said it intends to establish an Islamic state in Trinidad and has claimed to be manufacturing chemical and biological weapons for use against U.S. and British oil and gas interests on the island. Concerns within the U.S. government are deep enough that FBI and CIA counterterrorism experts have been sent to Trinidad to assist the government in cracking down on the fundamentalist organizations.

2. Safety Record of the LNG Industry

a. History

Built in 1941 in Cleveland, Ohio, the first commercial liquid nitrogen gas liquefaction facility bolstered the nation's available energy sources. The subsequent international demand for LNG drove the United States to ship between international locations and in January 1959, the converted WW II liberty freighter *The Methane Pioneer* tanker carried LNG from a facility in Lake Charles, Louisiana to Canvey Island, United Kingdom.⁷⁰ As an alternative energy source to oil, LNG consumption and demand rose steadily, creating the need for higher production levels, both from domestic and international sources. With finite natural resources, the U.S. quickly met its LNG production capacity and began seeking additional sources internationally (although the U.S. does exports some of its LNG). Since the 1970's, the U.S. has bolstered its LNG resources by

⁷⁰ Energy Information Administration. "*U.S. LNG Markets and Uses.*" Washington, D.C.: Department of Energy. June, 2004. p.1.

importing from a wide range of nations, including Algeria, Trinidad, Qatar, Nigeria, Oman, the United Arab Emirates.⁷¹

As the need for fuel continued to rise with consumer demand, LNG has become an increasingly important part of the energy sector. Once a relatively small market (with only 1% of the total U.S. gas consumption in 2002), expectations for growth in the LNG industry are high.⁷² Consumption is expected to increase significantly over the coming years, with estimates of the total global LNG trade increasing by 35-50% by 2020, assuming that appropriate facility and tanker capacity meets demand.^{73, 74} Although only accounting for 2.7% of the U.S. energy consumption and 13% of total imported energy sources, shipped LNG measures over 53 billion cubic feet per year (in 2003).⁷⁵

b. Market and Production Facilities

The need for producing and storing LNG spawned onshore, marine and off-shore receiving facilities, storage facilities, and re-gasification terminals. Currently, there are 108 working LNG facilities in the U.S, including baseload receiving, re-gasification and storage terminals. As of March, 2005, there are 4 active onshore terminals in the U.S.: Everett, Massachusetts; Lake Charles, Louisiana; Cove Point, Maryland; Elba Island, Georgia.⁷⁶

⁷¹ Parformak, Paul. "*Liquefied Natural Gas Infrastructure Security: Background and Issues for Congress.*" Washington, D.C.: Congressional Research Service, September 9, 2003. p.2.

⁷² Parformak, Paul. "*Liquefied Natural Gas Import Terminals: Siting, Safety, and Regulation.*" Washington, D.C.: Congressional Research Service, January 28, 2004. p.2.

⁷³ Sandia National Laboratories. "*Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water.*" Washington, D.C.: Department of Energy, December 2004. p.26

⁷⁴ Energy Information Administration. "*The Global Liquefied Natural Gas Market: Status and Outlook.*" DOE/EIA-0637. Washington, D.C.: Department of Energy. December, 2003.

⁷⁵ Energy Information Administration. P. 6.

⁷⁶ Parformak, Paul. "*Liquefied Natural Gas Import Terminals: Siting, Safety, and Regulation.*" Washington, D.C.: Congressional Research Service, January 28, 2004. p.2.



Figure 1.4: LNG Storage Sites in Utilities and Marine Terminals. Source: Energy Information Administration, 2004

These facilities are supplied through the movement of LNG via tankers and pipeline systems. As LNG demand increases, so will the need for moving increasing quantities of LNG via tanker. Sea traffic is high for LNG tankers, with over 7 million miles logged each year. In the 45-year span that LNG has been imported, there have been over 80,000 loaded port transits made,⁷⁷ involving 33,000 shipments, logging over 100,000,000 miles.⁷⁸ There are currently 142 specially

⁷⁷ Pitblado, R.M. J. Baik, G.J. Huges, C. Ferro, S.J. Shaw. "Consequences of LNG Marine Incidents." Delivered at Center for Chemical Process Safety Conference. Orlando, Florida, June 29, 2004. p.5.

⁷⁸ Parformak. "Liquefied Natural Gas Import Terminals" p.2.

designed LNG tankers in operation globally, with over 16 million cubic meters (120 million tons) shipped each year. An additional 55 tankers are currently on order to help meet expected demand, providing another 7.6 million cubic meters of capacity over the next 5 years.⁷⁹

As previously noted, there have only been five significant LNG safety incidents (i.e., resulting in death) in either in port or at sea, with thirty incidents total in the 45 year history of the industry.^{80, 81} The low incident rate is credited to regulation, improved tanker design and technology, improved tanker crew and ship management competency.⁸² In contrast, the Federal Aviation Administration posted for the Year 2003 a large aircraft carrier accident rate of 54 accidents per 100,000 flight hours, an incident rate of .3% for total flight time, vastly higher than the accident rate for LNG tankers.⁸³

3. The Potential Threats

a. Providence as a Potential Target

The proposed upgrade of the KeySpan facility would convert the existing site from a LNG storage depot to a terminal capable of receiving marine deliveries from tankers carrying as much as 33 million gallons of LNG. The 17.5-acre facility is located at Fields Point, an industrial area on the western bank of the Providence River that is home to, in addition to the existing KeySpan LNG plant, a cement facility, a liquefied petroleum gas (LPG) tank, a sewage treatment plant, and a scrap metal yard, among other industrial facilities. The FERC estimates that there are

⁷⁹ Sandia National Laboratories.. p.26.

⁸⁰ Parformak, "LNG Infrastructure Security." P.10.

⁸¹ Sandia National Laboratories. p 28.

⁸² Pitblado, p.5.

⁸³ Federal Aviation Administration. "Administrator's Fact Book." <http://www.actctraining.faa.gov/factbook>. November, 2004. p.5.

2,580 residences within one mile of the site, with the Washington Park neighborhood being the closest in proximity, approximately 1000 feet to the south.

In addition, there are 12 schools and three hospitals located within one mile of the KeySpan facility. Rhode Island Hospital (RIH), the largest hospital in the state, is located less than a mile from the LNG site. RIH is designated as the Level I Trauma Center for southeastern New England, which is the highest designation a trauma center can receive. "Trauma" is defined as any severe or life-threatening injury - often times the consequence of a motor vehicle crash, violent attack, or fires and burns. To maintain Level I status, RIH must demonstrate that it has an ongoing quality assurance program, maintains a standard response for treatment of major trauma and has a trauma surgeon and anesthesiologist available at all times. RIH's emergency department sees over 100,000 patients a year, 22,000 of which are trauma patients. The study by Sandia National Laboratories said that a terrorist attack on a LNG tanker, in the worst case scenario, could cause second-degree burns to people more than a mile away from the tanker. It is not difficult to imagine the disaster that would ensue if the thermal radiation of a LNG fire were burning people at the very hospital that would be treating the majority of the fire's victims.⁸⁴

⁸⁴ "Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water," (Albuquerque, NM: Sandia National Laboratories, December 2004).

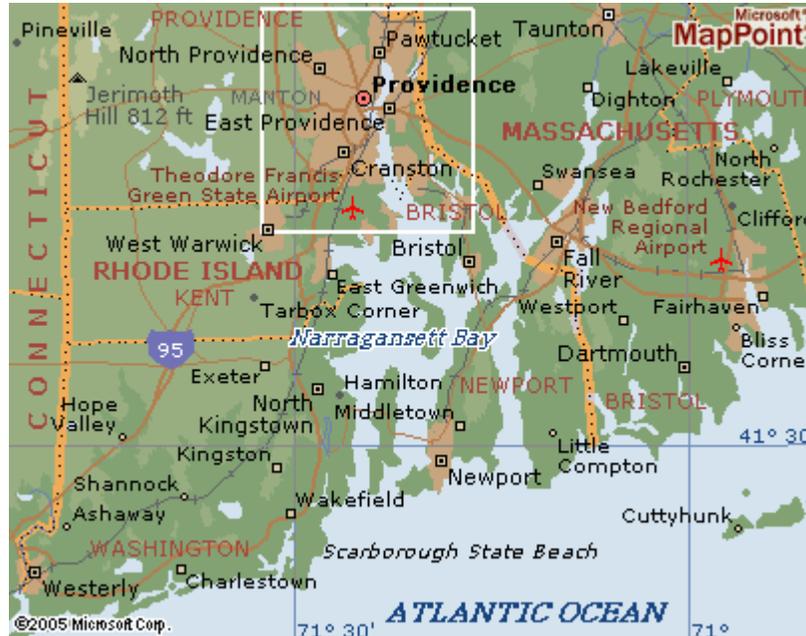


Figure 1.5: Narragansett Bay and Providence, Rhode Island

b. Potential LNG Tanker Route

On their entrance to the proposed KeySpan facility, LNG tankers would travel a 29 nautical mile route from the mouth of the harbor south of Newport to the LNG terminal on the western bank of the Providence River, just south of downtown Providence. Coast Guard officials would board the tanker before its entrance into Narragansett Bay, having received the requisite 96-hour advance notification of a tanker's arrival, to conduct a safety and security sweep of the ship's instruments, cargo, and crew. A pilot from the Northeast Marine Pilots, a private firm that expedites vessels through inland and coastal waterways to ports in Rhode Island, Massachusetts, Connecticut, and New York, would board the tanker at a point in the Rhode Island sound before entering the federal navigation channel. The pilot would remain on board for the ship's entire transit through Narragansett Bay and the Providence River to oversee the

navigation and berthing of the ship, although the ship's captain would retain overall control of the tanker. During its navigation of Narragansett Bay, the tanker would pass beneath the Pell Bridge, a Rhode Island landmark, and past densely populated tourist destinations, including Newport and Jamestown.

Coast Guard requirements for the escort of the LNG tanker along the 29-mile route would be similar to those imposed upon LNG tankers approaching the LNG import terminal in Everett, MA. Take-offs and landings are halted at Boston's Logan Airport as the vessel passes alongside several of its runways. The tanker is surrounded by escort vessels alongside it and helicopters above, on the lookout for suspicious activity. The typical procession is led by small police boats capable of speeds of more than 60 miles per hour. Next are two 41-foot Coast Guard patrol boats, equipped with mounted M60 machine guns on both sides. Towing the tanker through the harbor are six tugs, some with fire-boat capabilities. Immediately following the tanker is a Massachusetts Port Authority fire boat, while a 110-foot Coast Guard cutter with a cannon mounted on the deck brings up the rear. The Coast Guard's rules state that all other vessels must keep clear two miles ahead and one mile behind a moving LNG tanker, with no vessels moving at all alongside it in the narrow confines of the inner harbor. Police cars are posted at points on the piers and the shore lining the route, and the Tobin Bridge is shut down while the tanker is towed beneath it. The weekly event brings together more than 40 federal, state, and local law and safety agencies, as well as the private sector, to ensure the safe passage of ships.

The Coast Guard has proposed the establishment of a safety and security zone around the LNG tankers headed for Providence similar the zone required for Everett-bound ships (no vessels 2 miles ahead, 1 mile behind, and 3000 feet on either side). But the distance the tankers must travel through inland Rhode Island waterways is far greater than

the distance tankers must travel in Boston. The security zones required for Providence-bound LNG tankers during its 3-hour voyage are large enough to effectively seal off entire sections of Narragansett Bay to the numerous recreational, commercial, and transportation vessels that frequent the waters.

KeySpan proposes to schedule docking the tankers in the early morning or at night to avoid interfering with the regular traffic and transit of the waterway, as well as to reduce safety concerns associated with the higher number of people and vehicles in close proximity to the ship's route during daytime hours. However, legitimate concerns have been raised about the increased difficulty of law enforcement officials detecting and thwarting a potential attack on the tanker or on the unloading facility during the dark overnight and early morning hours. It is estimated that the unloading of the LNG will take approximately 24 hours.

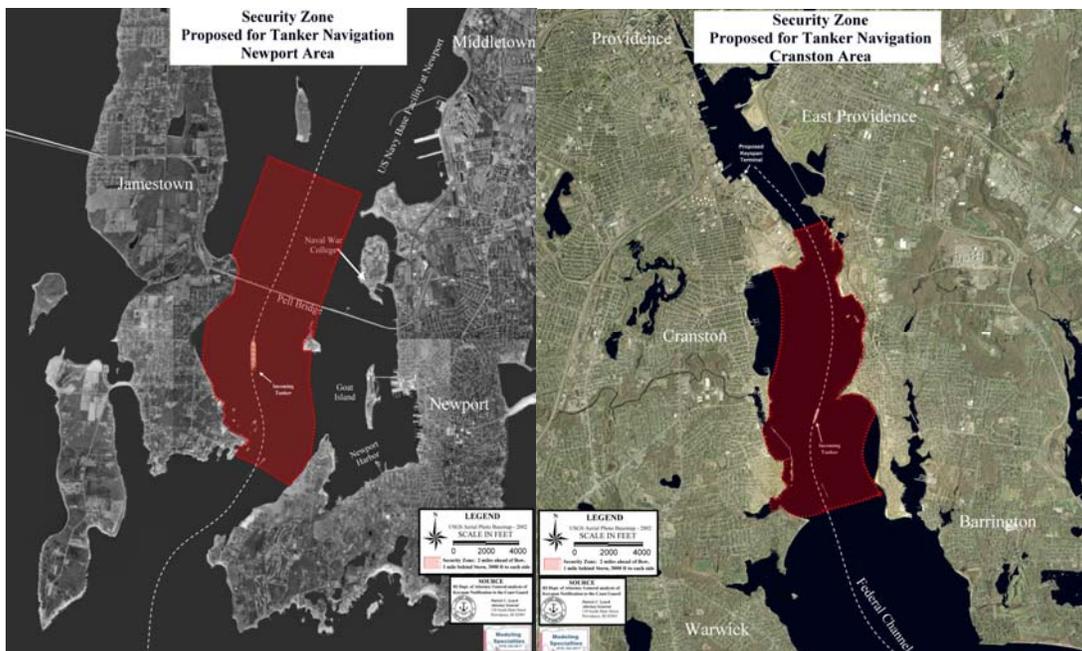


Figure 1.6: Proposed Security Zones for Newport, RI, and Cranston, RI

4. Properties of LNG

The uses of natural gas in the United States are varied. The industrial sector accounts for the largest proportion of natural gas usage in the United States, especially for power generation, but also in the pulp and paper, metals, chemicals, petroleum refining, and food processing industries. Natural gas also provides the base ingredients for products such as fertilizer, anti-freeze, plastic, and fabrics. In the residential and commercial sectors, natural gas is used primarily for heating, cooling, and cooking. The transportation sector also is making use of natural gas, with 130,000 natural gas vehicles on the road in the U.S. (and 2.5 million worldwide), with new technology continually in development. Rising gasoline prices, oil price volatility, and the possibility of domestic oil shortages has increased U.S. demand for natural gas, despite the fact that it is more expensive to produce and transport. Domestic natural gas reserves are no longer sufficient to satisfy the growing demand, so the U.S. relies on foreign natural gas imports, which tend to be cheaper, mostly from Trinidad.

LNG vapor is colorless, odorless, and non-toxic, but is considered a flammable liquid. It is typically 85 to 96% methane by volume, with the balance comprised mainly of ethane, propane, butane, and nitrogen. LNG vapor at ambient temperatures is lighter than air and typically appears as a visible white cloud when released because its cold temperature condenses water vapor in the surrounding atmosphere. LNG vapor from a liquid release will tend to stay near the surface of the ground or water, depending on the location from which it is released, until it mixes with air and warms to a temperature of -162°F . When this occurs, it will become less dense than air and will rise and disperse more rapidly as a flammable vapor cloud. If not ignited, the cloud will drift downwind until the effects of

dispersion dilute the vapors below a flammable concentration. LNG vapors will only ignite when the concentration of gas in the air is between 5 and 15 % - its lower and upper flammability limits, respectively. These vapor clouds have low explosion potential, so the primary concern does not center upon a large blast resulting from a LNG release. An ignition source, such as an open flame or a spark, would need to be present for the cloud to ignite, and one can assume that such a source would be abundant as a result of the likely violent and dramatic event that caused the breach in the first place.⁸⁵

Natural gas condenses into liquid, or LNG, when it is cooled to temperatures below -260° Fahrenheit. As a liquid, natural gas occupies only 1/600th the volume of its gaseous state, which allows it to be stored and transported more effectively. LNG is then "regasified" when it is warmed. The regasification process takes place at the nation's four LNG terminals: Chesapeake Bay, Maryland; Lake Charles, Louisiana; Elba Island, Georgia; and Everett, Massachusetts. All four were built in the 1970s, at the beginning of the natural gas boom in the United States. Today, more than 30 new terminals are being planned, are in the licensing process, or are currently under construction in the United States and Puerto Rico.

a. Possible Spill Scenarios

The tankers that transport LNG are typically more than 900 feet long, equipped with five 6-million gallon tanks filled with LNG. Each ship carries enough natural gas to heat 30,000 homes for a year. The tanks are designed to conform to the shape of the ship's hull and therefore occupy the majority of the internal area of the vessel, minimizing the space into which spilled or leaked LNG can accumulate. The tanks are specially built to store LNG at subzero

⁸⁵ Sandia, Op. Cit.

temperatures and to maintain the stability of the fuel in its liquefied state. Today's LNG tankers are built with double hulls to protect the tanks from rupturing in the event of a collision or deliberate attack, with approximately 10 feet separating the two hulls. Between the cargo tank and the first hull is a layer of insulation approximately one foot thick.

Another concern of scientists about a LNG spill is a rapid phase transition (RPT). The least is known about this phenomenon, but its potential consequences merit discussion. RPT is the natural gas' instantaneous transition from its liquid phase to its vapor phase, and the associated pressure increase that results from the conversion. Were LNG to be released from a tanker, the liquid would pool on the surface of the water, and the warmer water would rapidly vaporize the LNG. The RPT occurs when a portion of the spilled LNG transitions from a liquid to a gas nearly instantaneously. RPTs have caused numerous steam explosions in industrial operations but are not known to have resulted in any LNG explosions.



Figure 1.7: LNG Tanker in Boston Harbor. Source: AP.

The pool fire scenario is the most likely event to cause major devastation from a LNG release on water. The LNG would seep out of the breached tank and form a pool on the surface of the water. As the pool forms, some of the liquid will evaporate as the warmer water condenses the colder LNG. If an ignition source is present, as it likely would be in the case of a large-scale LNG release, the flammable vapor will ignite and the flame will travel back to the spill, resulting in the ignition of the LNG that had pooled on the surface of the water. Most scientists believe that if one of a tanker's five tanks were to fully release onto the water's surface, a pool fire could result that could potentially envelop the entire tanker. LNG fires cannot be extinguished by conventional fire-fighting techniques and will burn much more rapidly and at much greater intensities and levels of heat than crude oil or even gasoline fires.^{86, 87}

Factors affecting these scenarios:

- Release rate of the LNG from the tanker or storage facility, creating a sufficient supply of liquid gas released. Creating this sufficient supply would require creating a hole of at least 5 meters in diameter, according to the Sandia report.
- For the gas to remain in liquid state, compressing the gas to prevent it from turning to vapor is critical. For this compression, it would be necessary to release the liquid gas in some enclosed or confined space.

⁸⁶ *Consequence Assessment Methods for Incidents Involving Releases from Liquefied Natural Gas Carriers* (accessed March 19, 2005); available from <http://www.ferc.gov/industries/gas/indus-act/lng-model.pdf>.

⁸⁷ Jerry Havens, "Terrorism: Ready to Blow?" *Bulletin of the Atomic Scientists* 59, no. 4 (2003): 16-8.

- If the gas turns into vapor, the ignition rate is much lower, as vapor only ignites if in a confined space.
- Providing an ignition source to the liquid or vapor gas is an additional requirement for explosion.

Therefore, causing maximum physical and casualty damage through an intentional or terrorist attack on an LNG facility or tanker would require a multi-tiered approach.

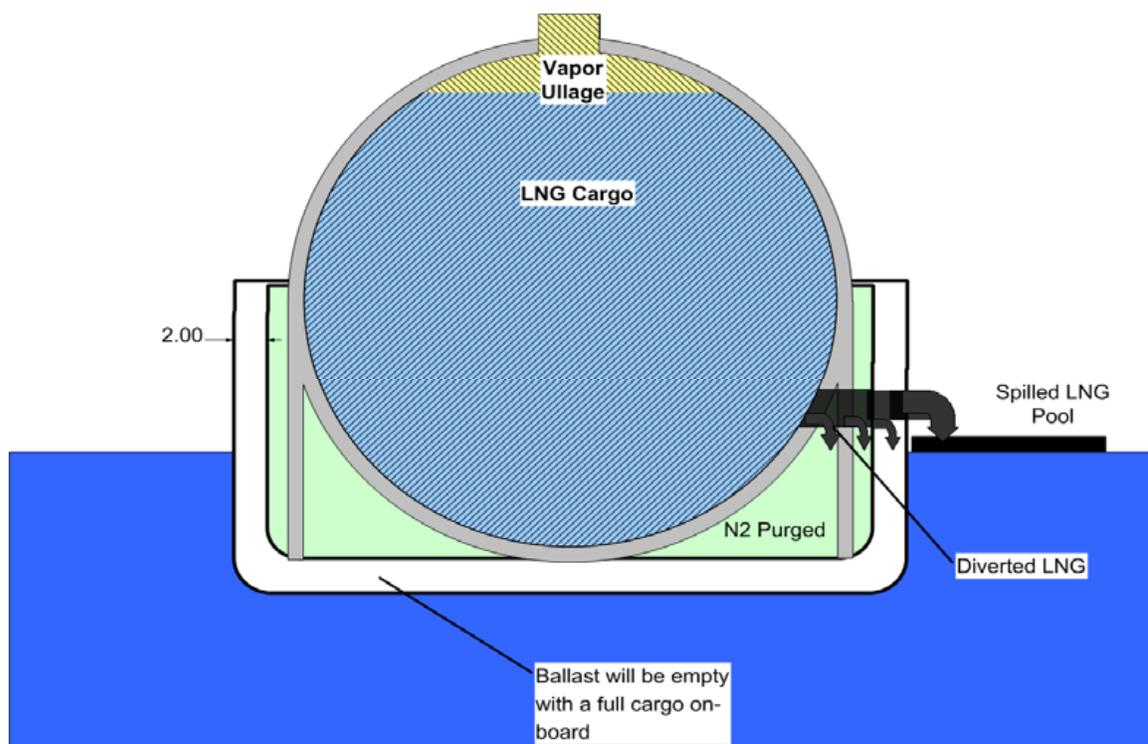


Figure 1.8: LNG Spill on Water. Source: Sandia National Laboratories, 2004.

b. Variables of LNG Effecting Threat Potential

Creating a destructive LNG incident through an intentional attack on an LNG facility an intentional could be achieved through several means:

- Vaporized LNG
 - Using the gas in vapor form to cause physical harm to the surrounding population. As LNG is a colorless, odorless gas, it would be possible to have the gas spread.
 - Using the gas in vapor form to ignite a fire.
 - Using the gas in vapor form to cause an explosion
- Liquefied Natural Gas
- Using the liquid gas to physical harm to surrounding population.
- Using the liquid gas to ignite a fire.
- Using the liquid gas to cause an explosion.

5. Extant Threat Analyses

Given the existing and the anticipated lucrative market for LNG, stakes are high in determining the feasibility of safe LNG facilities and in reducing the perceived associated risks that are more apparent to us today, post-9/11. As such, there have been a number of studies conducted and commissioned to explore the risk of accidental breaches on LNG facilities, tankers in particular. These studies consist primarily of theoretical and computer modeled incidents, as there have been so few LNG breaches. There are far fewer studies that address intentional breaches,

such as terrorist incidents, as these incidents to date have been uncommon. Therefore, our analysis on risk and consequence management of intentional breaches is based primarily on what is known about accidental breaches.

The body of literature on LNG breaches is additionally complicated by the vast amount of information that exists and by the fact that much of the research has been funded or initiated by interested parties, either private companies with LNG interests or groups that stand to gain or lose from the placement of LNG facilities. In creating this report, we have done an exhaustive literature search but in drawing our conclusions, we have relied on those studies done by independent and scientific research laboratories, to insure we have used unbiased findings.

To date, the definitive study on intentional and unintentional LNG breaches is the Sandia Laboratories report released in December, 2004. The report was designed to be the definitive study that drew from the best existing research. It examines the report presents its own research and compares it with 3 additional spill modeling studies Sandia deems to be of sufficient scientific merit: The Lehr Study (2003), the Fay Study (2003), the Quest Study (2003), and the Vallejo Study (2003).

6. FERC's Risk Assessment of the Threat

The Federal Energy Regulatory Commission (FERC) produced a draft Environmental Impact Statement (DEIS) of the KeySpan proposal in November 2004 as part of the standard licensing process for the construction or expansion of energy facilities. The DEIS examined numerous technical aspects of the KeySpan proposal and the effect of the construction and operation of the facility on the surrounding area. The section of the DEIS upon which this report will focus is FERC's analysis of the potential threat and damage associated with a deliberate attack on a LNG tanker in

transit to the facility, while docked and unloading, or an attack on the facility itself.⁸⁸

FERC determined that the risks of a terrorist attack can be "managed." While there is a level of risk associated with the transport of any hazardous cargo, the potential catastrophe that could ensue from an attack on a LNG tanker or on the facility is drastic enough to merit a serious reconsideration of building a LNG import terminal near the heart of downtown Providence. Alternatives exist to the location KeySpan has proposed, and these alternatives - where the damage caused by a terrorist attack would be significantly reduced - should be strongly considered. FERC examined alternatives to the proposal, including locating the facility at a different site, expanding the pipeline system, or building an offshore terminal, and determined that while certain ideas would eliminate or reduce the safety risks associated with the current proposal, they would not meet the objectives for improved natural gas storage and delivery laid out in the current proposal.

a. Risk of Attack

FERC determined that the likelihood of a terrorist attack on the Providence LNG facility is "unpredictable given the disparate motives and abilities of terrorist groups," and said that the continuing need to expand the natural gas industry "is not diminished by the threat of any such unpredictable acts." Of course terrorist attacks are by their nature unpredictable, but as was shown in the previous section, terrorist groups have a stated intent and demonstrated capability to inflict damage upon the oil and gas industry. The potential disaster that would result from an attack on a LNG tanker or facility could be of the "spectacular" nature that groups like al Qaeda are keen to

⁸⁸ Federal Energy Regulatory Commission, Office of Energy Projects, *Draft Environmental Impact Statement: KeySpan LNG Facility Upgrade Project*, November 2004, Washington, D.C.

produce. Discounting the threat of terrorist attack on the Providence LNG facility as unpredictable and manageable ignores evidence that shows that certain attacks are more likely than others.

b. Analysis of Recommended Safety Measures

FERC listed the reasons that the current proposal, if amended to include FERC's suggested mitigation measures, satisfactorily addresses all safety concerns associated with the expanded facility. The primary reasons for its support of the project are:

- The import terminal facilities would be constructed or modified to meet current federal safety standards;
- The safety features that would be incorporated into the design and operation of the LNG import terminal and the LNG vessels;
- The operational controls to be imposed by the local pilots and Coast Guard to direct the movement of LNG vessels, and the security provisions to deter attacks by potential terrorists.

Many of the safety mechanisms and protocols that KeySpan feels will be necessary, and the amendments that FERC put forward before it will authorize the construction, fall short and simply will be ineffective in protecting against a terrorist attack.

According to the DEIS, security at the site will be provided by both active and passive systems. The entire site is surrounded by a protective enclosure, such as a fence and/or wall, "with sufficient strength to deter unauthorized access." The DEIS says that "intrusion detection systems and day/night camera coverage identify unauthorized access." KeySpan did not intend to hire its own security staff to conduct patrols of the facility, screen visitors and contractors, and monitor for any suspicious activity. FERC

recommends, however, that KeySpan provide a separate security staff to enhance security at the terminal and during unloading. KeySpan could benefit from this additional security. However, for terrorists to attack the facility or the tanker, they need not infiltrate the KeySpan facility itself. Several of the adjacent industrial facilities provide unfettered access to areas of the shoreline surrounding the proposed tanker route and berthing terminal. This was evident during a March 2005 visit to the facility, when several unauthorized visitors were able to drive up within close proximity of the LNG tank. A chain-link barbed wire fence surrounding the adjacent facility was wide open, with an unlocked padlock hanging off the latch. These unauthorized visitors walked through the gate and got within close proximity of the tank, taking pictures throughout. There were no security officers or KeySpan employees in sight. This disregard for basic security measures was highly worrisome and raises concerns about the surrounding companies to provide adequate security should the KeySpan proposal be approved.



Figure 1.9: Access to industrial facility adjacent to KeySpan LNG tank, Providence, RI, March 2005.

Emergency response procedures are a critical part of the overall safety of a LNG facility, and FERC is right to recommend that KeySpan develop emergency evacuation routes for areas along the tanker's 29-mile transit route prior to construction of the proposed facility. Typically, the preparation of emergency procedures occurs toward the end of the construction phase rather than before it begins. In a situation in which the potential scale of an emergency is so great, it is important that such procedures are drafted, vetted, and formalized as early in the process as possible.

However, according to the studies done on the characteristics of a LNG fire, the initial damage to property and injuries to people would occur within 30 seconds of ignition, at distances as much as a half-mile from the site of the spill (see consequence management section). The damage would be done so quickly that the efficacy of evacuation procedures would be significantly curtailed. The steps recommended by FERC to be incorporated into the emergency response plan will be of little use in the event of a large-scale release and ignition of LNG. Designated contact people in the various emergency response agencies, notification procedures, and sirens and warning devices are standard elements of emergency response scenarios, and are useful in the event of a building fire or a natural disaster, but would be rendered useless during a major LNG fire.

As previously mentioned, KeySpan's proposal to bring LNG tankers into Providence only at night or in the early morning to reduce interference with daily activity and traffic poses an associated security risk. Detecting suspicious activity on the shore, on the Pell Bridge, or in the water is much more difficult in the dark.

Traffic in Narragansett Bay and the Providence River will be restricted to one-way only during the transit of LNG tankers to the proposed facility. This restriction is useful to avoid accidental collisions between the tanker and other

vessels, but of course does not apply to a situation in which, for example, a dinghy laden with explosives, like the ones used to attack the *Cole* and the *Limburg*, were deliberately trying to ram the tanker at any point during its 3-hour journey to the terminal.

The Coast Guard has the option to close the Pell Bridge when the tanker goes beneath it, but FERC says it should not be assumed that routine bridge closures would be mandatory. FERC suggests various alternatives to complete closure: closing the outboard lanes only; placing law enforcement officials at strategic locations along the bridge; or employing technology that provides suitable security alternatives. The Pell Bridge is the only bridge under which a LNG tanker would pass, and were it to close during the tanker's transit, the closure would last only 5 to 7 minutes. FERC is correct in saying that bridge closures should not be mandatory, but not for the reasons it suggests. A complete bridge closure would do little to increase the security of the tanker from an attack. If a terrorist wanted to shoot a rocket-propelled grenade off the bridge into the tanker, he could just as easily do it after the tanker has passed beneath. If the closure will only last 5 to 7 minutes, the tanker will still be in very close proximity to the bridge when traffic is allowed to cross again.

The bulk of security measures proposed in the DEIS sufficiently reduce the likelihood of a tank breach due to an accident, such as a collision or grounding. Indeed, the LNG industry's commendable safety record over the past 40 years speaks to the sound requirements and regulations governing the transit, unloading, storage, and delivery of natural gas. FERC has sufficiently accounted for most conceivable scenarios that could result in an accidental breach. Sandia determined that the risk from accidents is generally low.

But Sandia says the consequences of an intentional breach, in which the LNG release would likely be far greater, could have "severe negative impacts" in its damage to bridges, industrial/commercial centers, LNG terminals, harbors, and populated areas. In its DEIS, FERC tends to downplay the terrorist threat to the LNG industry in the United States. It is reluctant to acknowledge the potential for large-scale disaster should a worst-case scenario LNG release result from a deliberate attack on a tanker or a facility. FERC concludes its analysis of the terrorist threat by shifting the focus of the discussion away from LNG to other potential terrorist targets in the U.S. "At the national level," the DEIS says, "potential terrorist targets are plentiful, many having national significance, while others with a large concentration of the public (major sporting events, skyscrapers, etc,) or critical infrastructure facilities." FERC points out that the U.S. currently has over 500 chemical facilities operating near large populations, with over 100,000 shipments of hazardous cargo being shipped through U.S. waterways each year. FERC says that "resources can be directed to mitigate possible attack paths" for potential targets where the threat is perceived to be high, and that decision makers must determine "whether the resources required to manage the risks are justified by the benefits" provided by the potential target in question.

7. Conclusions

After reviewing the KeySpan report as well as the other risk assessments and consequence management reports, we conclude:

- These facts do little to strengthen the argument for building another facility and increasing annual marine shipments, especially those that would put densely populated residential and commercial areas in harm's way.

- Expanding the KeySpan facility near the heart of Providence provides another attractive target for terrorists.
- Decision makers must also carefully weigh whether these benefits could also be attained through various alternatives to the plan that is laden with risk.
- Offshore facilities or locating onshore facilities in remote areas are two viable alternatives to KeySpan's proposal, both of which pose far less risk to the environment, our energy infrastructure, and the public.

SECTION TWO: Threat Scenarios Involving an LNG Tanker in Narragansett Bay

I. INTRODUCTION

The recent attacks on the *USS Cole* and the French supertanker *Limburg* offer a stark illustration of terrorist interest in maritime targets. Intelligence reports also indicate an increase in peripheral terrorist activity regarding, ships, port facilities, bridges and attacks using scuba. These warnings highlight the need for detailed analysis regarding the potential vulnerabilities of industrial infrastructure and safety and emphasize the need to adequately understand the level at which these vulnerabilities hazard our citizens and our communities.

A. Purpose

This threat analysis was performed to determine possible vulnerabilities associated with LNG transportation and storage procedures that could be exploited by terrorists, specifically, to determine the Terrorist Threat Potential associated with the expansion of the Key Span Liquid Natural Gas facility in the Port of Providence in Providence Rhode Island.

B. Summary of Analysis

An effective terrorist attack against any target can only be culminated after the sequencing of multiple links in a dynamic chain of events. Each link is dependent upon the next and all contribute to the overall success or failure of the operation. Law enforcement and military planners recognize this fact and structure their defensive strategies around the disruption of this chain. While it has been said

that a terrorist attack need only succeed once and that the defenders need to succeed always, understanding the chain of events and the potential for disruption shows that terrorists may be less effective than it would initially appear. Despite this presumption, analysis clearly indicates that a LNG carrier transiting the Narragansett Bay is susceptible to a number of potential terrorist threats.

1) Four distinct threat scenarios were considered during this analysis. These scenarios are based upon the combined experience of the U.S. Coast Guard and the United States Navy and their ongoing efforts to ensure the safety of the maritime environment. In developing these scenarios, it must be understood, that an effective attack can only be culminated after the sequencing of multiple links in a dynamic chain of events. Each link is dependent upon the next and all contribute to the overall success or failure of the operation. Law enforcement and military planners recognize this fact and structure their defensive strategies around the disruption of this chain. The scenarios considered in this analysis are:

- a) Air Attack
 - i. low, slow, flyer/private
 - ii. commercial plane

- b) Stand Off Weapon
 - i. heavy caliber rifle
 - ii. small caliber rocket/RPG
 - iii. medium caliber rocket
 - iv. explosive charge

- c) Surface Attack
 - i. small boat/high speed boat
 - ii. surface swimmer

- d) Subsurface Attack
 - i. diver
 - ii. mine/mine like device

- 2) Through analysis the following conclusions can be made:
 - a) Eight distinct Threat Sectors exist within the Narragansett Bay. Risk within sectors is based upon:
 - i. proximity to shore
 - ii. proximity to structures
 - iii. proximity to marinas, inlets or bays
 - iv. proximity to population centers
 - v. proximity to infrastructure
 - b) TWO sectors should be considered to be EXTREMELY HIGH RISK, Sector 2 and Sector 8.
- 3) Threats within sectors can be ranked according to vulnerability and consequence
- 4) Numerical value can be applied to each scenario within each sector. This value provides a basis for risk analysis
- 5) An assessment of the cumulative risk analysis indicates a scale of incident probability
- 6) Incident probability can be ranked from most probable/most effective (a) to least probable/least effective (h)
 - a. small boat attack
 - b. medium rocket
 - c. small rocket
 - d. mortar
 - e. mine
 - f. shaped charge
 - g. air attack and
 - h. swimmer-diver, heavy rifle.
- 7) Application of the CARVER Threat Assessment process further refines the tactical planning aspects associated with determination of incident probability.

8) The following assumptions will be utilized for baseline planning when considering the desired terrorist effect and the potential weapon system that will deliver this effect.

i. LNG cargo tank hole sizes for most credible threats range from two to twelve square meters; expected sizes for intentional threats are nominally five square meters.⁸⁹

ii. The most significant impacts to public safety and property exist within approximately 500 m of a spill, due to thermal hazards from fires, with lower public health and safety impacts at distances beyond approximately 1600 m.⁹⁰

iii. Large, unignited LNG vapor releases are unlikely. If they do not ignite, vapor clouds could spread over distances greater than 1600 m from a spill. For nominal accidental spills, the resulting hazard ranges could extend up to 1700 m. For a nominal intentional spill, the hazard range could extend to 2500 m. The actual hazard distances will depend on breach and spill size, site-specific conditions, and environmental conditions.⁹¹

iv. Cascading damage (multiple cargo tank failures) due to brittle fracture from exposure to cryogenic liquid or fire-induced damage to foam insulation was considered. Such releases were evaluated and, while possible under certain conditions, are not likely to involve more than two or three cargo tanks for any single incident. Cascading events were analyzed and are not expected to greatly increase (not more than 20%-30%) the overall fire size or hazard ranges noted in Conclusion 4 above, but will increase the expected fire duration.⁹²

⁸⁹ Sandia Report. Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water. SAND2004-6258. December 2004. section 1.2.3. pg. 21

⁹⁰ Ibid. 1.2.2. pg. 21

⁹¹ Ibid. 1.2 Safety Analysis, pg. 20

⁹² Sandia Report. Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water. SAND2004-6258. December 2004. section 1.2.1 pg. 21

II. CONSTRUCTION METHODS FOR THE STORAGE AND TRANSPORT OF LNG

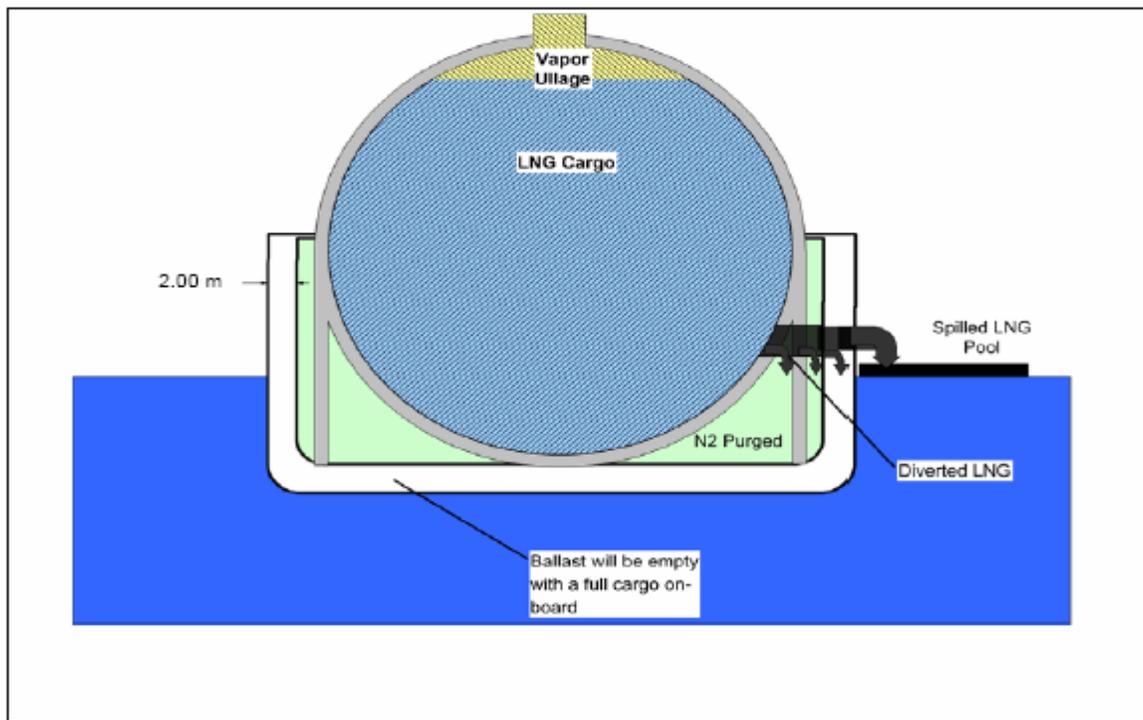
A. Methods of Construction

There are currently two methods of LNG storage tank construction accepted within the maritime industry. These methods are the 1) Moss Rosenberg and 2) the Prismatic tank design. These two methods employ similar construction methods and standards and are designed to contain LNG within a refrigerated and pressurized system. The Moss Rosenberg system is oval in shape and sits within an independent support structure within the ships hull. The prismatic tank design is shaped in a manner that contours more accurately with the shape of the inner ship.

Adjacent to these storage containers are containment reservoirs that isolate container spills within the ship and allow for the introduction of fire prevention materials such as nitrogen. Adjacent to this containment reservoir is the ships inner hull. Between the inner hull and the outer hull is a void that can be filled with water ballast when the ship is underway. These spaces are usually purged off shore prior to entering port. This void would in most cases be empty when the ship transits within the inner harbor but may be filled prior to departure after offloading the LNG cargo. Both of these designs would 1) raise the ballistic/explosive requirements of any weapon systems used to breach the hull and tank and 2) significantly reduce the effects that any weapon system employed would have in disrupting the structural integrity of the container.

1. Figure 2.1: LNG Tank Construction Cross Cut Diagram Moss Tanker

Source: Sandia National Laboratories



This diagram of a Moss Rosenberg tank shows the outer hull, void, inner hull, containment reservoir, tank support and storage tank. The diagram also depicts a spilled LNG diverting mechanism that is intended to void the inner containment reservoir of liquid in the case of an inadvertent discharge of material within the ship. This diagram also depicts the introduction of nitrogen, (a non-flammable gas) which is used to displace spilled LNG until it can be discharged overboard or vented to the atmosphere.

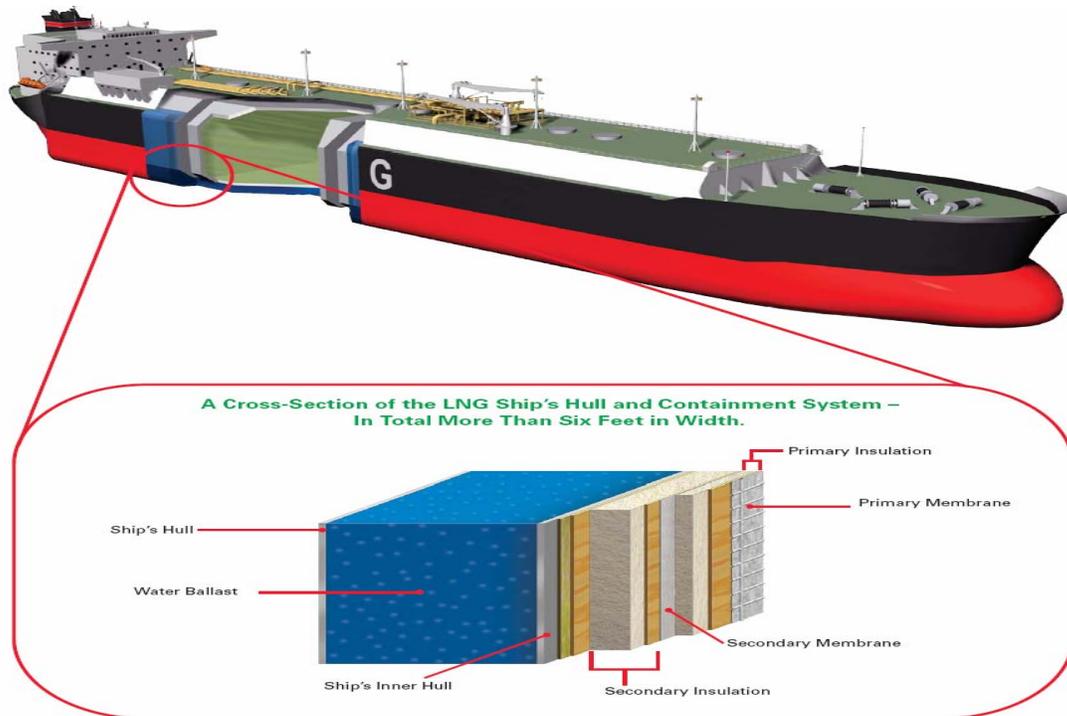
It can be estimated from this diagram that the standoff distance between the LNG cargo and the outer hull would

exceed ten feet anywhere below the ships upper deck limits. The diagram shows the void empty of ballast. This condition creates an air space between the outer hull and inner hull. Transiting this void would require far less explosive power when empty. A fully ballasted void would be very hard to breach explosively and would serve in a manner similar to the torpedo defense measures developed during World War II.⁹³

The vulnerability of this system can be found in the size and the surface area of container above the level of the uppermost ships deck and the top of the containment tank. Protection of the LNG cargo within this area is dependent upon the thickness and materials used in the tank construction.

⁹³ Torpedo Defense Systems. Joseph Czarnecki, 31 January 2001. Torpedo Defense Systems of WWII. Available on line at. [file:/m/lng/Torpedo Defense Systems of WWII.htm](file:/m/lng/Torpedo%20Defense%20Systems%20of%20WWII.htm)

**2. Figure 2.2: LNG Tank Construction Cross Cut Diagram
Prismatic Tanker**
Source: Shell Oil



The Prismatic tank design is similar to the Moss Rosenberg design with some notable differences. The Prismatic design is contoured to the inner hull but still incorporates a void in excess of six feet. This void would serve in a manner identical to that of the Moss Rosenberg design. There are also noticeable differences in the inner tank design and construction. Despite an increase in vertical surfaces, the sandwich effect provided by the ships inner hull, secondary insulation, secondary insulation, secondary membrane, primary insulation and primary membrane would provide considerable explosive standoff between the outer hull and inner cargo. This design creates far less freeboard between

the top of the ships uppermost deck and inner LNG container and would expose the LNG container to less horizontal threat than the Moss Rosenberg. The prismatic shape of the top of the container and the protection provided by the ships upper deck may provide both stand off and deflection in most directions with the exception of directly from above.

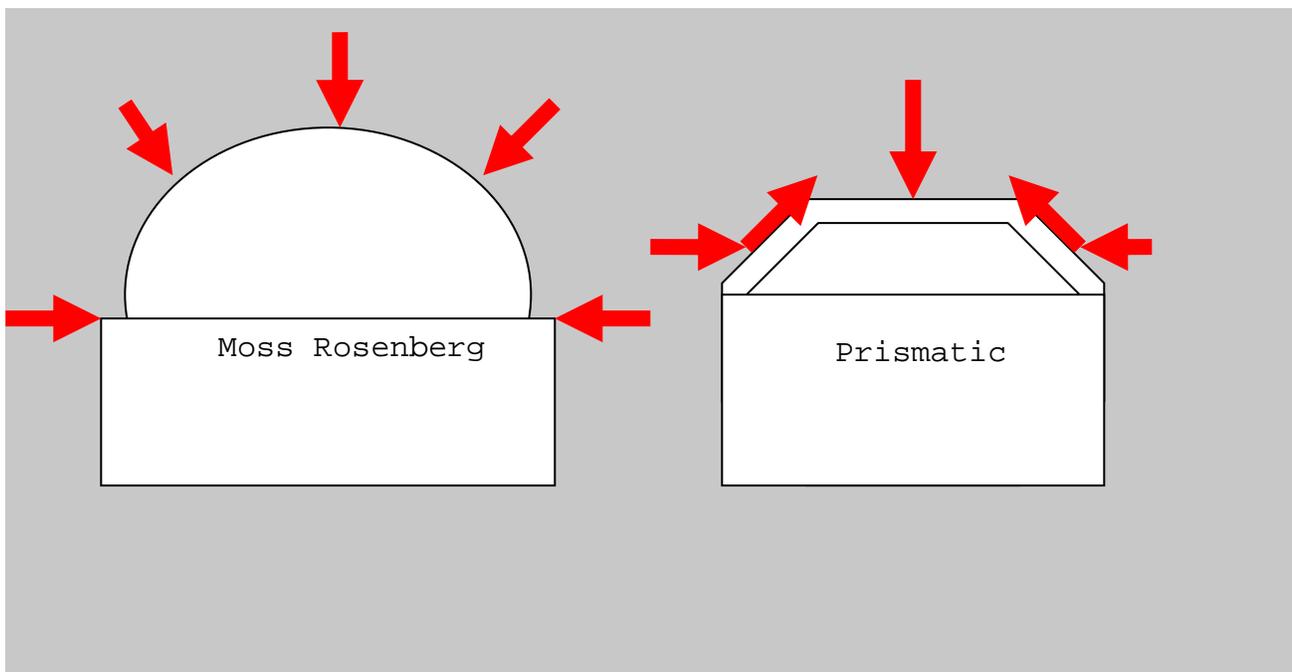


Figure 2.3: LNG Tank Designs. Source: Good Harbor.

III. RISK ASSESSMENT OF THE NARRAGANSETT BAY AND PROVIDENCE RIVER

A. Narragansett Bay and Providence River

The Narragansett Bay and Providence River LNG transit route can be broken down into three categories of risk: Extremely

High, High, and Medium. A fourth category, Low risk, was considered but is not noted in this report since it can be argued that risk exists with all associated transport of material on vessels. These risk conditions exist within eight distinct sectors. These sectors were chosen based upon their proximity to shore (within 1000yds), proximity to fixed structures such as bridges and jetties, and proximity to marinas/inlets or bays where a small boat threat may originate. These sectors may be congested or in close proximity to industrial based sectors and destruction of a cargo within these areas would cause significant destruction of the surrounding infrastructure.

B. Threat Sectors

The eight sectors of most significant risk begin at the seaward entrance of the Narragansett Bay, proceed north within established shipping channels and terminate at the existing Key Span facility.

- 1) Two of these eight sectors are considered **EXTREMELY HIGH RISK** (Sectors 2 and 8).
- 2) Four of these sectors are considered **HIGH RISK** (Sectors 1, 3, 4, and 7)
- 3) Two of these Sectors are considered **MEDIUM RISK** (Sectors 5 and 6).
- 4) The threat to vessels in transit between sectors has been assessed to be medium to medium-low. However, in no single sector could the threat posed by a small plane or high speed boat be completely eliminated.
- 5) The threat posed by a mine or mine-like device remains relatively consistent throughout the entire route.

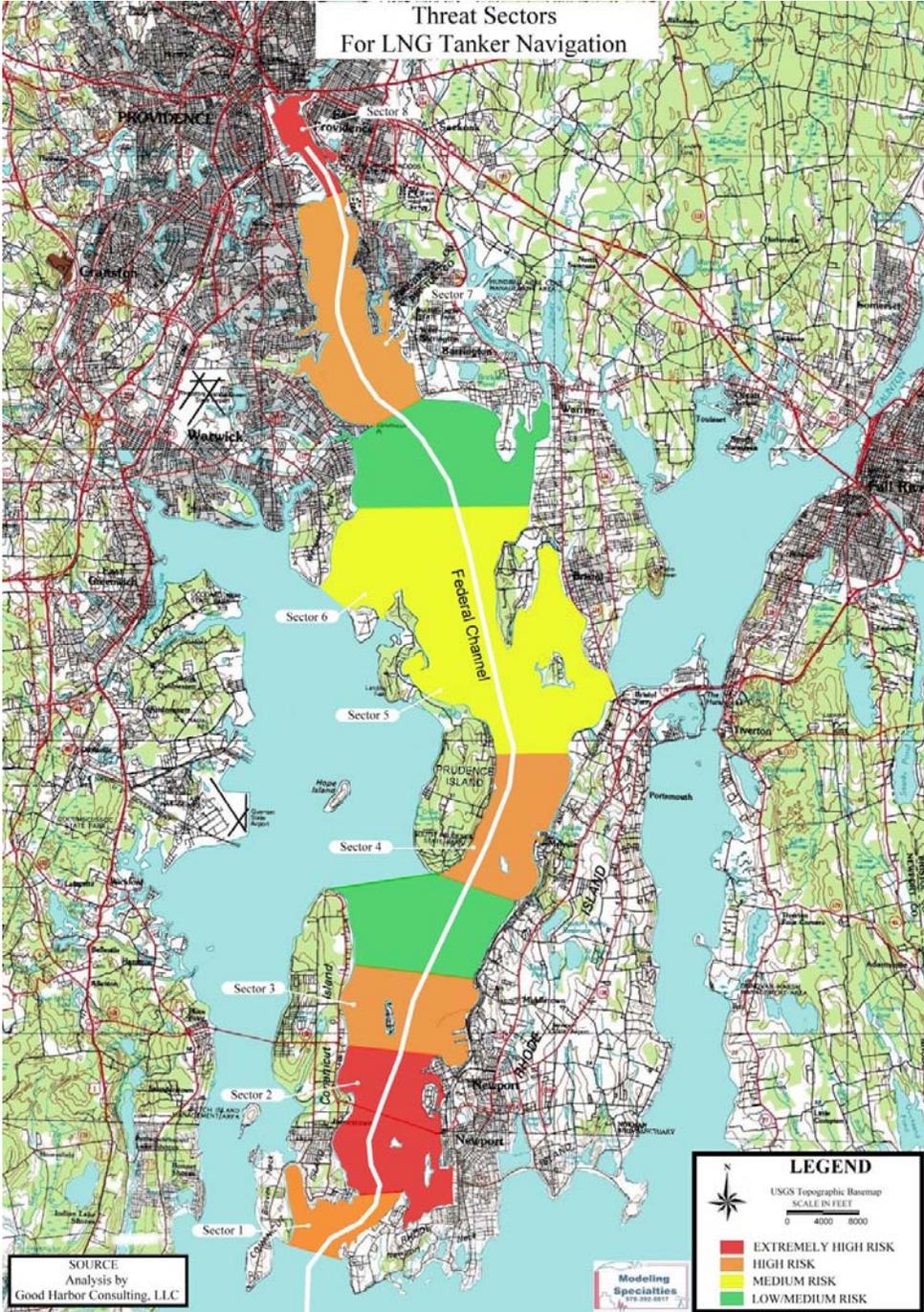
- 6) The threat of a swimmer/diver attack is absent in all sectors with the exception of Sector 8 in Port Providence.

C. Threat Sector Descriptions

The following sectors are described by location and vulnerability to potential threats. These are:

SECTOR 1, HIGH RISK, proximity to shore/boat traffic. This area begins at the initial approach of the Narragansett Bay on the seaward side of the Butterball Rocks, Newport Neck and extends for approximately two nautical miles to the Dumplings in an approximate line with Fort Adams Point, on the east and Bull Point to the west. Distances to shore vary from 300yds at Castle Hill, 200 yds at Ft. Wetherill/Bull Point, to over 1000yds. Distances exceeding 1000 yds are considered medium-medium-low threat areas with regards to shore based weapons systems.

A ship transiting this area would most likely slow to accept a coast pilot and navigate the congested area immediately adjacent Newport Harbor. A ship transiting this area could be subject to a very short duration high speed boat attack originating from any of the civilian moorings/marinas within the harbor. The extremely short reaction time and significant concentration of civilian pleasure craft would make U.S. Coast Guard enforcement of a stand off safety zone extremely difficult if not impossible, especially during the summer months. The on-load of explosives within Newport Harbor is as assessed as difficult due to the close proximity of other vessels and citizens however, cargo could be disguised as commercial fishing supplies or other industrial products transferred within this area by boat. This area also provides easy access to the waterfront by vehicle and because of the mixed civilian- commercial nature of the waterfront, provides easy access for the on-load of heavy cargo.



Map 2.1: Threat Sectors for LNG tanker transit.

SECTOR 2, EXTREMELY HIGH RISK, proximity to a fixed facility, shore, concentrated boat traffic, limited maneuver, threat to infrastructure. This area begins at Rose Island and extends under the Pell Bridge to an area adjacent Coasters Harbor Island. A vessel transiting this area could be subject to each attack scenario with the exception of a swimmer attack. The Pell Bridge serves as natural choke point and would be the perfect spot for a combined attack. The center span is less than 1500 feet wide and offers less than 194 feet of vertical clearance. A sea/shore attack initiated within this area combined with a mine/mine like object strike or a suspended shape charge, could potentially devastate the cargo of the ship, the Pell Bridge and the surrounding infrastructure. Casualties within this area would be significant.

SECTOR 3, HIGH RISK, proximity to shore, concentrated boat traffic. The northern tip of Coasters Harbor to the northern tip of Gould Island. Significant threat within this area would be a shore-based attack from Coddington point, 800 yrds or from the Coddington Cove breakwater, 700 yrds. A vessel transiting this area could be subject to a small boat attack originating from Coddington Cove. This area also provides easy access to the waterfront by vehicle and because of the mixed commercial/civilian nature of the waterfront provides easy access and on-load of heavy cargo.

SECTOR 4, HIGH RISK, proximity to shore, concentrated boat traffic. Southern end Prudence Island to north Mellville/Coggeshall. Western side channel southern end Prudence Island, 700 yrds, sandy Point, 500 yrds., eastern side Dyer Island, 400 yrds, three marinas in the Mellville, Coggeshall area. A vessel transiting this area could be subject to shore based or small boat attacks. This area also provides easy access to the waterfront by vehicle and because of the mixed commercial/civilian nature of the waterfront provides easy access and on-load of heavy cargo.

SECTOR 5, MEDIUM RISK, proximity to shore. Northern tip Prudence Island, Homestead, 1000 yrds., to area adjacent Mount Tom Rock, 1000 yrds. This area is assessed as moderate risk due to ranges from shore. The eastern side of the transit area is exposed to the threat of a small boat, high speed boat approaching from Mount Hope Bay, Fall River area. Vessels transiting from this area would be visible on clear days as they transit the Mount Hope Bridge (2 miles). Escort vessels could be positioned to intercept any vessel approaching on this side.

SECTOR 6, MEDIUM RISK, proximity to shore. Southern tip Papasquash Neck/Papasquash Point, 800 yrds to north Point, Papasquash Neck, 800 yrds. This area is assessed as moderate risk due to ranges from shore.

SECTOR 7, HIGH RISK, proximity to shore, concentrated boat traffic, proximity to industry, limited maneuver, threat to infrastructure. Conimicut Point Reach, Conimicut Point to Fields Point, Fuller Rock Reach. This entire area is considered HIGH RISK. Vessels transiting this region would have to slow to maneuver the four reaches of this approach and would be within range from a shore based attack from Bullock Neck to Fields Point. Area is also subject to extensive boat traffic including commercial and civilian vessels. Proximity to liquid petroleum carriers and other potentially volatile cargos makes this transit area extremely dangerous. Liquid petroleum carriers could be used as an ignition source during a combined sea/shore attack. Limited maneuver and proximity to civilian traffic would facilitate small boat attack with limited warning and reaction time and challenges to maintaining the safety or security exclusion zone. Limited transit of deep draft vessels could facilitate employment of a bottom influence or other mine, mine like device.

SECTOR 8, EXTREMELY HIGH RISK, proximity to shore, concentrated boat traffic, choke point, limited maneuver, proximity to industry, threat to infrastructure. Sector Eight begins at Fields Point adjacent the Fuller Rock Reach and proceeds northwards to the northern boundary of the Fox Point Reach. Transit is restricted in this sector by the Fuller Rock Lighthouse to the south and the Point street bridge and Washington Bridge (HWY 195) to the north. A vessel transiting this area could be subject to all attack scenarios. The resulting destruction of cargo and surrounding infrastructure could be significant. Resultant casualties could also be significant.

**D. Scenario Driven Risk Assessment Matrix
(REGIONAL ANALYSIS)**

Table 2.1. Source: Good Harbor

	Sector1	Sector2	Sector3	Sector4	Sector5	Conse- quence	Risk Analysis
Air Attack	2/1	2/5	2/4	2/2	2/2	16/28	44
HVY Rifle	2/1	2/2	2/1	2/1	2/1	16/9	25
Small Rocket	5/2	7/5	5/4	4/3	3/3	41/28	69
Medium Rocket	6/2	7/8	5/6	4/4	4/4	44/43	87
Shaped Charge	0/2	5/7	0/6	0/3	0/3	18/40	58
Mortar	3/2	5/5	4/3	3/3	3/3	32/30	62
Small Boat	9/2	9/9	9/6	9/6	9/6	72/51	123
Swimmer/ Diver	1/1	1/1	1/1	1/1	1/1	17/12	29

Risk = f (Vulnerability + Consequence)

Vulnerability considers: applied security, detection, attractiveness, exposure and inherent resilience

Consequence considers: response cost/capability, numbers of casualties, environmental impact, short term economic impact and long term economic impact.

E. TARGET SELECTION METHOD

1. CARVER Threat Assessment Process

US Special Operations forces use the CARVER Threat Assessment Process to select targets in support of US objectives. Since we are aware that al Qaeda has adopted much of US Army doctrine for use in its training camps, it is fair to assume the principals in the CARVER matrix apply to their targeting. We should consider this in assessing the risk of an LNG facility contrasted against the variety of other targets available. We can also use it to help us shape examination of an LNG facility through the eyes of a terrorist.

CARVER stands for: Criticality, Accessibility, Recoverability, Vulnerability, Effect, and Recognizability.

a. Criticality is the importance of a system, subsystem, complex, or component. A target is critical when its destruction or damage has a significant impact on the output of the targeted system, subsystem, or complex.

b. Accessibility is the ease with which a target can be reached, either physically or by fire. A target is accessible when an action element can physically infiltrate the target, or if the target can be hit by direct or indirect fire. Accessibility varies with the infiltration and exfiltration, the survival and evasion and security situation en route to and at the target, and the need for barrier penetration, climbing, and so on, at the target. The use of standoff weapons should always be considered when evaluating accessibility. Survivability of the attacker is usually most closely correlated to a target's accessibility.

c. Recoverability is a measure of the time required to replace, repair, or bypass the destruction or damage inflicted on the target. Recoverability varies with the

sources and ages of targeted components and with the availability of spare parts.

d. Vulnerability is a measure of the ability of the action element to damage the target using available assets (both men and material). A target is vulnerable if the unit has the capability and expertise to successfully attack it. Vulnerability depends on:

- Nature and construction of the target.
- Amount of damage required.
- Assets available (manpower, transportation, weapons, explosives, and equipment).

e. Effect is the positive or negative influence on the population as a result of the action taken. Effect considers public reaction in the vicinity of the target, but also considers the domestic and international reaction as well. Effects to consider include the following:

f. Recognizability is the degree to which a target can be recognized under varying weather, light, and seasonal conditions without confusion with other targets or components. Factors that influence recognizability include:

- The size and complexity of the target
- The existence of distinctive target signatures
- Technical sophistication and training of the attackers.

2. CARVER Matrix

Target selection factors may be used to construct a CARVER matrix.

The matrix is a decision tool for rating the relative desirability of potential targets and for wisely allocating attack resources. To construct the matrix, analysts list the potential targets in the left column. For strategic-level analysis, analysts list the enemy's systems or subsystems (electric, power, rail). For tactical-level analysis,

analysts list the complexes or components of the subsystems selected for attack by their higher HQ. Next, analysts develop concrete criteria for evaluating each CARVER factor. For instance, time may be used to evaluate criticality. If loss of a component results in an immediate halt of output, then that component is very critical. If loss of the component results in a halt of output, but only after several days or weeks, then that component is less critical. Similarly, percentage of output curtailed might be used as the evaluation criterion.

Once the evaluation criteria have been established, analysts use a numerical rating system (for example, 1-to-5 or 1-to-10) to rank the CARVER factors for each potential target. In a 1-to-10 numbering system, a score of 10 would indicate a very desirable rating (from the attacker's point of view), and a score of 1 would reflect an undesirable rating. The evaluation criteria and numerical rating scheme shown are only included as examples. The analyst must tailor the criteria and rating scheme to suit the particular strategic or tactical situation and the particular targets being analyzed.

The CARVER Threat Assessment Matrix provides a more tactical assessment of the probability of attack within a particular Threat Sector. Higher numbers indicate a greater likelihood for attack.

Table 2.2. Source: Good Harbor

	<u>Criticality</u>	<u>Accessibility</u>	<u>Recoverability</u>	<u>Vulnerability</u>	<u>Effect</u>	<u>Recognizability</u>	<u>Cumulative</u>
Sector 2	4	5	2	4	3	4	22
Sector 8	8	7	8	7	7	8	45

IV. LNG TANKER ATTACK SCENARIOS

A. AIRCRAFT ATTACK SCENARIO

Since the attacks of September 11th, the potential use of aircraft as weapons has received considerable attention. Despite momentous efforts to reduce the risk of terrorists seizing an aircraft, there is very little that has actually been done to prevent the use of an aircraft as a weapon once it is in terrorist hands. Additionally, law enforcement, Coast Guard and other Department of Homeland Security elements do not have the authority nor the will to engage civilian aircraft within U.S. Airspace. The availability of civilian and commercial aircraft within Rhode Island provides a rich background for imaginative scenario driven

planning. The aircraft attack scenario was analyzed from two perspectives. 1) The availability of civilian aircraft within the Providence region and 2) the effects that use of such an aircraft would have against a LNG carrier.

1. Assumptions

The following assumptions have been made regarding the use of an aircraft as a weapon in this scenario.

- a) Attack aircraft would be light civil laden with explosives.
- b) Attack would not come from commercial aircraft. Hijacking of commercial aircraft would not target LNG tanker, but would seek more spectacular target (e.g. World Trade Center, Pentagon).
- c) Attacking aircraft would have to carry sufficient explosives to achieve tank penetration, cargo discharge and ignition.
- d) Attack would occur in daylight, VMC (visual meteorological conditions defined as having 3 miles of visibility and a distance of 500 feet below, 1000 feet above, and 2000 feet to the side of clouds)
- e) Available explosive load would not exceed 700 lbs. Typical light civil aircraft specs with nominal 150 lbs pilot provides for 700 lbs of available load for explosives. Typical light civil fuel capacity 50-70 US gallons would be insignificant to achieve desired explosive force.
- f) Selected airfield will be one that has general aviation rental.
- g) Tankers will not carry any anti-air point defense systems.

- h) Coast Guard escort will not be carrying anti-air specific systems.

2. Airfields within 33 nautical miles

There are nine airfields within a 33 nautical mile radius of Providence. Aircraft suitable for attack within this scenario could be acquired at any of these airfields. Their proximity to providence, short duration of flight and current regularity would all lessen detection and reaction to an actual attack. These Airfields include:

- a) Theodore Francis Greene State Airport (Providence) Aircraft rental available.
- b) North Kingstown Airport (Quonset State) No aircraft rental available.
- c) Newport State Airport. No aircraft rental available.
- d) West Kingston Airport (Richmond) No rental available.
- e) Westerly State Airport. No aircraft rental available
- f) New Bedford Regional Airport. Aircraft rental available
- g) Taunton Muni Airport. Aircraft rental available
- h) Mansfield Muni Airport. Aircraft rental available
- i) North Central State Airport (Pawtucket) Aircraft rental available.

3. Attack Profiles

The following attack profiles have been analyzed:

- a) Attack could be conducted anywhere along the waterway route to Providence. Most likely airfield will be a non-Class C airfield, due to strict pilot reporting requirements. Therefore, attack aircraft originating from Theodore Francis Greene State Airport (Providence) is highly unlikely.
- b) Attack will most likely be conducted in daylight hours and in VMC. Night/IMC would present too many difficulties/challenges for attack aircraft to locate and impact tanker at the correct location.
- c) Expected average airspeed: 100 knots.
- d) Average flight time after takeoff could be as low as 15 minutes to close to 30 minutes. Time will depend on airfield of origin versus tanker location and time for attack aircraft to locate tanker. Small civil aircraft could stay airborne for ~2 hours depending on weight of explosives on board.
- e) Expected altitude below 500 feet until tanker is located. There are very few tall obstacles to prohibit low flight along entire waterway.
- f) Once tanker is located, aircraft may climb to gain altitude prior to power descent to impact. Dive could take less than 30 seconds.
- g) Angle of impact will be dependent on chosen impact location on tanker.

4. General Protection Against an Aircraft Attack

The following measures are relevant when considering prevention of an attack utilizing an aircraft:

- a) It is highly unlikely that the Coast Guard would be able to recognize an attack in progress, seek and receive authorization to shoot down civil aircraft in time to prevent such an attack. It can then be concluded that without prior knowledge of attack, there is no defense, whether tanker is under Coast Guard escort or not.
- b) Tanker transiting at night will decrease vulnerability to air attack.
- c) Prior intelligence is a key factor in the determination of a potential attack. Local airfield controllers must be trained for what to look for in order to spot potential attack planning. Considerations:
 - Rental of aircraft with minimum credentials and with cash payment.
 - Unusual activity and/or baggage being loaded aboard aircraft.
 - Aircraft not communicating after takeoff; not responding to communications from ATC.
 - Unusual activity with aircraft during hours when airport is closed or unattended.
 - Any other information as put out by FBI, DHS, etc.
 - All airfields should have adequate security to prevent aircraft theft.

5. Summary

An air attack conducted utilizing a small plane could occur along any portion of the 28 mile transit route. Defense against an air attack is nearly impossible. However, the

probability of a terrorist utilizing a small aircraft to attack an LNG carrier is assessed as low. The effect of a kinetic strike upon an LNG carrier is assessed as low. A terrorist could combine the use of a shaped charge with an air attack/crash however construction and employment of this type of device would require extensive preparation and secrecy.

B. Stand-Off Weapons Attack Scenario

A standoff weapon attack against an LNG carrier could occur at almost any point along the 28 mile route. Many of the weapons described in this section can be acquired on the black market. Stand off weapons can be employed with very little preparation and onsite rehearsal. Terrorists around the world have already used many of these weapons systems and are therefore familiar, even highly competent, with their use. The descriptions provided in this section refer primarily to U.S. style weapons. Most of these weapons have foreign equivalents that are less expensive and more readily available.

1. Weapons Categories

Stand off weapons can be divided into FIVE categories:

- a. Heavy rifle/Grenade launcher
- b. Small caliber rocket/RPG
- c. Large caliber rocket
- d. Mortars
- e. Explosive Charge/shaped charge

Heavy rifle/Grenade Launcher

This category of weapons includes the .50 caliber machine gun, foreign weapons in the 12.7 mm range and grenade

launchers. The U.S. version of the .50 caliber machine gun can be used effectively against machinery at a range exceeding 2000 yds.⁹⁴ This weapon has been configured for sniper use and uses a variety of ammunition to include armor piercing and incendiary. This weapon would be effective in penetrating a Moss Rosenberg tank but would not create a large enough hole or provide a significant ignition source to ignite LNG in any great quantity. Onboard fire fighting equipment would in all probability be able to keep ahead of any fires even after the perforation of multiple tanks.

The 40mm grenade launcher is an effective weapon against personnel and against light vehicles. Terrorist use of this weapon would result in the death of any crew members exposed on deck, could be used as a diversionary tactic in conjunction with another form of attack but would not be an effective weapon choice for this application.

M2 .50 Caliber [12.7mm] Machine Gun

The Browning M2 .50 caliber (12.7mm) Machine Gun, is a World War II era automatic, belt-fed, recoil operated, air-cooled, crew-operated machine gun. The M2 is crew transportable with limited amounts of ammunition over short distances. This gun may be mounted on ground mounts and most vehicles as an anti-personnel and anti-aircraft weapon. Associated components are the M63 anti-aircraft mount and the M3 tripod mount. The weapon provides automatic weapon suppressive fire for offensive and defensive purposes. This weapon can be used effectively against personnel, light armored vehicles;

⁹⁴ Federation of American Scientists Military Analysis network. Available online at <http://www.fas.org/main/home.jsp> military analysis network. key word search, grenade launcher.

low, slow flying aircraft; and small boats and has a max range of 2000ydrds.⁹⁵



M79 Grenade Launcher

The M79 grenade launcher is a single-shot, break-open, shoulder-fired weapon. It is breech-loading and fires a 40mm grenade. This weapon is most effective against personnel and lightly skinned vehicles.⁹⁶



⁹⁵ Federation of American Scientists Military Analysis network. Available online at <http://www.fas.org/main/home.jsp> military analysis network. key word search, M2 .50 cal machine gun

⁹⁶ Federation of American Scientists Military Analysis network. Available online at <http://www.fas.org/main/home.jsp> military analysis network. key word search, grenade launcher.

Small Rocket/RPG

This category of weapons includes small rockets such as the Light anti tank weapon LAW-72, and rocket propelled grenades including the RPG-7, 18 and 26. These weapons were designed to destroy light armored vehicles and tanks with less than one foot of armor. The penetration capability of these weapons is impressive, however the blast effect of these weapons would not be sufficient to achieve the desired effect of a 12m2 hole in either the Moss Rosenberg tank or the Prismatic tank design. The manufacture of these weapons is widespread. The United States, Norway, Czech, Russia, China, Korea and others all produce versions of these weapons.

Soviet/Chi-Com Rocket Propelled Grenade (RPG-7)



Issued by former forces of the U.S.S.R., the Chinese Military, North Korea, and used by a large number of countries that have previously received weapons and training from the former Soviet/Communist Bloc, the RPG-7 proved to be a very simple and functional weapon that has an anti-vehicle/armor role as well as being effective against fixed emplacements. Its effective range is thought to be approx. 500 meters when used against a fixed target, and about 300 meters when fired at a moving target. It is reported that it can penetrate at about 12 inches of conventional armor plate.⁹⁷ This weapon has been used extensively by terrorist organizations in the Mid-East and Latin America. The RPG-7

⁹⁷ Federation of American Scientists Military Analysis network. Available online at <http://www.fas.org/main/home.jsp> military analysis network, key word search RPG.

is thought to still be available in illegal international arms markets, particularly in Eastern Europe and the Mid-East. It can be expected to be used by extremists of several kinds, when engaging in urban combat or vehicle ambushes.⁹⁸

M-72 Light Anti-tank Weapon (LAW)

The M-72 Light Anti-tank Weapon (LAW) is a shoulder-fired, man-portable, light anti-tank rocket. The M72 66mm LAW (Light Anti-armor Weapon) was developed in the 1960s. Like the RPG-7, the M72 is capable of penetrating a foot of armor, but its effective range is only 170 to 220 meters. Manufactured by Talley Industries in the U.S. and under license in Norway, it not only became a NATO standard but was copied and produced in Czechoslovakia and Russia (as the RPG-18 and RPG-26).

The M72-series LAW is mainly used as an anti-armor weapon, it may be used with limited success against secondary targets such as gun emplacements, pillboxes, buildings, or light vehicles.⁹⁹

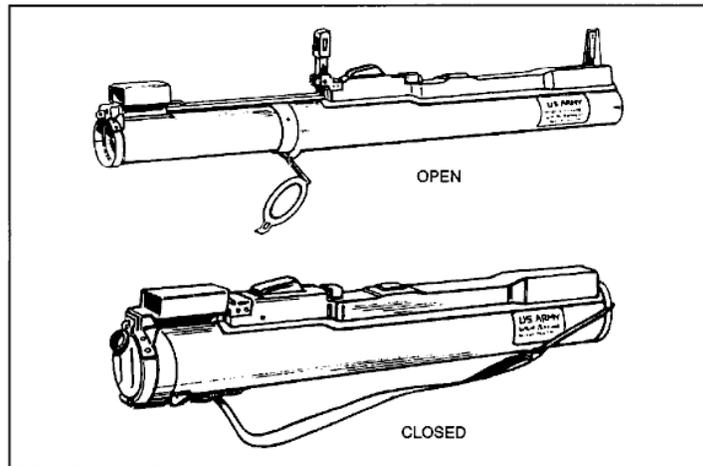


Figure 2-1. The M72A2 or M72A3 LAW.

⁹⁸ Ibid, key word search RPG

⁹⁹ Ibid, key word search, LAW

Large Caliber Rocket

This category of weapons includes large caliber, man portable missiles and missile systems to include the Carl Gustaf recoilless rifle, AT-4 anti tank recoilless rifle, Dragon anti tank missile and the ATGM, anti tank guided missile. A wide combination of multi purpose explosive heads can be employed with most of these weapons systems. These systems are man portable and are re-useable. These weapons may be re-loaded and re-fired rapidly by one man or in teams of personnel. These weapons present considerable threat to an LNG carrier throughout the designated channel. Weapons systems could be employed easily from a car, boat or shoreline position. The use of multiple systems would most likely achieve the desired effects of tank penetration, cargo discharge and ignition. The characteristics of these weapons are easily learned. These weapons have been manufactured extensively by Russia, Norway, Korea, Taiwan, China and others. These weapons are in use throughout the world.¹⁰⁰

M3 Multi-Role Anti-Armor Anti-Personnel Weapon System (MAAWS)

The Multi-Role Anti-Armor Anti-Personnel Weapon System (MAAWS) consists of the M3 Carl Gustaf Rifle and a family of 84mm ammunition. The family of ammunition consists of a High Explosive Anti Tank (HEAT), High Explosive (HE), High Explosive Dual Purpose (HEDP), Smoke, Illumination, Target Practice (TP) and Sub-Caliber Adapter training system. The ammunition weighs between 7 to 10 pounds. The effective range depending on the ammunition type varies from 200 to

¹⁰⁰ Federation of American Scientists Military Analysis network. Available online at <http://www.fas.org/main/home.jsp> military analysis network, key word search AT4.

1300 meters. The M3 Rifle weighs approximately 25 pounds and is 42 inches in length.¹⁰¹



M136 AT4

The M136 AT4 is a recoilless rifle used primarily for engagement and defeat of light armor. The recoilless rifle design permits accurate delivery of an 84mm High Explosive Anti-Armor warhead. The M136 AT4 is man-portable and is fired from the right shoulder only. Though the M136 AT4 can be employed in limited visibility, the firer must be able to see and identify the target and estimate the range to it. The system's tactical engagement range is 250 meters and has been used in multiple combat situations. The round of ammunition is self-contained in a disposable launch tube.

¹⁰¹ Ibid., key word search, MAAWS

The system weighs 15 pounds and can be utilized effectively with minimal training.

The M136 AT4's warhead has excellent penetration ability and lethal after-armor effects. The extremely destructive, 440 gram shaped-charge explosive penetrates more than 14 inches (35.6 cm) of armor.¹⁰²

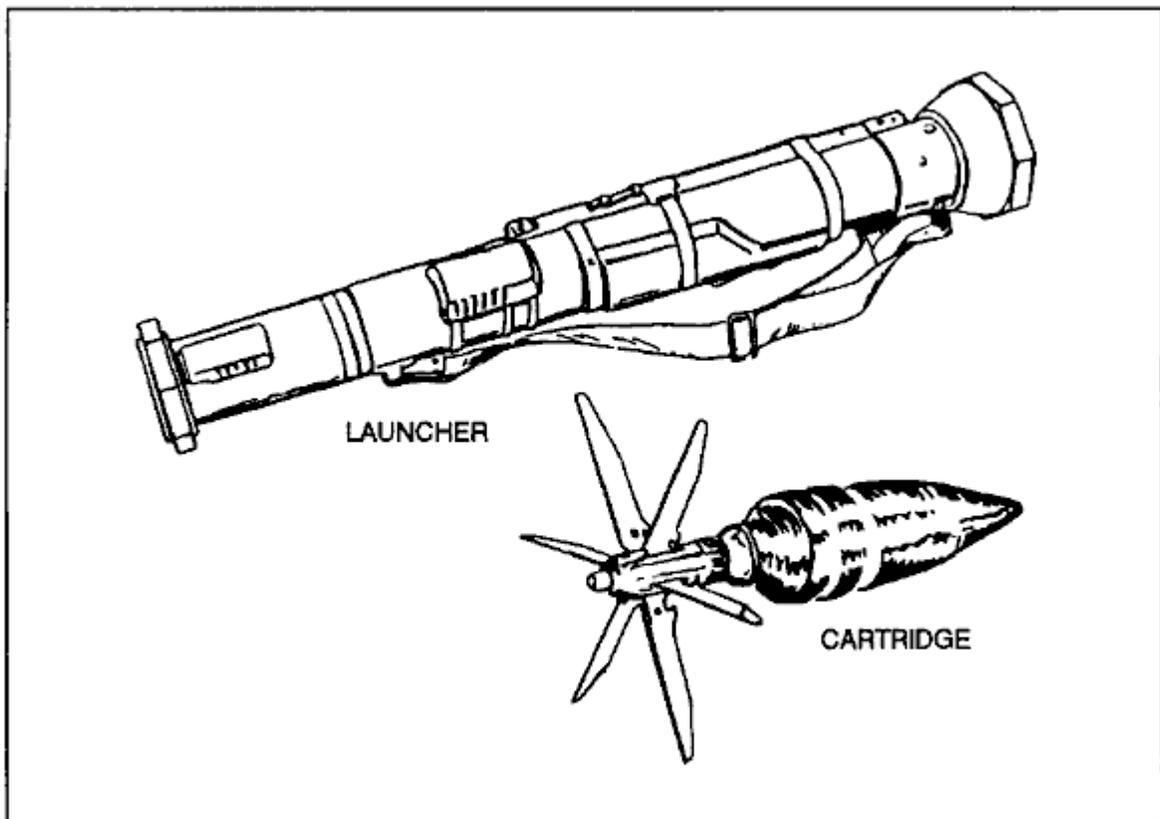
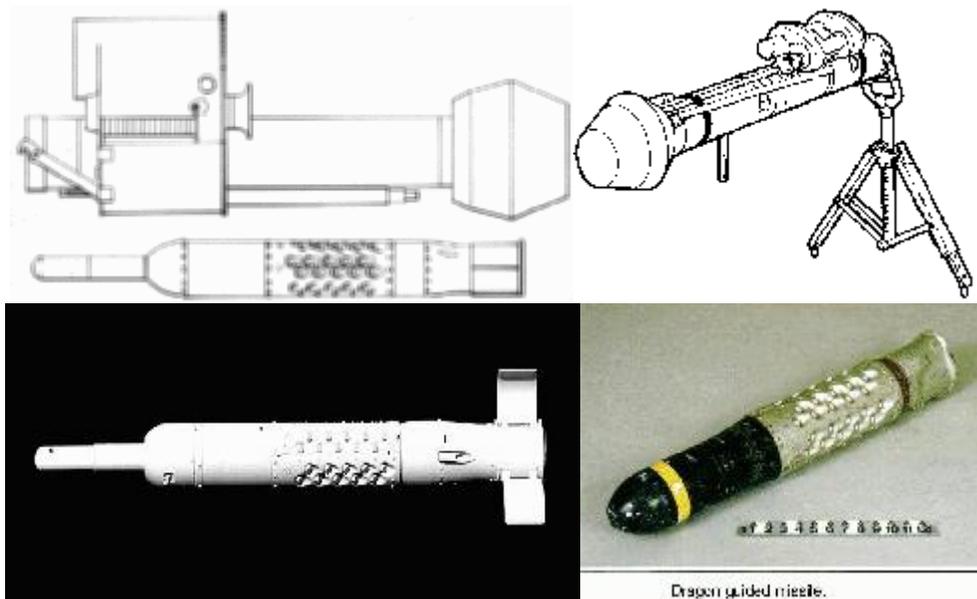


Figure 3-1. Launcher and HEAT cartridge.

¹⁰² Federation of American Scientists Military Analysis network. Available online at <http://www.fas.org/main/home.jsp> military analysis network, key word search, AT4

M-47 DRAGON Anti-Tank Guided Missile

The Dragon is a medium range, wire-guided (guidance of the missile to target is controlled by a thin wire), line-of-sight anti-tank/assault missile weapon capable of defeating armored vehicles, fortified bunkers, concrete gun emplacements and other hard targets.. It is designed to be carried and fired by an individual gunner. ¹⁰³



Shoulder-Launched Multipurpose Assault Weapon (SMAW)

The SMAW is an 83mm man-portable weapon system. The High Explosive, Dual Purpose (HEDP) rocket is effective against bunkers, masonry and concrete walls, and light armor. The High Explosive Anti-Armor (HEAA) rocket is effective against

¹⁰³ Federation of American Scientists Military Analysis network. Available online at <http://www.fas.org/main/home.jsp> military analysis network, key word search, Dragon

current tanks without additional armor. Max Range, 500 yards.¹⁰⁴



¹⁰⁴ Federation of American Scientists Military Analysis network. Available online at <http://www.fas.org/main/home.jsp> military analysis network, key word search SMAW



Summary

A standoff weapon attack could occur at almost any point along the 28 mile route. Analysis indicates that the use of a shaped charge would be the most effective choice in stand of weapon use and a heavy rifle would be the least effective.

C. Mortars

Terrorist throughout the world effectively use mortars against both civilian and military targets. In Columbia, narco-terrorists have developed a wide variety of simple mortars than are capable of launching large compressed gas canisters. The Irish republican Army has effectively used mortars through Ireland and England. Mortars have been used effectively in Somalia, al-Qaeda, Hezbollah etc have all used mortars.

Mortars provide unique indirect fires through rapid, high-angle, plunging fires. The wide variety of rounds and the simplicity of their use has made mortars a terrorist weapon of choice in both urban and open setting. A simple mortar

attack involves two men in the back of a pickup truck who drive to an open intersection place the mortar in the truck bed, fire two or three shots on a rough azimuth to the target and flee. The entire process can be accomplished in under 30 seconds.¹⁰⁵



Figure E-19: Improvised Mortar System (Source: File Photo)

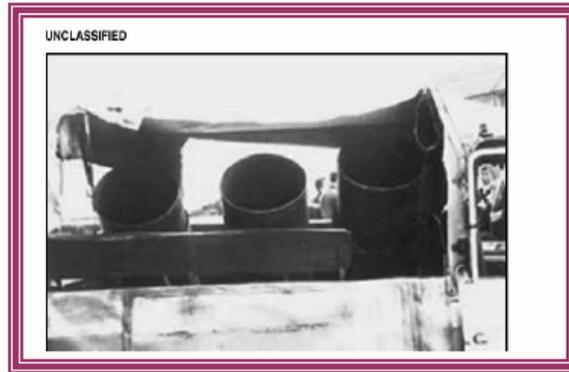


Figure E-20: Multi-tube Battery Mounted in Truck (Source: File Photo)

Light mortar

The 60mm mortar, M224, can be employed in several different configurations. The lightest weighs about 18 pounds; the heaviest weighs about 45 pounds. Each round weighs about 4 pounds.

Medium mortar

The 81-mm mortars, M29A1 are the current US medium mortars. Their range and explosive power is greater than the M224, yet they are still light enough to be man-packed over long distances. The M29A1 weighs about 98 pounds. The M252 is slightly lighter, about 93 pounds. Both can be broken down into several smaller loads for easier carrying. Rounds for these mortars weigh about 15 pounds each.

¹⁰⁵ OPFOR Worldwide Equipment Guide. Available online at <http://www.fas.org/man/dod-101/sys/land/row/weq.pdf>. key word search, mortars.

Summary

Mortars are effective weapons that have been utilized successfully by terrorist organizations throughout the world. The effectiveness of mortar systems against an LNG carrier in transit is however assessed as low. Despite the fact that a terrorist element could set up a mortar position with relative speed, the requirement for accuracy and the effectiveness of a round striking the LNG containment vessels would not accomplish the desired end state of tank penetration, discharge of cargo and ignition.

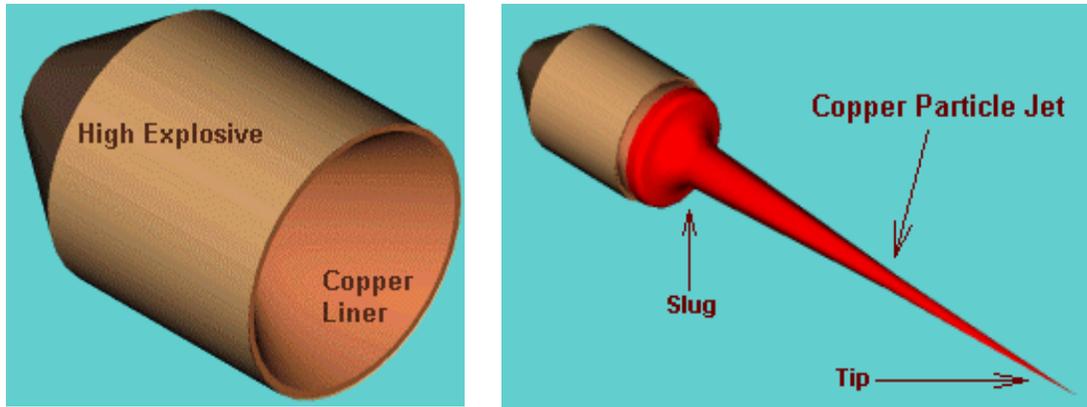
D. Shaped Charges

Devices of this type were manufactured extensively during WWII for use against armored vehicles, bunkers and reinforced structures. Further development has occurred since then within the mining industry for use in cratering. Improvised devices can be constructed in almost any size utilizing a variety of materials. Stand off distance from the target and sophistication with regards to the explosive train will improve accuracy and precision but very crude, devices can still produce dramatic results. Terrorist organizations have mastered the design of these devices and they are used to disrupt vehicle convoys or destroy armored vehicles.

Shaped charges or flying plate charges can be suspended from frames and structures or can be simply laid on a flat surface and sited along an azimuth towards the target.

A large shaped charge or flying plate charge would be very effective in achieving a hole with the required diameter to ensure a significant discharge of cargo. Charges could be set in series and coupled with an ignition source.

The high explosive is placed in the rear of the device (pictured in black, to the left of the device). When the explosive detonates, it sends a shock wave through the shaped charge. The shock wave in the picture travels to the apex of the conical indentation first. This powerful shock wave actually pushes out the metal starting at this point. The metal continues to deform and push outwards until a very narrow, very fast moving jet of molten metal is formed.¹⁰⁶



Summary

This type of charge represents the greatest threat to an LNG carrier in this analysis. Terrorist organizations throughout the world have demonstrated the effective use of shaped charges in a variety of applications. The narrow confines of Narragansett Bay and the effective destructive capability of these charges could severely endanger an LNG carrier at a number of locations. These systems however do require a secure location for assembly. They require secure lines of

¹⁰⁶ Reactive Armor. Travis Hagan, march 18, 2002. Explosives engineering MGN 498, pg 65. Available online at http://www.mines.edu/academy/mining/CSM-isee/CSM_isee_student_papers/student-papers-dynamic.htm.

transport and the successful placement and timely employment to achieve maximum effect.

E. Small Boat Attack Scenario

The bombing of the French supertanker *Limburg* in the Gulf of Aden by al-Qaeda on Oct. 6, 2002, as it headed for Asia with a cargo of 400,000 barrels of Saudi crude was a wake-up call. A small boat loaded with explosives was rammed into the tanker by an al-Qaeda team. It was the same tactic, first employed by Tamil Tiger rebels against the Sri Lankan Navy in the 1980s, that al-Qaeda used to strike the US destroyer *Cole* in Aden Harbor on Oct. 12, 2000. Although there have been no known attacks on tankers since the *Limburg*, a group of Islamic extremists in Morocco were planning attacks on ships traversing the Straits of Gibraltar, the western gateway to the Mediterranean, before they were arrested in 2002.¹⁰⁷

The attack upon the *USS Cole* was conducted with a rigid hull inflatable boat of less than 25 feet. The explosive device was first assumed to have been a charge of approximately 400lbs gross weight. It was later determined that a more sophisticated charge may have been utilized.¹⁰⁸ The use of a shaped charge is now considered the agreed upon explosive. The attack was strategically positioned adjacent a large inner space. The *USS Cole* was a single hulled vessel with no water filled ballast void or standoff between the explosive and the crew and structure on the ships interior. The explosion ripped a 40 ft x 20 ft hole in the ship at the water line and caused extensive internal damage.

¹⁰⁷ Tanker Terror: Gulf's Oil Routes Under Threat. Robert Spencer. April 22, 2004. Available online at <http://www.jihadwatch.org/archives001677.pdf>

¹⁰⁸ CRS report for Congress Terrorist Attack on USS Cole: Background and Issues for Congress. RS20721, 30 January 2001.



Figure 2.4: Damage to the *Cole*.

The *Limburg* was also attacked by a small boat laden with explosives. The ship sustained a 30 foot hole. MV *Limburg* was a double hulled ship. In this attack, both the outer and the inner hull were breached, the ship caught on fire and over 90,000 barrels of cargo were released.¹⁰⁹

Maritime Exclusion Zones and Rules of Engagement

There are two maritime security exclusion zones that have been proposed within the Narragansett Bay. These are: Newport Area Security Zone in the vicinity of Threat Sector 2, from approximately Ft. Wetherhill to Coddington Point and the Cranston Security Zone, vicinity Threat Sector 7, Conimicut Point to Fields Point in the Providence River.

¹⁰⁹ Jonathan Howard. Hazardous Seas: Maritime Sector Vulnerable to Devastating Terrorist Attacks. JINSA online, 1 April 2004. Available online at <http://www.jinsa.org/articles.htm/>

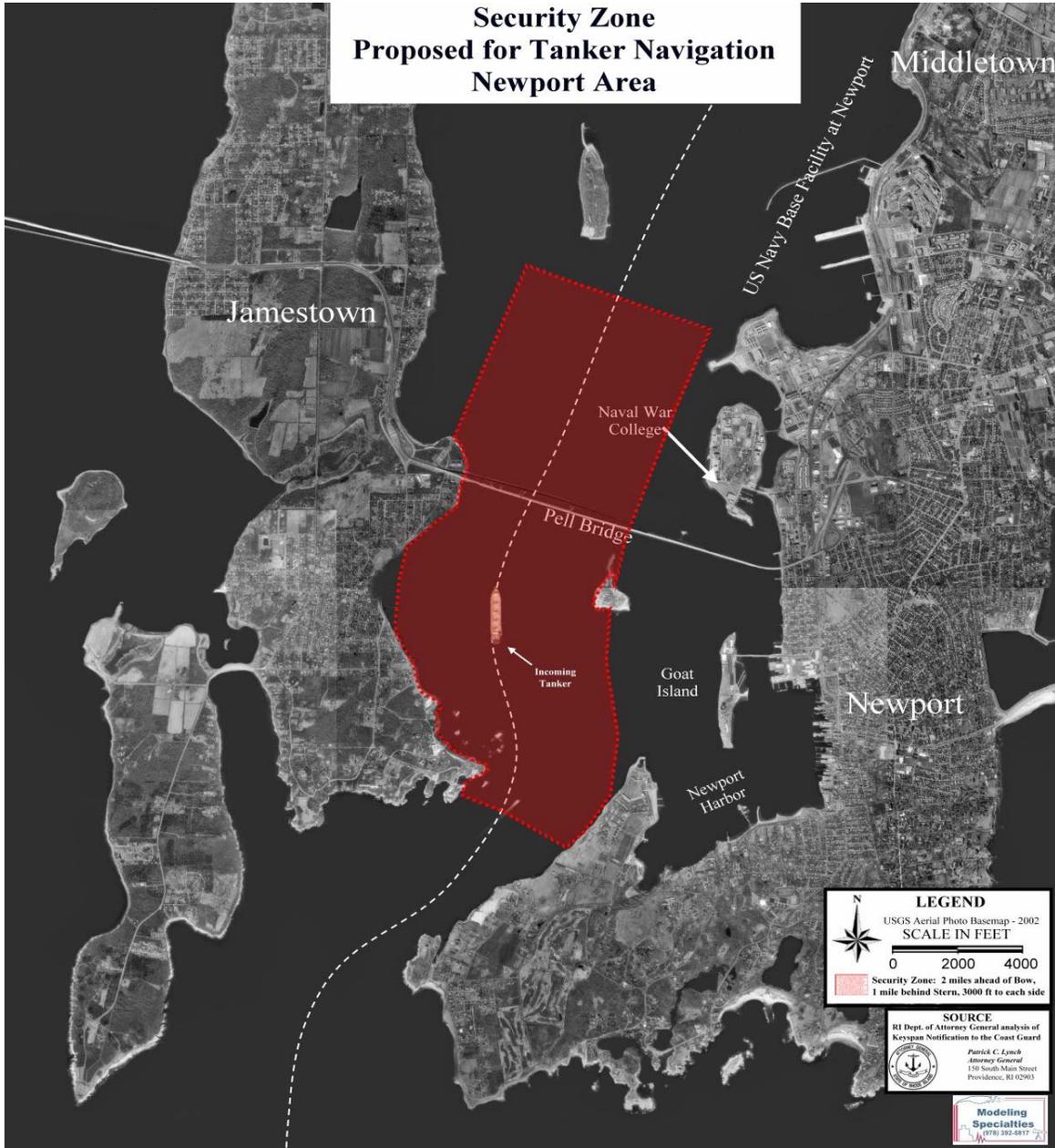


Figure 2.5: Security zones for LNG tankers. Source: RIAG.

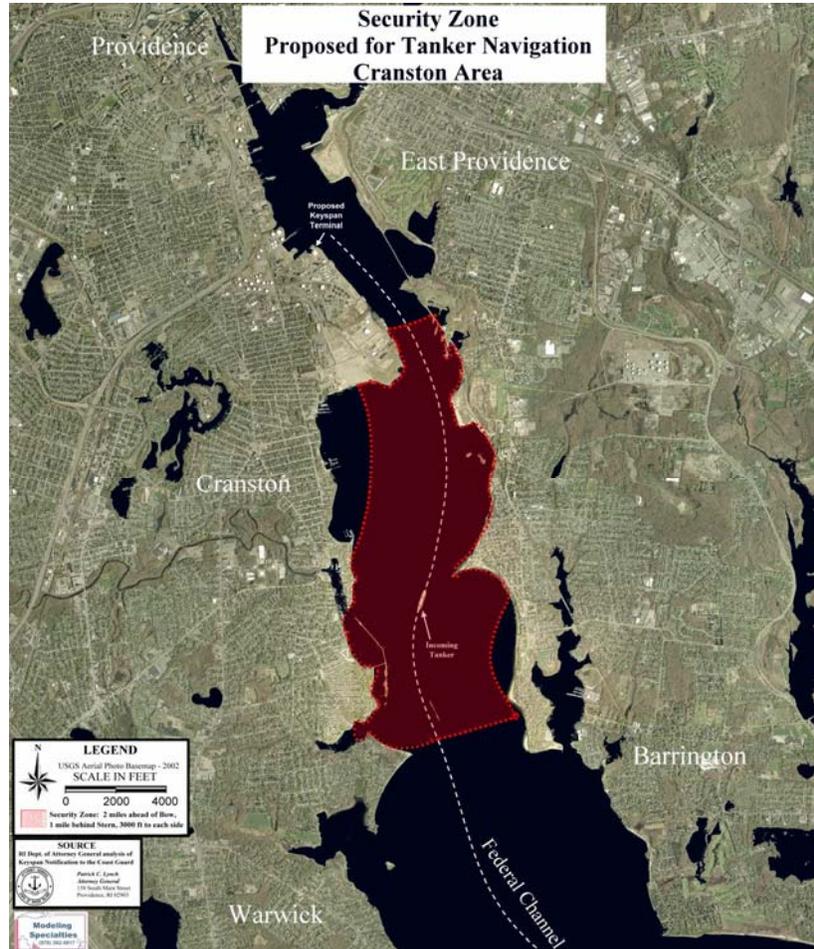


Figure 2.6: Security zones for LNG tankers. Source: RIAG.

Establishing security zones will do nothing to secure the transport of LNG unless the Coast Guard is authorized the necessary use of force required to enforce these zones. Current Rules of Engagement (ROE) allow for the interception and shouldering of approaching surface traffic considered a threat to the LNG carrier. The use of deadly force is authorized if the surface contact demonstrates hostile intent or commits a hostile act. Determination of hostile intent in a congested maritime environment is nearly

impossible and most, if not all law enforcement agencies lack the will to engage a civilian surface vessel even within a security zone. The proximity of heavy surface congestion within the Newport area would require the near instantaneous identification of a surface threat, interception, shouldering and in the event of a hostile act, engagement in order to prevent a surface vessel from contacting the LNG carrier.

Enforcement of the Cranston area security zone would be less problematic due to a reduced volume of surface traffic. Additionally, the reduced surface area of this zone and the upriver, down river choke points associated with the Providence River, facilitate establishing security boundaries within the natural confines of this waterway. Ensuring the safety of an LNG carrier approaching the Key Span facility or moored and unloading at the facility would require the total exclusion of all surface vessels during the entire period of cargo transfer.

Ensuring the total exclusion of all surface traffic for periods exceeding 48 hours one to two times per week would have a significant and disruptive effect upon the local boating and commercial vessel population.

Summary

The seasonal congestion of civilian boaters within the Narragansett Bay provides an excellent backdrop for a terrorist scenario depicting a determined terrorist group dedicated to attacking a LNG ship while on approach to the Key Span Facility. A brief analysis of marine facilities indicates that there are over a dozen marinas in close proximity to the main shipping channel. There are far more numerous facilities within the surrounding bays. There are also ten public boat launch facilities on the main shipping channel. Estimates of civilian boats are as high as the ten's of thousands. Estimates of commercial boats in the area are in the thousands. The mixed nature of the waterway

which includes industry, commercial and civilian use is an ideal setting for a potential attack. Despite Herculean efforts by the Department of Homeland Security and the U.S. Coast Guard, a terrorist group possessing a boat and armed with the necessary explosives could potentially achieve the same effect as the group that attacked the *USS Cole* or the *Limburg*.

F. Limpet Attack Scenario

Analysis of the eight threat sectors found within the Narragansett Bay that would support a swimmer or submerged (scuba) attack against a LNG carrier indicates that only one sector, Sector 8, the Port of Providence provides the necessary conditions for a successful attack. Swimmer attacks could be launched in Sector 7 and Sector 2, however the success rates of swimmer attacks against moving targets is very low.

Within the port area, swimmers/divers could approach a vessel moored at the KeySpan facility from any direction. Tides and currents support diving operations during most hour of the day or night. Diving operations in the protected waters of the port region would be relatively short in duration and the distances covered could be reduced significantly through surface swimming prior to attacking the target. These conditions would allow relatively poorly trained individuals to successfully reach their target from almost anywhere within the Fox Point Reach. Distances across the Fox Point Reach vary between 800 yds. to as narrow as 300 yards at Fields Point. This distance could be halved if a swimmer/diver rested at the Fuller Rock Light. Approaches could be made from the north, from Fox point.

A swimmer/diver starting an attack from this location could move relatively free from detection throughout the industrial infrastructure that borders the western shoreline. A swimmer/diver could begin at any number of

locations along the shoreline in East Providence. The park and rail line along the East Providence shoreline allow easy foot access to the water way and provide adequate cover for shore side movement. The Fox Point Reach can be entered from the south via multiple access points on both the east and western shorelines. The proposed Cranston area security zone begins at the head of the Fuller Rock Reach and extends southward through Cranston to Gaspee Point. This security zone will limit boat traffic within the channel proper, however pockets not covered by the security zone exist on the west shore in the vicinity of Edgewood and to the south east below Sabin Point. Boat traffic within these pockets could be utilized to mask the movements of swimmers/divers entering this area from a boat.

The probability of a swimmer entering the water below Sabin Point is unlikely due to the distance to the KeySpan facility.

Explosive Device Selection

Terrorist selection of an explosive device for use in a swimmer/diver scenario would be more problematic. The United States Navy SEALs train their divers to conduct combat swimmer attacks using the standard MK 1, Limpet. The MK 1, is a ten and one half pound device that is attached to a ships hull with magnets. The device contains a 3.5 lb shaped charge and will put a hole of approximately three square feet in a standard ships hull. The effects of this charge vary with the composition of the ships hull, structural members that support the hull and placement.¹¹⁰

A standard attack scenario would include placement of a number of mines to achieve the maximum desired effect. Limpet mines of this size are designed for use against single hulled vessels and would not be effective in

¹¹⁰ MK 1 Limpet. Available online at http://www.odu.edu/ao/nrotc/naval_science.courses

rupturing both the outer and inner hulls of a LNG carrier. This is however the standard limpet for small boats and single hulled ships. Multiple U.S. devices in much larger sizes than this have been developed to include specialty devices designed to sink vessels/ships of considerable size and displacement.

Limpet mines that exceed the capabilities of the MK1 have been used to great success during offensive operations in several of our past wars. Vietcong saboteurs effectively utilized limpet like explosive devices against small craft, patrol craft, troop barges and cargo ships throughout the Mekong River Delta region during the Vietnam War. British, French, German, Italian and U.S. dive teams, effectively utilized limpets during WWII against various craft to include capitol ships. These attacks were however extremely well rehearsed and employed multiple teams of divers in order to guarantee the highest probability of success. A number of these attacks utilized mini submarines or other subsurface/surface devices to transport the bulk explosives that were required to achieve the desired effect.

Limpet mines that exceed the capabilities of the MK1, could be acquired through black market sources. Former Soviet stockpiles, South African, Chinese, Korean, French, and German manufactures are all potential sources for limpets that equal or exceed the characteristics of even the most capable U.S. specialty weapons.

The probability of a swimmer/diver reaching a LNG carrier moored at the KeySpan facility is assessed as very high. Trained combat swimmers utilizing re-breathing systems that do not discharge bubbles would be nearly impossible to detect or prevent from reaching a target vessel.

The probability of a terrorist successfully acquiring and employing a limpet of the size required to generate a hole in excess of 12 sq meters through both the inner and outer ship hulls is assessed as very low. The use of multiple

small limpets even 10 times the size of the MK1 would not achieve the desired effect. Limited hole diameter and the hydrostatic pressure exerted by the surrounding sea water 8.3 lb/gal would keep most of the lighter 3.5 lb/gal LNG trapped within the tanks.

The placement of a device above the water line would require far more explosive weight to achieve the same effect of a subsurface device due to a loss of effectiveness through the tamping effect of water. A device of this size could not be easily moved by divers and would be subject to detection following a visual inspection of the hull.

Summary

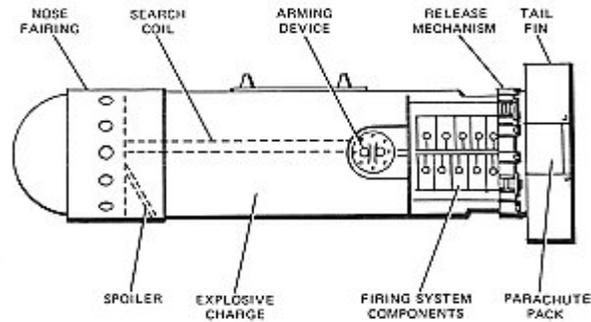
The Port of Providence provides the necessary conditions for a successful swimmer-diver attack. Swimmer attacks could be launched in sector Seven and sector Two, however the success rates of swimmer attacks against moving targets is very low. The probability of this attack is assessed as negligible in most sectors. The probability of attack in Sector Eight is assessed as high. The effect of this attack is assessed as medium.

G. Mines or Mine-Like Devices

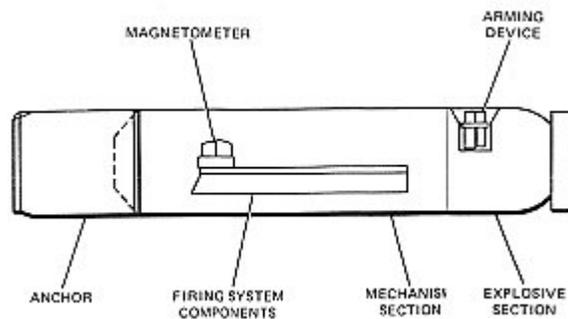
Mines are relatively low-cost and highly effective weapons and have been utilized effectively since the earliest days of naval warfare. They can be set to activate when a certain ship signature the ship's machinery sounds, movement through the water, or hull metal is detected. Ship counts can be set in the mine to allow a specific number of ships to pass before the mine fires.

Two categories of mines were considered during this analysis.

Bottom mines are most effective in comparatively shallow waters. A large negative buoyancy (tendency to sink) brings the bottom mine to rest on the ocean floor and keeps it there.¹¹¹



Moored mines are used for deep water plants and are effective against submarines and surface ships. The explosive charge and firing mechanism in a moored mine are housed in a positive-buoyancy case, i.e., one that tends to float. A cable, attached to an anchor on the bottom, holds the case at a predetermined depth below the surface.¹¹²



¹¹¹ Airborne Mine Countermeasures, Naval Mines. Available online at, <http://members.aol.com/helminron/mines.htm>

¹¹² Airborne Mine Countermeasures, Naval Mines. Available online at, <http://members.aol.com/helminron/mines.htm>

Method of Delivery

Mines can be deployed by aircraft, submarine, or surface ship. Any mine type can be deployed by a surface ship. In this scenario, a mine or mine like device would be delivered by boat. An attack that combines the detonation of a mine with a surface attack would achieve the desired effects of hole size, cargo discharge and ignition.¹¹³

Method of Actuation

Mines can be activated by contact, target influence, or remote control. Contact mines are activated by physical touch and are the oldest and most common type. Target influence mines seek to detect ships or submarines using a magnetometer, hydrophone, or pressure device. Influence mines can be calibrated to detonate only near ships of a certain size. Controlled mines are remotely operated by a cable connected to the shore.¹¹⁴

Mine Effectiveness

The employment of mines would be very effective throughout the entire length of the East Passage along the Rumstick Neck Reach and the Providence River. Maximum effect could be achieved through placement and detonation of a mine at either of two locations; Sector 2, within the center span of the Pell Bridge and Sector 8, in close proximity to the KeySpan Facility. A bottom influence mine placed in Sector 8

¹¹³ Ibid

¹¹⁴ Airborne Mine Countermeasures, Naval Mines. Available online at, <http://members.aol.com/helminron/mines.htm>

in close proximity to the LNG terminal would almost certainly detonate only after an LNG tanker were moored to the facility. Other traffic within this sector would displace too little water to activate the device.

Use of a bottom influence mine in Sector 2, combined with an attack utilizing a shaped charge or surface attack would achieve the desired characteristics of hole size, cargo discharge and ignition within a highly congested area surrounded by significant infrastructure.

Summary

The probability of a terrorist acquiring, transporting, employing and activating a mine anywhere within this waterway is assessed as low. Despite a proliferation of mines since WWII, and despite the demonstrated capabilities of offensive mines during the Iranian crisis of the late 1980's, there are too many factors that could affect this attack in a negative way. These include acquisition of surface vessel, transport and on-load of the device, the undetected delivery of the device, accurate fusing and calibration of the device to detonate only beneath a LNG carrier and the effective detonation of the device.

The probability of a terrorist developing/acquiring, transporting, employing and effectively activating a mine-like device is also assessed as very low. The historical use of mines has demonstrated that very crude mines can be developed and effectively employed. Devices of this type have not, however been utilized against double hulled ships of this design or construction.

V. CONCLUSION

Scenario driven analysis of an LNG carrier transiting the Narragansett Bay and the Providence River clearly demonstrates the potential vulnerabilities of such a cargo. However, while the ship may be vulnerable to attack, the cargo may not be. Industrial design standards and the nature of LNG provide considerable security to the ship and to the cargo throughout most of the transit. Additionally, it can be seen that a terrorist attack is the culmination of a successive chain of dynamic events that must all occur for the desired end state to be achieved. Despite the challenges that a terrorist element would face in launching such an attack, we must not underestimate their capability or desire. The Narragansett Bay transit presents multiple opportunities for terrorist attack. If even one of these attack scenarios were effective in breaching the integrity of a single LNG containment vessel within a densely populated area, the effects upon the local community could be devastating.

SECTION THREE: Consequence Management

I. Summary

Consistent with the vulnerabilities outlined in Section 2, this section considers the flammable vapor and thermal radiation hazards created by an intentional breach of two tanks with puncture holes approximately 5 meters each in diameter. We assume a third tank is breached by cascading, cryogenic damage to the tanker. The detonation devices that terrorists are likely to use are assumed to serve as an ignition source, resulting in a 572 m diameter pool fire that burns for 8.1 minutes with no vapor cloud.

An LNG fire cannot be extinguished by conventional fire-fighting techniques and will burn more intensely than crude oil or gasoline fires.^{115,116} LNG fires can burn at temperatures of 3,000 degrees Fahrenheit,¹¹⁷ or 1,922 degrees Kelvin. Its emissive power can reach 265 kW/m² or 84,000 Btu/hr/ft².¹¹⁸ A 3-tank breach would extend thermal heat zones up to 37.5 kW/m² or 12,000 Btu to a radius of 630 m (2,066 ft) (the **"Red Ring"**) and up to 5 kW/m² or 1,600 Btu to a radius of 2,118 m (6,947 ft) (the **"Orange Ring"**).¹¹⁹

Firefighters cannot operate at radiant heat levels above 1,600 Btu for extended periods. As a result, first responders would be limited in their ability to operate

¹¹⁵ *Consequence Assessment Methods for Incidents Involving Releases from Liquefied Natural Gas Carriers*. ABS Consulting. <http://www.ferc.gov/industries/gas/indus-act/lng-model.pdf>

¹¹⁶ Havens, Jerry, "Terrorism: Ready to Blow?", *Bulletin of Atomic Scientists* 59, no. 4 (2003):16-8.

¹¹⁷ Sandia report, p. 150.

¹¹⁸ *Consequence Assessment Methods for Incidents Involving Releases from Liquefied Natural Gas Carriers*. ABS Consulting. P. 22. <http://www.ferc.gov/industries/gas/indus-act/lng-model.pdf>

¹¹⁹ See Map 3.1 on p. 113 for an aerial view of the port and the area encapsulated by the red and orange rings.

within the Orange Ring until temperatures subsided - after significant damage had been done. Approximately 36,386 residents live within the Orange Ring. Nearly 6,000 students attend schools dispersed throughout the Orange Ring

Within the Red Ring, death from this scenario is nearly certain, with damage to critical infrastructure such as bridges, industrial centers, harbors, etc.¹²⁰ Between the Red Ring and Orange Ring, thermal hazards decrease exponentially. Within the Orange Ring, radiant heat of 5 kW/m² or 1,600 Btu will cause unbearable pain to people exposed for 13 seconds and second-degree burns after exposure for 40 seconds. At levels of 10 kW/m², exposure for 40 seconds is the maximum threshold a person can withstand before death.¹²¹ Other lesser danger and damage will likely occur due to a domino effect on combustible structures once sympathetic fires spread outward from the Red Ring.

In this section we assess the consequences of a 3-tank breach for an attack on **Sector 8**, the site of the existing KeySpan facility proposed to house the new LNG facility near Providence Harbor.

In **Sector 8**, the attack scenario could produce the following consequences:

- Approximately 3,000 deaths and 10,000 injuries from severe burns in the first few minutes of the pool fire with numbers escalating due to sympathetic fires and untreated burns. Deaths will be concentrated among residents of Providence.
- Approximately 3,000 homes destroyed among the 10,085 contained in the Orange Ring, with hundreds of others

¹²⁰ Sandia Report, p. 21

¹²¹ James A. Fay, "Public Safety Issues at the Proposed Fall River LNG Terminal," Massachusetts Institute of Technology." January 2004, p. 2.

damaged. Homes in Providence, East Providence and Cranston will be affected.

- Possible sympathetic detonations of chlorine tanks, liquid propane gas tanks, kerosene tanks and oil stored on ships and piers. A chlorine leak or explosion could add significantly to death and injury. These risks merit further analysis.
- Destruction of the tanker and KeySpan facility, piers and port facilities, the Narragansett Bay Commission, the Allens Avenue Fire Station and local businesses.
- Damage and/or blockage of I-95 and Allens Avenue, which could impede evacuation and first responder access to victims.
- Eleven schools at risk.
- Telecommunications equipment, power infrastructure, parks and hospitals (including Rhode Island Hospital, the local trauma center) at risk.
- In the long run, tourism, home values and the state economy could suffer from a terrorist incident.

No amount of resources can mitigate much of the death, damage and injury expected within the Red and Orange Rings. Consequence Management resources can only be optimized and improved to triage structures that can be saved, evacuate the population and treat the wounded.



Map 3.1: Satellite image of KeySpan facility. Red and Orange Rings denote reach of thermal radiation and are referred to throughout this section.

II. Background: Scope and Scenario

In keeping with the baseline assumptions outlined in Section 2, the scope of this section considers the flammable vapor and thermal radiation hazards created by an intentional breach of two tankers with puncture holes approximately 5 meters each in diameter. The attack scenarios described in Section 2 are expected to result in a pool fire with no vapor cloud. Furthermore, the detonation devices that terrorists would be most likely to employ are assumed to produce a blast powerful enough to also serve as an ignition source. Sandia believes the potential for large vapor dispersion from an intentional breach is very unlikely.¹²²

Given that cascading failure of a third, but not a fourth, tank can be expected, the consequences discussed are based on a 3-tank breach using the parameters described on p. 51 of the Sandia report.¹²³ As per the added consequence of additional LNG spilling from a third tank, conversations with LNG expert Dr. James Fay have concluded that such a scenario is not expected to drastically increase the overall diameter of the pool fire but would add several minutes to its duration.¹²⁴

LNG fires can burn at temperatures of 3000 degrees Fahrenheit,¹²⁵ or 1922 degrees Kelvin. Its emissive power can reach 265 kW/m² or 84,000 Btu/hr/ft².¹²⁶ An LNG fire cannot be extinguished by conventional fire-fighting

¹²² Sandia Report, p. 53.

¹²³ Sandia Report, p. 51

¹²⁴ Phone conversation with Dr. James Fay, Massachusetts Institute of Technology (April 9, 2005)

¹²⁵ Sandia report, p. 150.

¹²⁶ *Consequence Assessment Methods for Incidents Involving Releases from Liquefied Natural Gas Carriers*. ABS Consulting. P. 22. <http://www.ferc.gov/industries/gas/indus-act/lng-model.pdf>

techniques and will burn more rapidly and intensely than crude oil or gasoline fires.¹²⁷¹²⁸

Sandia developed nominal fire modeling parameters to calculate expected thermal hazards from a LNG fire for intentional breaches involving both 1 and 3 tanks with hole sizes ranging from 2 to 12 meters. The scenarios take into consideration that cascading damage resulting from fire or cryogenic-induced failure is a distinct possibility that exponentially increases as more tanks are involved.

It is important to consider that the results contained in the Sandia report were designed to provide guidance only, and that actual distances will vary due to the site-specific factors and environmental conditions of Narragansett Bay. Wherever possible, we have incorporated our knowledge of the topography, river currents, wind conditions, physical structures, hazardous material and other relevant factors specific to Providence to make informed calculations about potential consequences to people and property in the surrounding area.

The following is an assessment of the consequences of a 3-tank breach for Sector 8, which was designated as "extremely high risk" in Section 2. Sector 8 is the unloading area adjacent to the existing KeySpan facility proposed to house the new LNG facility near Providence Harbor.

A. Effects of Thermal Radiation

Thermal radiation is the transfer of heat by electromagnetic waves. The example most commonly referred to is the transfer of heat from a fireplace to a person across a room in the line of sight. According to the ABS study, the extent

¹²⁷ *Consequence Assessment Methods for Incidents Involving Releases from Liquefied Natural Gas Carriers*. ABS Consulting. <http://www.ferc.gov/industries/gas/indus-act/lng-model.pdf>

¹²⁸ Havens, Jerry, "Terrorism: Ready to Blow?", *Bulletin of Atomic Scientists* 59, no. 4 (2003): 16-8.

to which people are injured by thermal radiation depends on both the incident heat flux and the exposure time. Experiments have been performed on both humans (at low level radiation) and animals to calculate various risks. ABS provided a list of other important factors to consider when gauging the affect of thermal radiation on people. These include:¹²⁹

- Protection afforded by shelter
- Protection afforded by clothing
- Contribution of solar radiation to total exposure (250-330 Btu/hr-ft²)
- Susceptibility of individual exposed
- Response of individual (e.g., ability to take shelter)

Burning LNG can emit levels of thermal radiation so intense that people as far as 1.5 miles from the pool fire would be exposed to a thermal flux of 5 kilowatts per square meter (kW/m²) or 1,600 Btu. Using the thermal radiation burn criteria provided by FEMA in Table 3.1, that amount of radiant heat would be sufficient to cause unbearable pain to people exposed for 13 seconds and second-degree burns to people exposed for 40 seconds. At levels of 10 kW/m², or 3,200 Btu, 40 seconds is the maximum threshold a person can withstand before death.¹³⁰ Heat levels higher than 3,800 Btu were not analyzed by FEMA but according to conversations with fire officials, exposure to 10,000 Btu will result in near instantaneous death regardless of protective clothing or quality of shelter.

¹²⁹ ABS p. 31.

¹³⁰ Fay p. 2.

Table 3.1: Thermal Radiation Burn Injury Criteria

Thermal Radiation Intensity		Time for Severe Pain (sec)	Time for Second-degree Burns (sec)
BTU/hr/ft ²	kW/m ²		
300	1	115	663
600	2	45	187
1000	3	27	92
1300	4	18	57
1600	5	13	40
1900	6	11	30
2500	8	7	20
3200	10	5	14
3800	12	4	11

Source: ABS Consulting Report, p. 30

1. Predominant Injuries Expected

Approximately a half-mile from the pool fire, the predominant injuries people are likely to experience would be third degree burns, potentially fatal depending on distance and shelter. Beyond a half-mile, victims would suffer lesser degree burns. The following is a description of various consequences associated with first, second and third degree burns.

First Degree Burns

First-degree burns are red and very sensitive to touch, and the skin will appear blanched when light pressure is applied. First-degree burns involve minimal tissue damage and are concentrated on the skin's surface. These burns affect the outer-layer of skin causing pain, redness and swelling. Sunburn is a good example of a first-degree burn.

Minor burns of this type will not require medical attention. Victims will be able to rely on basic first aid and over the counter medicines to treat themselves.¹³¹

Second Degree Burns

Second-degree burns affect both the outer-layer and the under lying layer of skin resulting in redness, pain, swelling and blisters. These burns often affect sweat glands, and hair follicles. Shock is often a complicating factor of second-degree burns.

If a deep second-degree burn is not properly treated, swelling and decreased blood flow in the tissue can result in the burn becoming a third-degree burn. Second-degree burns will require further medical attention.¹³²

Third Degree Burns

Third-degree burns penetrate all skin layers causing charring of skin or a translucent white color, with coagulated vessels visible just below the skin surface. These burn areas may be numb, but the person may experience pain, usually resulting from second-degree burns.

Third-degree burns are very serious and require medical attention. Shock adds another complicating factor with this type of severe injury. Within moments after a person receives extensive burns, such as the type many within close proximity to the port will be susceptible to, moisture escapes the body, and death from dehydration can follow if not properly treated.

It can be assumed that in a worst-case scenario a large percentage of burn victims will die from their wounds before

¹³¹ Burn Survivor Resource Center website (accessed April 2005):

http://www.burnsurvivor.com/burn_types_first.html.

¹³² *ibid*: http://www.burnsurvivor.com/burn_types_second.html

help arrives. The term used for this type of casualty is a "non-prompt death." For third-degree burn victims that do survive, healing would be very slow due the skin tissue and structures being destroyed, which usually results in extensive scarring.¹³³

B. Distances to Thermal Hazards

Map 3.1 on p. 113 depicts an aerial view of sector 8, site of the proposed KeySpan LNG facility. Also visible are the neighborhoods inside Providence, East Providence and Cranston that will be most impacted by an LNG pool fire. As section 2 concludes, it is highly probable that a terrorist attack on a LNG tanker in Narragansett Bay would be able to achieve a 3-tank breach with a 572-meter diameter pool fire that lasts for 8.1 minutes. According to Sandia, this size fire would emit thermal radiation levels of 11,890 Btu at a distance of 630 m/2,066 ft (Red Ring) and 1,600 Btu at a distance of 2,118 m/6,947 ft (Orange Ring). The Red and Orange rings drawn in Map 3.1 illustrate the neighborhoods contained within these two distances and highlight some of the schools, hospitals, recreational parks and industrial facilities that could be affected.

Within the Red Ring, most people would suffer instant death and the damage to critical infrastructure such as power plants, roads, industrial centers, harbors, etc. would be significant.¹³⁴ In between the Red and Orange Ring, roughly 0.5 to 1.5 miles away from the spill, thermal levels are expected to decrease exponentially but would still be high enough to cause considerable numbers of dead and injured as well as substantial damage to critical infrastructure. Many of the severe consequences occurring at this distance would be the result of sympathetic fires burning throughout the area long after the pool fire evaporates. Beyond the Orange

¹³³ *ibid*: http://www.burnsurvivor.com/burn_types_third.html

¹³⁴ Sandia Report, p. 21.

Ring, the effects will taper off as distance from the spill increases.

Although drawn as a perfect circle, the spill's radius will in reality be affected by various atmospheric and site-specific conditions causing some areas to experience more extreme side effects than the other. If the wind is blowing a certain direction or sympathetic fires extend the danger zones outward, a larger number of people and property will obviously be affected. We expect both conditions to occur but given that site-specific modeling tests have not yet been performed it is difficult to determine the extent to which the two danger zones will be expanded.

III. Sector 8: Providence Harbor

A. Death & Injury

Our estimates suggest that a terrorist attack on an LNG tanker in Sector 8 could result in approximately 3,000 deaths and 10,000 injuries due to severe burns within the first few minutes of a pool fire. Although a reduction in the thermal radiation hazard would directly correlate with the evaporation of the LNG, it is probable that more casualties would occur after the 8.1 minute pool fire than during it. This is in large part due to sympathetic fires and release of toxic materials into the air that can be expected in the wake of an event of this magnitude. Therefore our estimation of total casualties due to LNG related consequences could include as many as 50-75% of those within the incident zone at the time of the attack. This number could range anywhere from 10,000 to 30,000 people depending upon the time of day. Surviving victims would require some degree of medical attention for injuries ranging from minor bruises to third degree burns. The death toll could increase to 8,000 and would be concentrated

mainly among residents of Providence. The following is a more detailed analysis of potential consequences within specific neighborhoods from an attack on an LNG tanker near the port.

1. The Port of Providence (Red Ring)

Approximately 658 people work within the Red Ring, less than a third of a mile away from the Port of Providence, on a typical day. With 140 employees, the Providence Public Works Department is the largest employer in the area. The remaining 518 employees work at one of the 26 business operating within the ring, including the existing KeySpan facility.¹³⁵ When a tanker arrives, the working population of the Red Ring would increase as coast guard, police, and fire officials are needed to safely guide the tanker through the channel. Assuming the attack occurs as the ship approaches the facility, the ignited LNG will engulf all boats within close distance to the tanker, including the tanker itself, instantly killing all crewmembers of these vessels.

Within seconds of the blaze all persons in the port and its immediate surroundings will be subject to intense radiant heat exceeding 12,000 Btu. The 658 employees working at the port, as well as unknown numbers of state and local security personnel would be killed instantly from the thermal shockwaves emanating off the fire. At such close distance, even those working inside non-combustible structures would not survive given the presence of thermal levels strong enough to cause significant damage to steel structures and industrial equipment.

If the attack occurs before the ship reaches the dock, it is assumed the elevated seawall along the shoreline will prevent the ignited vapors from spreading onto land. If the attack occurs on the inland side of the tanker as it is docked at the facility, the LNG might spill onto the port

¹³⁵ Office of the Attorney General of Rhode Island

but it is presumed the KeySpan dike would force the burning vapors back into the water. The river's southward currents would propel the LNG vapors along the coast until either all the liquid above the breach empties into the water, or the evaporation rate of the LNG equals the spill rate. Moving at a speed of less than 1.5 knots, the spilled LNG would be expected to travel approximately 572 meters from the tank as projected in Sandia's 3-tank breach scenario.¹³⁶ Factoring in results from modeling-tests designed to predict the spread of an unconfined pool fire on water, Sandia estimates the entire event, from the time of ignition until the fire burns out, would last 8.1 minutes.

2. Overview: Providence, East Providence & Cranston (Orange Ring)

Beyond the port, significant portions of the population living, working and attending school within Providence and East Providence (across the river) as well as the northern most section of Cranston will suffer consequences ranging from minor burns to death. Although the area consists of mostly residential properties, a number of schools, hospitals and light manufacturing facilities are also dispersed throughout. There are 28,780 residents and 10,085 housing units inside the Orange Ring.¹³⁷ In addition to residents, there are 729 businesses with a total of 10,081 employees.¹³⁸

The population numbers for residents within the affected areas of each city are as follows:¹³⁹

¹³⁶ Chief Michael Dillon, The Providence Fire Department, Phone Interview, April 2005

¹³⁷ Information sent via email by Providence Plan (May 5, 2005).

¹³⁸ *ibid*

¹³⁹ Actual population figures for the Orange Ring will fluctuate depending upon both the time of day and season that the attack occurs

Table 3.2: Population and Housing Units for Affected Cities

Affected Cities	Population	Housing Units
Providence	19,543	6,308
East Providence	6,792	2,884
Cranston	2,445	893

Source: Providence Plan

Including workers in local businesses, the total population within the Orange Ring could approach 40,000 people depending on both time and day.

People outside and within a half-mile radius from the site of the pool fire would have only a limited possibility of surviving given the presence of thermal levels above the threshold at which fatalities can occur. Even those indoors at the time of the attack would be at considerable risk due to the rapid spread of sympathetic fires and potential for release of toxic materials in the surrounding area. In just a few minutes after the LNG ignites it is estimated that the number of deaths within the Orange Ring could total three thousand people with nearly ten thousand severely injured.¹⁴⁰ Survivors at this distance would most likely experience permanent disfiguring and/or life threatening burns.

If casualties due to sympathetic fires and/or the release of noxious materials following the pool fire are taken consideration, the city could suffer nearly eight thousand deaths with more than 20,000 injured before the situation is deemed safely under control. These figures largely depend upon the ability of emergency responders to quickly access the affected neighborhoods and set-up triage stations to treat burn victims inside the Orange Ring. Realistically, firefighters would probably have to adopt a "let it burn" response before entering the affected areas resulting in numerous non-prompt deaths. Percentage wise, the most

¹⁴⁰ Casualty estimates are based on several factors including: population density, building materials, topography, evacuation routes, and proximity to the port.

severely impacted would include the elderly, handicapped and small children who would be unable to evacuate their premises without help.

Most residences within the Orange Ring are A-framed wooden structures with asphalt shingles. According to the ABS study, 7,930 Btu is the minimum energy required to ignite a wooden structure without the presence of an ignition source. Furthermore, 3,960 Btu is the minimum energy required to ignite wooden structures with the presence of a nearby flame.¹⁴¹ Given that energy levels exceeding 4,000 Btu could be present close to three quarters of a mile away, it is presumed that sympathetic fires would spread rapidly beyond the initial row of exposed houses putting thousands of additional lives in danger. Getting these fires under control would prove extremely difficult for the approximately 200 fire companies marshaled to the scene. Compounding the problem is that one row of burning houses can emit over 1,600 Btu. It is generally accepted that 2,000 Btu is the absolute upper limit at which firefighters are able to operate with protective clothing.

In addition, the port of Providence is surrounded by numerous industrial facilities many of which store toxic liquids and gaseous materials that could be potentially lethal if released in large quantities. Most alarming is the close proximity of the Univar chemical plant that houses large amounts of chlorine. Although these facilities are built to withstand extreme temperatures, they remain a largely unknown variable that could make the situation far more deadly. The potential for sympathetic detonation of industrial facilities and the hazardous materials stored in the area are discussed further in Parts B and C of this section.

Inside the Orange Ring the knowledge and availability of quick evacuation routes could potentially save thousands of

¹⁴¹ ABS study, p. 33

lives. At the time of this writing, there existed no comprehensive evacuation plan for any of the neighborhoods surrounding the port. Conversations with Providence fire officials have revealed that evacuation plans are being developed but may not be approved until late spring 2005. Once the evacuation plans are approved, the next step is to begin informing the public about how to proceed in the event of a catastrophic emergency. This process is expected to begin in early 2006. Regardless of plans in place, the natural inclination for many after the attack will be to flee the scene immediately. Without an understanding of the dangerous conditions that await them outside, many people would unnecessarily expose themselves to high levels of thermal radiation before the pool fire evaporates. In addition, simulated mass evacuations for densely populated areas in other parts of the country have concluded that the number of vehicular deaths could be fairly substantial following a catastrophic event. Given that only a limited number of evacuation routes would be available for residents inside the affected areas, traffic related deaths should be expected.

a. Providence

The two neighborhoods within Providence that would be most affected by an LNG attack are Washington Park and Lower South Providence. Sections of Upper South Providence and Downtown Providence would also experience potentially dangerous levels of thermal radiation though not as concentrated as the two neighborhoods closest to the port.

Washington Park Neighborhood

The Washington Park neighborhood is situated in the southwestern quadrant of Providence or southeast of the existing LNG facility. The neighborhood's official boundaries consist of the waterfront to the east, the city of Cranston to the south, and Interstate 95 to the west and north. It has a population density of 4,509 people per

square mile.¹⁴² Those people living in the residential sections east of Eddy Street or working in the manufacturing center (manu-center) south of I-95 would experience the deadliest consequences within the first few minutes of an attack.



Figure 3.1: Aerial view of Washington Park neighborhood looking east toward KeySpan facility.

Houses east of Allens Avenue between Chapman Street and Indiana Ave (southeast of the port) would be among the first residences to catch fire given their close proximity to the port. All occupants would be killed within seconds of the attack. Once the first few rows of wooden houses ignite the fires would quickly spread into the densely populated residential blocks west of Allens Ave. The fires would be fueled by thermal radiation levels high enough to spontaneously ignite wooden structures without the presence

¹⁴² *Draft Environmental Impact Statement, KeySpan LNG Facility Upgrade Project, Federal Energy Regulation Commission (Washington, DC: November 2004) 4-55.*

of an ignition source close to half-mile from the port. Within minutes after an attack, a residential section of Washington Park stretching from Tennessee Avenue to the intersection of Eddy Street and Broad Street (close to three quarters of a mile away from the spill zone) could be entirely engulfed in flames.

Also within Washington Park is the Harborside campus of Johnson and Wales University. The Harborside campus enrolls approximately 2,500 students and employs 1,230 faculty and staff.¹⁴³ Assuming the attack occurs while school is in session, hundreds of students would potentially be exposed to deadly levels of thermal radiation. Of particular concern would be the 950 students who live in the three residence halls (West, East and South) along Washington Avenue.¹⁴⁴ These structures are less than half a mile from the projected attack and would be directly exposed to the radiation coming off the pool fire given the relatively flat ground and lack of structural cover between the campus and the port. Many of the students and staff inside or within close proximity to the residence halls would suffer severe burns, potentially fatal. Lacking evacuation routes to the east and south, students and staff who survive the pool fire would be trapped by the sympathetic fires blocking most if not all land-based routes leading away from the campus.

The "manu-center" is home to 75 percent of the manufacturing facilities in Providence.¹⁴⁵ It occupies an area between Ernest Street to the north, New York Avenue to the south, Eddy Street to the west and Allens Ave to the east. The entire center is within a half-mile from the port. Most of the plants in the manu-center use relatively modest sized quantities of acids and alkaloids, which are kept stored in 55 gallon drums. These drums are not built to withstand

¹⁴³ Phone conversation with Johnson and Wales University administration officials (May 3, 2005)

¹⁴⁴ Johnson and Wales University website (accessed May 3, 2005):

http://www.jwu.edu/prov/reslife/h_west.htm

¹⁴⁵ Office of the Attorney General, State of Rhode Island (May 2005)

severe heat levels and could easily rupture in the wake of a pool fire adding another deadly component for people working inside the center as well as the bordering residential areas.

As distance from the spill increases the effects of the radiant heat would be less severe and eventually subside after the pool fire has evaporated. However, for most of the 8.1 minutes the pool fire would burn, Btu levels near the outer edge of Washington Park neighborhood would still be high enough to cause second degree burns to exposed skin in less than 40 seconds.

The major evacuation routes in Washington Park run northwest and southeast including both Broad and Eddy Streets. In the chaos following the pool fire, many of these routes could be choked off as panicked residents attempt to escape by any means necessary the encroaching sympathetic fires.

Emergency responders would not be able to access the interior sections of this neighborhood until thermal levels along the outer fringes have subsided below 2,000 Btu. It is estimated that emergency responders would need to be equipped to handle three to four thousand casualties, with a significant percentage of that number being deaths, as they prepared to access the Washington Park neighborhood following a terrorist attack on the tanker.

Lower South Providence Neighborhood

Lower South Providence is situated along the eastern shoreline of Providence River just south of Downtown Providence. Officially, the neighborhood's boundaries are Broad Street to the west, Public Street to the north, I-95 to the south and Providence River to the east.

The neighborhood has a population density of 6,527 people per square mile. According to the Providence Plan website, "nearly six out of ten housing units in Lower South

Providence are located in buildings with two to four units, about one-third of housing units are single family units, and about 10 percent of all units are in structures with five or more units."¹⁴⁶



Figure 3.2: Aerial view of Lower South Providence looking southeast toward KeySpan facility.

In Lower Providence, a roughly 1.5 mile section of I-95 runs parallel to the shoreline sealing off the neighborhood's residential areas from the port. The elevated portion of highway may help deflect some of the radiant heat from the nearby residences but probably not enough to significantly limit the amount of casualties in the immediate vicinity.

¹⁴⁶ The Providence Plan website (accessed May 2, 2005): http://www.provplan.org/nprof/lsp_bk.html

On I-95 itself, the Thurbers interchange would be closest to the spill and drivers along this stretch could be maimed or killed either from the radiant heat of the pool fire or from deadly traffic accidents, should the highway's structural foundations buckle from the heat. I-95 would also serve as a major transportation route for emergency responders and any impediments due to structural damage or deadly accidents would slow down response time in the area.

Although most of the populated areas in Lower Providence are located more than a half-mile from the port, thermal radiation levels would still be high enough to cause extensive burns and potentially death to people trapped outdoors for longer than thirty seconds. At this distance, people indoors have a much higher chance of surviving the 8.1 minutes of intense radiant heat. However, following the LNG fire, sympathetic fires would quickly engulf a substantial portion of the residential neighborhood putting thousands of people in danger regardless of shelter. This would include children at both the Fogarty School and Roger Williams School (approx. 1,000 students in total).

Washington Park and Lower Providence share the same major evacuation routes, which run northwest and southeast through the area. As stated earlier, firefighters arriving at the scene would be forced to take a "let it burn" approach given that thermal levels at the outer fringes of the neighborhood would approach the upper limit at which firefighters with protective clothing can operate.

Similar to estimates for Washington Park, emergency responders would need to be equipped to handle close to 3,000 casualties, with a significant percentage of that number being deaths, as they prepared to access the Lower Providence neighborhood.

b. East Providence

Approximately 6,792 people within East Providence reside within the Orange Ring depicted in Map 3.1. The residents most affected would be those closest to the Veterans Memorial Highway that runs along the western shoreline. These homes would be in direct line of sight to the pool fire and would be exposed to thermal heat levels high enough to cause spontaneous combustion of wood almost instantly. It is highly probable that all occupants inside would die in the first minutes of an attack. Located along the shoreline is also the Metacomet Golf Club where the lack of available shelter for those outside on the course would likely result in death as they would be directly exposed to the spill.



Figure 3.3: Aerial view of Providence River looking south along the proposed tanker route with East Providence along eastern shoreline.

Much like the residential neighborhoods across the river in Providence, as the first few homes along the East Providence shoreline ignite, the fires would quickly spread enveloping a large percentage of the surrounding area approximately one mile from the spill's epicenter. Thousands of lives would be put in danger from the raging infernos spreading eastward.

Thermal heat levels approaching 2,000 Btu could reach as far as Boyd Avenue hampering the response time of emergency officials who would first have to triage structures on the periphery before attempting to treat victims and evacuate residents close to the shoreline. For residents in East Providence the major evacuation routes run northeast and east away from the shoreline.

c. Cranston

Cranston is situated along the southern border of the Washington Park neighborhood, approximately 1 mile from the port. According to officials at Providence Plan, 2,445 people reside in this northern section of Cranston. People in this area would be subject to levels of thermal radiation severe enough to induce life-threatening burns if exposed to conditions outdoors for under a minute. People indoors would escape serious injury from the LNG fire but would then be faced with rapidly encroaching house fires and possible toxic clouds as a result of noxious gases released into the air from one of the many nearby industrial and chemical facilities that are closer to Cranston than the port is.



Figure 3.4: Aerial view of north Cranston. Tanker will pass along eastern shore on its way to KeySpan facility.

The two major evacuation routes most accessible for Cranston residents fleeing south of the port would be Broad Street and Narragansett Blvd. Minor casualties would be prevalent in this area although a low percentage of fatalities due to sympathetic house fires may occur.

B. Damage to Critical Infrastructure

According to the Sandia Report, "thermal radiation that will damage structures is approximately 37 kW/m^2 for durations more than 10 minutes. Damage can be expected to ... nearby steel structures, because steel strengths are reduced to 60-75% of their room temperature values at 800 degrees K.

Steel will melt at 1800 degrees K and is generally considered to have no strength at half the melt temperature, or 900 degree K. The calculations suggest that these temperatures could exist at a spill from an LNG cargo tank from 30 minutes to an hour, and therefore, potentially damage nearby steel and other structures."¹⁴⁷

Table 3.3: Structure Damage Criteria for Thermal Radiation Exposure

Thermal Radiation Intensity		Type of Damage
BTU/hr/ft ²	kW/m ²	
11,890	37.5	Sufficient to cause damage to process equipment (e.g., steel structures and equipment)
7,930	25.0	Minimum energy required to ignite wood at indefinitely long exposures without a flame
3,960	12.5	Minimum energy required to ignite wood with a flame or cause melting of plastic tubing

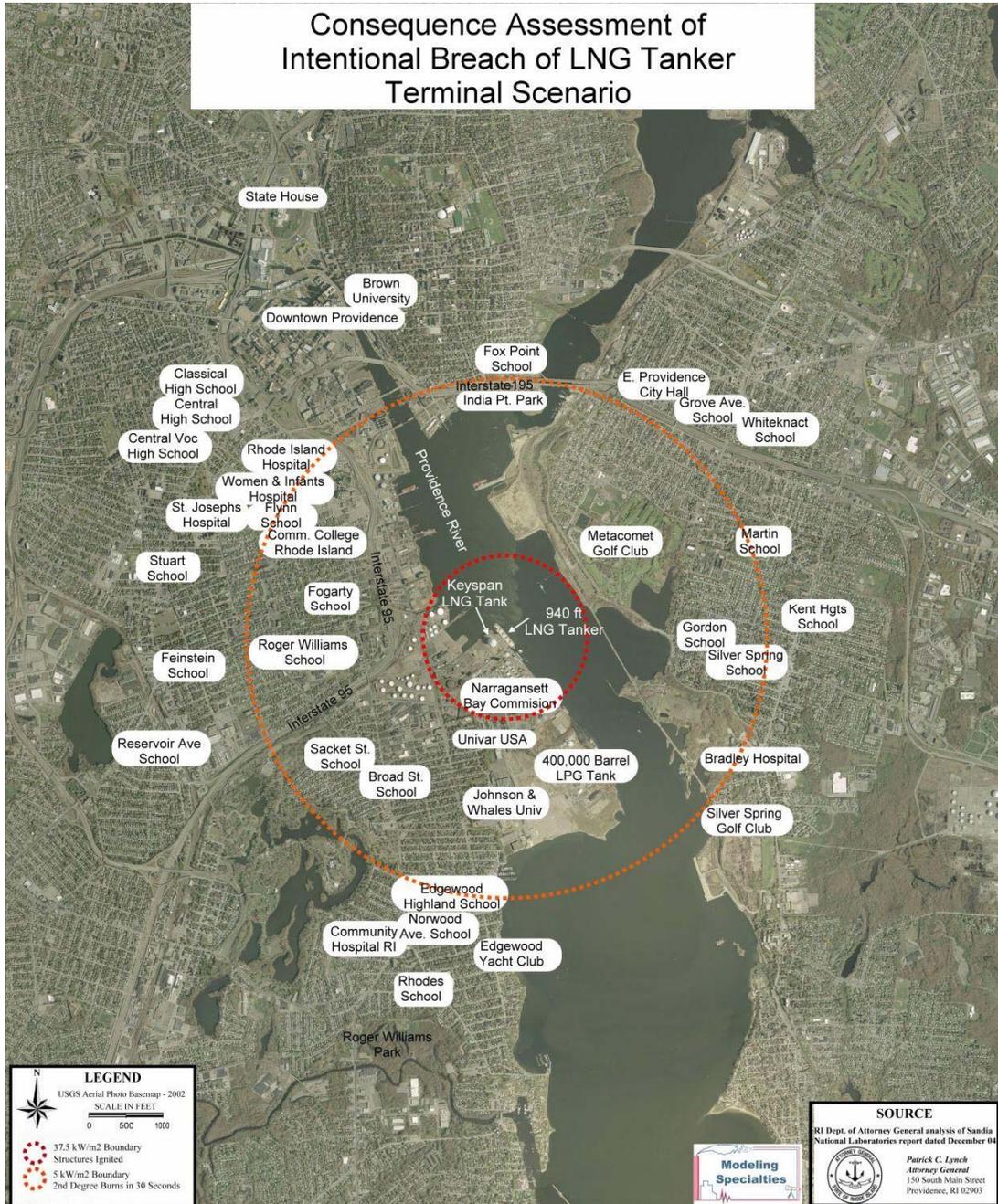
Source: ABS Consulting Report, p. 33

As shown in the table above, in addition to damaging steel, intense temperatures from an LNG fire would also ignite wood structures and melt plastics. The following guidelines are useful to associate temperature with types of infrastructure damaged:¹⁴⁸

- 12,000 Btu/hr/ft² (38 kW/m²) - Damage to steel, process equipment and storage tanks.
- 7,900 Btu/hr/ft² (25 kW/m²) - Ignition of wood without direct flame exposure.
- 3,800 Btu/hr/ft² (12 kW/m²) - Piloted ignition of wood, melting of plastic, ignition of vegetation.

¹⁴⁷ Sandia Report, p. 150.

¹⁴⁸ *Consequence Assessment Methods for Incidents Involving Releases from Liquefied Natural Gas Carriers*. ABS Consulting. P. 34. <http://www.ferc.gov/industries/gas/indus-act/lng-model.pdf>



Map 3.2: Satellite image of KeySpan facility, indicating various schools, hospitals, and industrial facilities.

1. Infrastructure, Facilities & Places at Risk within 630 Meters (Red Ring)

Virtually all critical infrastructure within the Red Ring would be severely damaged or destroyed.

a. Providence

Industrial

- **LNG Tanker** - The ship itself would be severely damaged or destroyed as a result of a pool-fire and cryogenic damage. All crewmembers would die.
- **KeySpan Facility** - The KeySpan facility itself would likely be severely damaged by the pool fire. Employees would die. Any LNG storage facilities on-site would be at risk for severe structural damage. If additional LNG leaked from damaged storage facilities, the pool-fire could burn longer or increase in size.
- **Harbor Junction Pier** - Owned and operated by Texaco, this pier is used for the receipt and shipment of petroleum products and bunkering vessels.¹⁴⁹ An LNG pool-fire could result in sympathetic detonations of petroleum stored on ships at this site.
- **Providence & Worcester Railroad Tracks** - The P&W Railroad has tracks very close to the proposed LNG site. P&W is a regional freight railroad that transports a wide variety of commodities for its customers, including construction aggregate, iron and steel products, lumber, coal, chemicals, scrap metals, plastic resins, cement, processed foods and edible food stuffs, such as frozen foods, corn syrup and animal and vegetable oils.¹⁵⁰ An LNG fire could damage P&W's tracks, as well as any freight stored in rail cars at

¹⁴⁹ National Oceanic and Atmospheric Administration (NOAA) website (accessed April 2005): http://chartmaker.ncd.noaa.gov/nsd/CP2/CP2-34ed-Ch06_2.pdf

¹⁵⁰ Providence and Worcester Railroad Company website (accessed April 2005): <http://www.pwrr.com/DEFAULT.html>

the time. Sympathetic detonations are possible and should be studied further.

- **Cement Facility** - Glens Falls Lehigh Cement Co. owns a 44,000-mt-capacity cement storage facility inside the Red Ring.¹⁵¹

Telecommunications Infrastructure

- **Verizon Cell Site** - Verizon operates one cell site within the Red Ring that would be destroyed. Loss of this cell site could interrupt service for those nearby trying to make phone calls to emergency personnel or result in more busy signals and dropped calls. (Additional research is needed to locate potential Cingular, T-Mobile, Nextel and Sprint sites in the area.) After temperatures subsided, Verizon could deploy a temporary "site on wheels."

Transportation Infrastructure

- **Allens Avenue** - Allens Avenue is a major North-South route that follows the Providence Harbor. Cars traveling on Allens Avenue would be destroyed by the pool-fire, potentially blocking the roadway and impeding access to the proposed facility, as well as blocking a natural North/South evacuation route.

Public Infrastructure

- **Narragansett Bay Commission (NBC)** - The NBC is Rhode Island's largest wastewater authority and employs a staff of approximately 90 people that provides wastewater collection and treatment services to over 360,000 residents and 8,000 businesses in ten Rhode Island communities in the metropolitan Providence and Blackstone Valley areas. As the largest secondary wastewater treatment facility in Rhode Island and the second largest in New England, the Field's Point

¹⁵¹ Cement Americas website (accessed April 2005):
http://cementamericas.com/mag/cement_glens_falls_positioned/

Wastewater Treatment Facility provides preliminary and primary treatment for up to 200 million gallons per day (MGD) of wastewater, and secondary treatment for up to 91 MGD. Death of NBC personnel and catastrophic damage to NBC infrastructure would result from the breach scenarios described above. The 103 year-old facility is also listed in the National Register of Historic Places. NBC has submitted a letter to FERC raising concerns with KeySpan's proposed facility.

2. Infrastructure, Facilities & Places at Risk between 630 & 2,118 Meters (Orange Ring)

Infrastructure within the Orange Ring would be at risk of being damaged. Wood structures could burn. Firefighters would be unable to operate within the Orange Ring until thermal radiation dropped below 2,000 Btu. Sympathetic detonations could exacerbate death, damage and injury in the Orange Ring.

a. Providence

Schools

- **Johnson & Wales University**, Harborside Campus - This campus includes 11 buildings, including residence halls, academic buildings, computer halls, athletic facilities and open spaces.¹⁵² Approximately 2,500 students are enrolled at this campus, primarily in J&W Culinary School. Johnson & Wales is one of the closest schools to the proposed facility and also has one the largest enrollments of any institutions that could be at risk.

¹⁵² Johnson and Wales University website (accessed April 2005): www.jwu.edu

- **Roger Williams Middle School** - Approximately 841 students attend this school.¹⁵³
- **Mary E. Fogarty Elementary School** - Approximately 507 students attend this school.¹⁵⁴
- **Community College of Rhode Island, Liston Campus**
- **Edmund W. Flynn Elementary School** - Approximately 559 students attend this school.¹⁵⁵
- **Lillian Feinstein School at Sackett Street** - Approximately 481 students attend this school.¹⁵⁶

Emergency Services

- **Allens Avenue Fire Station** (close to Red Ring) - The Allens Avenue Fire Station is located just beyond the Red Ring and would likely suffer significant damage as a result of a pool fire. Firefighters lives could be at risk, and emergency equipment could be damaged. Allens Avenue is home to Engine Company 13, Rescue Company 1 and Marine Boat 2.¹⁵⁷ Therefore this fire station, the one closest to the scene, would be unable to fight the LNG and sympathetic fires, limiting the city's emergency response.
- **Women and Infants Hospital** - Women & Infants Hospital of Rhode Island is one of the nation's leading specialty hospitals for women and newborns. Women & Infants is the eleventh largest obstetrical service in the country with more than 9,700 deliveries per year.¹⁵⁸ It is located next to Rhode Island Hospital.

¹⁵³ GreatSchools.net website (accessed April 2005):

http://www.greatschools.net/modperl/browse_school/ri/229

¹⁵⁴ *ibid*: http://www.greatschools.net/modperl/browse_school/ri/221

¹⁵⁵ *ibid*: http://www.greatschools.net/modperl/browse_school/ri/213/

¹⁵⁶ National Center for Education Statistics website (accessed April 2005): <http://nces.ed.gov/>

¹⁵⁷ Providence Firefighters Local 799 website (accessed April 2005): <http://www.local799.com/allens.html>

¹⁵⁸ Women & Infants Hospital of Rhode Island website (accessed April 2005):

<http://www.womenandinfants.org/body.cfm?id=10>

- **Rhode Island Hospital** - Rhode Island Hospital (RIH) is a private, 719-bed, acute care hospital and academic medical center. RIH is the largest of the state's general acute care hospitals. RIH is designated as the Level I Trauma Center for southeastern New England, providing expert staff and equipment in emergency situations 24 hours a day.¹⁵⁹ Until heat from the pool fire subsided, RIH emergency professionals and incoming patients would be at risk for second degree burns if they left the protection of the building or emergency vehicles. RIH is also accessible via I-95 and Allens Avenue, two major roadways that could be compromised or impassible in the moments shortly after the pool-fire subsides, slowing down emergency care.

Industrial

- **Univar USA** (close to Red Ring) - Univar USA operates a chemicals distribution facility just outside the Red Ring. In the event of a pool-fire, temperatures could be high enough to compromise chemical storage tanks. Univar workers handle such chemicals as chlorine, sodium hydroxide, hydrogen peroxide and potassium hydroxide at the site.¹⁶⁰ Chlorine leaks can be lethal. For example, a recent chlorine gas leak in South Carolina killed nine people and required evacuations one mile from the site.¹⁶¹ We do not know all the effects of gas leaks for these chemicals, or the potential consequences of an explosion of these chemicals caused by high heat from an LNG pool-fire. Additional research into the safety of this chemical facility is needed in

¹⁵⁹ Lifespan website (accessed April 2005): <http://www.lifespan.org/partners/rih/>

¹⁶⁰ Teamster website (accessed April 2005):

http://www.teamster.org/divisions/Tankhaul/newsletters/nl_tankhaul_sp04.pdf

¹⁶¹ CNN website (accessed April 2005): <http://www.cnn.com/2005/US/01/07/train.wreck/>

assessing the risks posed by the proposed KeySpan operation.

- **LPG Tank** (close to Red Ring) -- TEPPCO Partners operates a liquid propane gas terminal, including a 400,000 barrel (16 million gallon) storage tank, just outside the Red Ring.¹⁶² High heat could compromise the storage facility and result in an LPG fire or explosion. LPG explosions have killed many people in multiple incidents around the world.
- **Gasoline Tank Farm** (close to Red Ring) -- Located just beyond the Red Ring is a cluster of gasoline storage tanks between Allens Avenue and I-95. These tanks sit on flat land and are relatively unprotected by neighboring structures, leaving them clearly in the path of intense thermal radiation from the pool fire. High heat could compromise these storage facilities and result in sympathetic detonations, causing fires or an explosion. Such an event could extend the reach, duration and temperature of thermal heat zones in the Green Ring. Drivers on I-95 could also be at risk in such an event. Accidents on this part of I-95 could cause blockage of emergency vehicles or evacuation traffic.
- **Scrap Metal Yard** (close to Red Ring) - Metals Recycling LLC operates a scrap metal recycling export facility just outside the Red Ring that handles approximately 350,000 to 400,000 tons of scrap metal per year.¹⁶³
- **Municipal Wharf** (close to Red Ring) - Owned by the City of Providence, the wharf has storage facilities and two 45-ton container cranes. It manages receipt and shipment of general and containerized cargo, heavy equipment, lumber, paper products, automobiles, petroleum products, liquefied petroleum gas, scrap

¹⁶² Find Articles website (accessed April 2005):

http://www.findarticles.com/p/articles/mi_m0CXI/is_2_67/ai_n6179799

¹⁶³ Hugo Neu Corporation website (accessed April 2004):

http://hugoneu.com/usa_locations/metals_recycling.html

metal, pig iron, and caustic soda.¹⁶⁴ Given its proximity to the Red Ring, the Municipal Wharf could be destroyed, and sympathetic detonations of materials on site could result as well.

- **Manu-Center** (close to Red Ring) - The manu-center is home to over 75 percent of Providence's manufacturing facilities and is located inside the Washington Park neighborhood due south of I-95 between Eddy Street and Allens Avenue. Conversations with local plant owners reveal that most if not all companies in the area use modest amounts of acids and alkaloids in their production processes including sulfuric, nitric and phosphoric acid as well as cyanide. The chemicals are stored in 55-gallon drums and dispersed throughout the center. Given the proximity of the center to the Red Ring, most plants will undergo substantial damage sending plumes of toxic material into the air. The center is also bordered by a gasoline tank farm directly to the north that could further impact the center and surrounding area if ignited.
- **Northeast Petroleum Corp. Pier** - This pier receives petroleum products and is owned and operated by Northeast Petroleum Corp.¹⁶⁵
- **City Wharf**
- **State Pier No. 1**

Telecommunications

- **Verizon Repair Equipment Garage** (close to Red Ring) - Verizon operates a garage containing company vehicles and repair equipment just outside the Red Ring. If this facility were damaged, Verizon would lose repair capabilities in the region.

¹⁶⁴ National Oceanic and Atmospheric Administration (NOAA) website (accessed April 2005):
http://chartmaker.ncd.noaa.gov/nsd/CP2/CP2-34ed-Ch06_2.pdf

¹⁶⁵ *ibid*

- **Verizon Central Office** - Verizon operates a central office that provides dial-tone service to thousands of customers in the area. If it were damaged and dial-tone service were compromised, injured residents might have difficulty calling 911.
- **Verizon telecommunication wires** - Verizon owns thousands of above ground telecommunications wires and electronics throughout the area that could be damaged by an LNG pool fire.
- **Verizon Cell Site** - Verizon operates another cell site within the Orange Ring that would be at risk. Loss of this cell site could interrupt service for those nearby trying to make phone calls to emergency personnel or result in more busy signals and dropped calls. (Additional research is needed to locate potential Cingular, T-Mobile, Nextel and Sprint sites in the area.) After temperatures subsided, Verizon could deploy a temporary "site on wheels."

Electricity

- **Manchester Street Power Station** - Dominion, an energy company, operates the 495-megawatt combined-cycle natural gas-fired Manchester Street Station. The Manchester Street Station produces electricity and is one of the largest suppliers in the area, with clients such as Rhode Island Hospital.

Transportation Infrastructure

- **I-95, Thurbers Interchange** (close to Red Ring) - I-95 and its Thurbers Avenue interchange are located just outside the Red Ring. Cars on I-95 and the overpass located there could be severely damaged by an LNG pool-fire. Annual daily traffic, in 2003, for this

section of I-95 was 212,100 cars per day.¹⁶⁶ Approximately 1.5 miles of I-95 are located within the Orange Ring. If I-95 were congested, access to areas damaged by the pool-fire would be impeded, particularly for emergency personnel arriving from outside the area. Transportation of wounded people from the area to Rhode Island Hospital would also be impeded.

- **Interstate 195 / Washington Bridge** - I-195 and the Washington Bridge connect Providence and East Providence. Annual daily traffic, in 2003, for this section of 195 was 150,000 cars per day.¹⁶⁷ Blockage of I-195 could slow down EMS professionals crossing from East Providence to Providence to manage consequences of the LNG fire, as well as slow down ambulances carrying burn victims en route to Rhode Island Hospital from East Providence.

Other

- **India Point Park** - India Point Park has 18 acres of open space, trees, and walking paths along its 3,600-foot shoreline. It is one of the three most heavily used parks in the City of Providence, with 75,000 visitors per year.¹⁶⁸ Park visitors outside during an LNG pool fire could be subject to second-degree burns. The Park is used for festivals and concerts that can bring together thousands of people on a given day.¹⁶⁹

¹⁶⁶ Department of Transportation, State of Rhode Island, website (accessed May 6, 2005): <http://www.dot.state.ri.us/WebMaps/maps/SM02.pdf>

¹⁶⁷ Department of Transportation, State of Rhode Island, website (accessed May 6, 2005): <http://www.dot.state.ri.us/WebMaps/maps/SM02.pdf>

¹⁶⁸ Department of Transportation, State of Rhode Island, website (accessed May 6, 2005): <http://www.friendsofindiapointpark.org/park.html>

¹⁶⁹ Friends of India Point Park website (accessed April 2005): <http://www.friendsofindiapointpark.org/park.html>

- **Fox Point Hurricane Barrier** - The Fox Point Hurricane Barrier serves two central functions: 1) to retard high tides from potential storm surges in Narragansett Bay and 2) to maintain river flow such that water levels do not get too high behind the barrier. The 3,000-foot long structure consists of several complex components. The Hurricane Barrier provides protection during any weather conditions that would cause flooding in the Downtown area and protects several hundred million dollars of downtown property in a 280 acre area.¹⁷⁰
- **Roger Williams Park** - Roger Williams Park is a 430-acre park that attracts 3.5 million visitors per year.^{171, 172} Its attractions include a zoo with over 800 animals, landscaped grounds, outdoor facilities, a natural history museum and a casino. The Orange Ring extends into parts of the park. Sympathetic detonations could spread fires into this area.

b. East Providence

Schools

- **Gordon School** - Approximately 394 students attend this pre-Kindergarten through 8th grade school.¹⁷³
- **Silver Spring Elementary School** - Approximately 273 students attend this school.¹⁷⁴

Industrial

- **Wilkes Barre Pier** - This pier receives petroleum products and naphtha and is owned by Providence and Worcester Railroad Co. It is operated by Union Oil

¹⁷⁰ Providence RI.com website (accessed April 2005):

http://www.providenceri.com/publicworks/fox_point.html

¹⁷¹ Woonsocket.com website (accessed April 2005): <http://www.woonsocket.org/river/rogwilpark.htm>

¹⁷² Roger Williams Park website (accessed April 2005): www.rogerwilliamspark.org

¹⁷³ GreatSchools.net website (accessed April 2005): <http://www.greatschools.net/cgi-bin/ri/private/537>

¹⁷⁴ *ibid*: http://www.greatschools.net/modperl/browse_school/ri/97

Co. of California, Getty Refining and Marketing Co., and Astroline Corp.

Other

- **Pierce Stadium** - Johnson & Wales owns Pierce Stadium, an outdoor recreational facility for soccer, baseball, and softball. The stadium capacity is 8,000.¹⁷⁵
- **Metacomet Golf Club** - The Metacomet Golf Club would be at risk of catching fire as a result of an LNG pool fire.
- **East Bay Bike Path** - East Bay Pike Path cuts across the Orange Ring, with certain sections quite close to the Red Ring. Outdoor bikers would be at risk for serious burns.

c. Cranston

Schools

- **Edgewood Highland Elementary School** - Approximately 231 students attend this school.¹⁷⁶
- **Norwood Avenue Elementary School** - Approximately 136 students attend this school.¹⁷⁷

Other

- **Port Edgewood Marina** - Port Edgewood is one of the largest full-service marinas on Narragansett Bay with 150 slips.¹⁷⁸

¹⁷⁵ Dan's Soccer Zone website (accessed May 2005):

<http://dansoccerzone.com/SoccerGuide/guide.php?id=30>

¹⁷⁶ GreatSchools.net website (accessed April 2005):

http://www.greatschools.net/modperl/browse_school/ri/55/

¹⁷⁷ *ibid*: http://www.greatschools.net/modperl/browse_school/ri/62/

¹⁷⁸ <http://www.portedgewood.com/>

- **Oakland Cemetery** - The Oakland Cemetery grounds could be at risk from the spread of sympathetic fires.

C. Sympathetic Detonation Potential

As mentioned above, risk of sympathetic detonations exists as a result of an LNG pool-fire. Thermal radiation resulting from an LNG fire would cause many wood structures, such as houses, to ignite. However, the first layer of wood structures exposed to the pool fire would provide a protective barrier to structures behind the first layer. These house-fires could cause other houses, trees, etc. to subsequently catch fire. Because of the high heat levels in the Red and Orange Ring, fire fighters would not be able to enter the area of the Orange Ring until temperatures dropped, well after the initial sympathetic detonations.

Other sympathetic detonations mentioned above include petroleum tanks, LPG tanks and kerosene tanks. While these fires under other circumstances could cause great concern, they would not significantly add to the damage caused by an LNG pool fire.

There is particular concern about the risk of sympathetic detonations of noxious chemicals. Because Univar USA is so close to the Red Ring, heat levels could rise high enough to compromise chemical storage facilities, creating risk of a chlorine gas leak or explosion. Chlorine gas leaks can cause asphyxiation, death, and burns of the eyes and skin. Chlorine poses a serious fire and explosion risk because it promotes combustion, similar to oxygen. Containers or cylinders may rupture violently due to over-pressurization, if exposed to fire or excessive heat. Temperatures over 200 degrees Celsius on the steel walls of chlorine cylinders can

cause an iron/chlorine fire resulting in rupture of the container.¹⁷⁹

D. LONG-TERM EFFECTS

As America learned on September 11, terrorist attacks can have significant economic impact. While it is difficult to estimate the potential long-term economic impact of a terrorist attack on the proposed LNG facility, it is instructive to consider the following data points:

- **Tourism** - Visitors to Rhode Island spent \$2.7 billion in 2003, with 25 percent of lodging tax revenue generated in Providence.¹⁸⁰ Assuming Providence accounts for 25 percent of State tourist expenditures, tourism in Providence is roughly a \$675 million industry. Tourism in New York declined roughly 10 percent in the year following September 11th.¹⁸¹ A similar decline in Providence would amount to a \$68 million loss for the City.
- **Home Values** - The median home value in Providence is \$275,600.¹⁸² An estimated 1,643 houses are included in the Orange Ring, using the median value¹⁸³ this represents approximately \$450 million. A 5 percent decline in the value of these homes would wipe out approximately \$25 million in real estate value.
- **Gross State Product** - Rhode Island's Gross State Product, in 2003, was \$40 billion.¹⁸⁴ A 0.5 percent

¹⁷⁹ Canadian Centre for Occupational Health and Safety website (accessed April 2005):

http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/chlorine/working_chlorine.html#_1_2

¹⁸⁰ Rhode Island Tourism Division website (accessed May 6, 2005):

<http://www.visitrhodeisland.com/pdf/TTRR21.pdf>

¹⁸¹ The Boston Consulting Group website (accessed May 6, 2005):

http://www.bcg.com/publications/files/nyc_report_bcg.pdf

¹⁸² CNN website (accessed April 20, 2005): http://money.cnn.com/pf/features/lists/nar_4q/

¹⁸³ See graphic prepared by City of Providence.

¹⁸⁴ USA Embassy website (accessed April 20, 2005): <http://usa.usembassy.de/rhodeisland.htm>

decline resulting from a terrorist attack would cost the State \$200 million.

Long-term environmental impacts from a release of LNG are negligible if there is no ignition of natural gas vapors.¹⁸⁵

IV. Consequence Management

Simply put, there is no way for the City of Providence to be fully prepared for the disaster scenario presented by a three tank breach with pool fire. Although emergency response units are actively working on planning scenarios related to a possible attack on the proposed KeySpan facility, the nature of the attack itself leaves the city ill-equipped to respond.

A. Incident Command and Control

In the event of an attack on the proposed KeySpan facility as previously described, emergency responders will follow the procedures set out in the Mass Casualty Scene Management Standard Operating Procedures.¹⁸⁶ These procedures were originally designed for a much smaller mass casualty operation, presuming approximately 21 injuries and 11 rescue or ambulance units, but will be expanded to fit the proposed casualty scenario.¹⁸⁷ In their expanded form, the procedures will be modeled to direct a series of strike teams staged at various locations on the perimeter of the incident area.¹⁸⁸ Of course, it will be impossible for this plan to

¹⁸⁵ *Consequence Assessment Methods for Incidents Involving Releases from Liquefied Natural Gas Carriers*. ABS Consulting. P. 3. <http://www.ferc.gov/industries/gas/indus-act/lng-model.pdf>

¹⁸⁶ Chief Michael Dillon

¹⁸⁷ Providence Fire Department. SOP No. #34. November 28, 2001.

¹⁸⁸ Chief Michael Dillon

effectively address a disaster which could produce more than the number of deaths of the 9/11 attacks on New York and Washington, D.C., especially considering the limited response capacity of a city the size of Providence.

B. Emergency Alert Notification

Under the Mass Casualty Scene Management Standard Operating Procedures (as noted in the Harbor Incident table top exercise), the incident commander would order the police department to activate the Emergency Alert System as well as perform door to door and area route warnings to the public. It was noted in the exercise however that door to door and area routes of public notification might not be efficient due to the large scale of the scenario.¹⁸⁹

The Rhode Island Emergency Alert System consists of:

- FM: WWLI 105.1, WPRO 92.3, WHKK 100.3, WWBB 101.5, WHJY 94.1
- AM: WPRO 630, WSKO 790, WHJJ 920
- Marine Channel 16¹⁹⁰

Additionally, alert notification can be broadcast on the thirteen permanent overhead dynamic message signs posted along major roadways operated by the Rhode Island Department of Transportation's Transportation Management Center.¹⁹¹

The process for activating the Emergency Alert System is as follows:

- The information is then faxed to radio stations designated as primary stations under the Emergency Alert System (EAS).

¹⁸⁹ After-action Report, Providence, Rhode Island Table-Top Exercise. September 29, 2004.

¹⁹⁰ Rhode Island Emergency Management Agency website (accessed April 2005):
<http://www.riema.ri.gov/eguide.htm>

¹⁹¹ Rhode Island Department of Transportation website (accessed April 2005):
<http://www.tmc.state.ri.us/technologies.asp>

- The primary stations send the same information to area radio and television stations and cable systems via the EAS, and it is immediately broadcast by participating stations to millions of radio listeners and television viewers.
- Radio stations interrupt programming to announce the alert, and television stations and cable systems run a "crawl" on the screen.¹⁹²

C. Fire Control

1. Response Plan

The Providence Fire Department would play the largest role in consequence management for an attack on the Keyspan facility. Emergency responders will not be able to operate in the 1800 meter radius in which the pool fire is burning above 1600 BTU. Instead, the fire department will focus on preventing from spreading into the residential communities of Washington Park, Edgewood, and Cranston, evacuating residents and treating radiant heat casualties. In this situation responders will be divided into strike forces comprised of approximately five engines and a chief, and assigned a sector along the burn perimeter by the incident commander, following a model employed by fire fighters combating California wild fires.

2. Capacity Required vs. Capacity Available

To respond to incident of this magnitude outside support will be required. It is estimated that fifty to one hundred engine companies would be needed to respond, with about a total of 200 to 400 fire fighters working each 12 hour

¹⁹² Rhode Island State Police website (accessed April 2005): <http://www.risp.state.ri.us/amber.php>

shift. The Providence Fire Department has 100 fire fighters, and fire departments from the surrounding region, including Massachusetts and Connecticut, would be required. Departments in the surrounding region are, on average, from one half to one third the size of the Providence Department. Response time of other companies would depend on the distance traveled. A full description of the capacity of the Providence Fire Department can be viewed in Exhibit One.

None of the Fire Department's critical infrastructure would be affected by the pool fire, and its ability to respond would not be significantly compromised by the fire, despite the location of the Allens Avenue station, just beyond the inner ring. All water mains needed to combat fires are underground and gravity fed, meaning that electricity is not required for water to remain flowing through the system.¹⁹³

D. Emergency Medical Response

1. Response Plan

On the scene medical operations will be directed by the Chief of the Emergency Medical Service, or an officer designated by the Incident Commander. The EMS Chief will report to the Incident Commander, and will direct the Primary Triage Officer, the Secondary Triage Officer, the Treatment Officer and Loading Officer. The EMS Chief will also be responsible for communicating casualty estimates to the Bureau of Operational Control who will in turn report those figures to receiving hospitals.

The Primary Triage Officer, typically the first arriving fire company officer, will be designated by the EMS Chief, and his/her primary responsibility will be to direct the emergency responders in judging the priority of need for first aid administration. The Secondary Triage Officer, typically an officer of the first arriving rescue company,

¹⁹³ Chief Michael Dillon.

along with his/her team, will be responsible for determining the order of patient evacuation from the scene to the treatment area. The Treatment Officer will establish and supervise the treatment area, including assigning personnel for patient care. The EMS Loading Officer will assign rescue companies and ambulance crews to transport patients, and communicate relevant information for each patient to the receiving hospital.

2. Capacity Required vs. Capacity Available

According to Standard Operating Procedures, the number of patients that can be served is twice the number of vehicles available.¹⁹⁴ Our estimates suggest that approximately 50-75% of those within the incident zone, or 18,000 to 27,000 people, will require treatment of injuries ranging from first degree burns to cuts and bruises, suggesting a need for 9,000- 13,5000 emergency response vehicles.¹⁹⁵ Clearly, it will be impossible to obtain the services of that many vehicles, nor would the infrastructure of the area be able to accommodate that many responders. It is more likely that only a few hundred rescue vehicles would be able to respond, and that the number of responders would find the casualty count overwhelming, leading to a high morbidity rate.

Rhode Island has 85 licensed Emergency Response Agencies, 85% of which are operated by cities and towns and 10% which are privately operated.¹⁹⁶ Combined, these agencies have a capacity of 285 response vehicles. State-wide Rhode Island has 2,145 EMTs certified at the Basic level, 270 at the Intermediate level, 1620 at the Cardiac level and 235 at the Paramedic level. Additionally there are specifications of

¹⁹⁴ Providence Fire Department. SOP No. #34. November 28, 2001.

¹⁹⁵ Robert Knake. Interview and discussion. April 2005.

¹⁹⁶ National EMSC Data Analysis Resource Center. State and Territory Data Collection—Rhode Island, July 21, 2003.

each class can be found in Exhibit two.¹⁹⁷ Vehicles and trained responders from the greater New England area would be needed to respond to this emergency.

3. Trauma Centers/Morgue

a. Capacity Required vs. Capacity Available

The state of Rhode Island as a whole has 14 hospitals with a mass casualty capacity of 500 emergency victims. The nearest trauma center to the presumed site would be the Rhode Island Trauma Center (RIH), a private, 719-bed, acute care hospital and academic medical center. RIH is the largest of the state's general acute care hospitals. RIH is the only Level I Trauma Center for southeastern New England, providing expert staff and equipment in emergency situations 24 hours a day.¹⁹⁸ RIH also houses the only specialized burn unit in Rhode Island. Until heat from the pool fire subsided, RIH emergency professionals and incoming patients would be at risk for second degree burns if they left the protection of the building or emergency vehicles. RIH is also accessible via I-95 and Allens Avenue, two major roadways that could be compromised or impassible in the moments shortly after the pool fire subsides, slowing down emergency care. After the fire subsides, provided the facility was in no way damaged, the emergency care department can serve approximately 196 patients per hour.

RIH mortuary has capacity for 8 bodies. RIH has a mass mortuary contingency plan where a preexisting agreement with refrigerator containment vehicles will allow them to stack bodies in refrigerator trucks. According to a hospital representative, the exact capacity is unknown as it depends on the number of trucks available at the time of the

¹⁹⁷ Emergency Medical Services Magazine website (accessed April 2005): www.emsmagazine.com/SURVEY/RhodeIsland.pdf

¹⁹⁸ Lifespan website (accessed April 2005): <http://www.lifespan.org/partners/rih/>

emergency.¹⁹⁹ Estimates from the 1995 Chicago Heat Disaster response suggest that such trucks could hold 38 bodies each.²⁰⁰ Given an estimated death toll of 3,000, eighty trucks would be necessary to keep the bodies in Rhode Island. Even if other local hospitals were able to provide mortuary capacity for 100 bodies, seventy-seven trucks would still be required.

4. Police Response

The prime police response to an attack would be to assist evacuation efforts and provide the public with information. The Providence Police Department could respond to the incident with a total of approximately 140 uniformed officers. This capacity could however be somewhat impacted by the attack as one of the four Providence police stations is located within the blast zone.²⁰¹ Interviews with the Providence Police were unclear about the number of officers that would be needed to help manage the conflict, but it is estimated that a force far larger than the force which could be assembled would be required to assist with consequence management and maintain law and order after an attack.

The police response would be coordinated by law enforcement branch manager of the incident operations unit, under the control of the incident commander, as is prescribed by the Mass Casualty Scene Management Standard Operating Procedures.²⁰²

¹⁹⁹ Peter Ginaitt., Phone interview. April 2005.

²⁰⁰ Suburban Emergency Management Project. The 1995 Chicago Heat Disaster: An Integrated EMS Response. http://www.semp.us/biots/biot_139.html November 2004.

²⁰¹ Sgt. Freddy Rocha, Providence Police Department, Phone interview conducted by Robert Berman. April 2005.

²⁰² Chief Michael Dillon

V. Exhibits

A. Exhibit One: Fire Stations in Providence

Housed in 14 stations throughout the city:

- 14 Engine Companies
- 8 Ladder Companies
- 5 Rescue Companies
- 1 Special Hazards Company
- 1 Air Supply Unit
- 4 Marine Units
- 2 Mini Pumper Units
- 2 Battalion Chiefs
- 1 Division Chief

In addition, the Chief and Assistant Chiefs of Department, the Fire Prevention Division, EMS Chief, and administrative personnel are located at the Washington Street Station. The Division of Training is located at the Reservoir Avenue Station.

1st Battalion - Allens Ave, Broad St, North Main St, Washington St

- Engines 3, 7, 10, 13
- Ladders 1, 4, 5
- Rescues 1, 4, 5
- Special Hazards 1
- Division 1

2nd Battalion - Atwells Ave, Hartford Ave, Messer St, Mt. Pleasant Ave, Reservoir Ave

- Engines 6, 8, 11, 14, 15
- Ladders 2, 6
- Rescue 2
- Battalion 2

3rd Battalion - Admiral St, Branch Ave, Brook St, Humboldt Ave, Rochambeau Ave

- Engines 2, 4, 5, 9, 12
- Ladders 3, 7, 8
- Rescues 3
- Air Supply 1
- Battalion 3

Source: Providence Firefighters Local 799

B. Exhibit Two: EMT Qualifications

As of July 2003

EMT-Basic. *Skills include:* All DOT skills plus Trauma Score Card and infection control. Current curriculum includes MAST, EOA and subcutaneous administration of epinephrine for anaphylaxis, administration of aspirin, nitroglycerin and albuterol via nebulizer.

Hours of training: 122.

Licensure requirements: Written and practical exam.

Relicensure requirements: Successful completion of DOT standard refresher training program every three years.

EMT-Intermediate.

Skills include: All EMT-A skills plus MAST, EOA and IV therapy (maintenance only).

Hours of training: 27. The EMT-Intermediate program was consolidated into the EMT-A course as described above in January 1989. While existing EMT-I licenses are renewed, no new EMT-I licenses are issued.

Relicensure requirements: Successful completion of DOT standard refresher training program every three years.

EMT-Cardiac. *Skills include:* IV therapy, cardiac monitoring and interpretation, defibrillation, administration of drugs and modern concepts of trauma care.

Hours of training: 196.

Licensure requirements: Pass a written and practical exam.

Relicensure requirements: Successful completion of DOT standard refresher training program and EMT-C refresher module every three years.

EMT-Paramedic. *Skills include:* IV therapy, cardiac monitoring and interpretation, defibrillation, administration of drugs, adult and pediatric endotracheal intubation, external pacemaker placement, pleural decompression by needle thoracostomy, cricothyrotomy and pediatric medical traumatic emergencies.

Hours of training: Required hours per U.S. DOT National Standard EMT-Paramedic Curriculum.

Licensure requirements: National Registry Paramedic written and practical examinations.

Relicensure requirements: Maintenance of current NREMT-P certification.

Source: Emergency Management Systems Magazine