# CANMET CANADIAN EXPLOSIVES RESEARCH LABORATORY

CANMET COMPLEX – BUILDING 12
555 BOOTH STREET
OTTAWA, ON   K1A 0G1

# DRAFT

## Effect of Proposed LNG Facility on Transport Canada Port Operations

**B. von Rosen, P. Lightfoot and J. Buszard**

**CERL 2006-15 (CF)**

**March 2006**

Natural Resources Canada    Ressources naturelles Canada

Canada

**CONTENTS**

## EXECUTIVE SUMMARY

The Explosives Branch of Natural Resources Canada has evaluated the potential effects of a proposed liquefied natural gas terminal (LNG) on the Transport Canada port at Gros-Cacouna, Quebec. The scope of work was to evaluate the technological risk assessment provided by the promoter of the project and to assess whether the current or future operations of the Transport Canada port might be put at risk or otherwise affected by the proposed terminal.

The technological risk assessment was carried out by Det Norske Veritas on behalf of Cacouna Energy. In our opinion, Det Norske Veritas were qualified to carry out the technological risk assessment. The methodology used by Det Norske Veritas to calculate risks follows is well accepted.

From the point of view of the Transport Canada port, the main conclusion of the technological risk assessment is that there is less than a 10-in-a-million chance that a person situated permanently at the Transport Canada port would be killed in a given year. This level of risk is generally acceptable for commercial operations. In broad terms, an accident at the onshore facility should have little effect on the TC port at Gros-Cacouna. We believe that this conclusion is credible.

A second conclusion from the risk assessment is that the worst-case scenario related to accidental release of LNG from a carrier could produce hazardous heat radiation out to 1400 m and a flammable vapour cloud out to 1800 m. As a result, the Transport Canada port could be affected in such an event. However, the cumulative frequency of all LNG carrier accident scenarios with significant spills was calculated by Det Norske Veritas to be less then one in three million years and classified as “negligible”. Again, we believe that this conclusion is credible.

The risk assessment deals only with accidental releases of LNG. No consideration is given to the possibility of deliberate (i.e. terrorist) attack on a LNG carrier. It is assumed that the probability of a deliberate attack is negligible. This omission could be important, as the consequences of a deliberate attack could be more severe than from an accidental spill. An assessment of the probability of a deliberate attack should be carried out by security personnel and is beyond the scope of this report.

Based on the information provided to us, and with certain qualifications, we believe that the presence of the proposed LNG terminal at Gros-Cacouna should not present unacceptable risk to workers at the Transport Canada port and should not unduly effect the operation of the port.

## RECOMMENDATIONS

We recommend that Transport Canada carry out the following actions:

- Ask the federal security agencies and a technical committee to work together to review the risk of a deliberate attack and the magnitude of the damages that may result. If there are no efficient security measures to prevent this kind of event, or if the maximum breach size in a carrier used in the DNV evaluation seems inappropriate, ask Cacouna Energy to provide a risk assessment based on a different worst-case scenario.
- The proposed project does not address the pipeline that will be needed to transport the natural gas and which may pass close to the Transport Canada port. Cacouna Energy should provide at least a draft plan for the future pipeline and a preliminary assessment of the risks associated with it.
- Ask Cacouna Energy to develop an emergency response plan that includes the Transport Canada port in the unlikely case of a large LNG leak from a carrier or onshore.
- If the LNG terminal is approved, carry out a quantified risk assessment on the explosives handling operations at the Transport Canada port, to establish if the explosives operations should continue.

## INTRODUCTION

The Canadian Explosives Research Laboratory (CERL) of Natural Resources Canada (NRCan) was approached in May 2005 by M. Vincent Jarry of Transport Canada (TC) for assistance in evaluating the potential effects of a proposed liquefied natural gas (LNG) terminal on the TC port at Gros-Cacouna, Quebec. The promoter of the LNG project is Cacouna Energy, a partnership between TransCanada Pipeline and PetroCanada.

The scope of work was to evaluate the technological risk assessment provided by the promoter of the project and to assess whether the current or future operations of the TC port might be put at risk or otherwise affected by the proposed terminal. TC approached CERL as the owner and operator of the Gros-Cacouna port. It should be noted that the work done by NRCan on behalf of TC reported on here was carried out independently of the provincial or federal regulatory processes undertaken by Cacouna Energy to obtain permission to go ahead with the project. CERL staff are also assisting TC with the TERMPOL marine security process associated with the same project.

The work reported on here was carried out under the umbrella of the partnership between NRCan's Energy Infrastructure Protection Division (EIPD) and CERL. The work was entirely sponsored by EIPD.

## ACTIVITIES

M. Jarry and M. Bélanger of TC visited CERL on May 25, 2005 to introduce the project and provide the context for the work through a PowerPoint presentation (Appendix A)

Following the visit, NRCan staff collected and analysed literature on LNG operations, with particular emphasis on existing risk assessments involving LNG facilities. The principal documents are listed in the bibliography. Copies of all documents are available at CERL.

B. von Rosen and P. Lightfoot of NRCan visited Gros-Cacouna on August 24, 2005, along with several TC staff members. Enérgie Cacouna gave a more detailed PowerPoint presentation on the proposed facility (Appendix B) and answered a number of questions about the project. The NRCan and TC staff also toured the TC port of Gros-Cacouna and the planned location of the LNG terminal.

Enérgie Cacouna (EC) initially provided a copy of Chapter 9 (Technological Risk Assessment) of their Environmental Impact Statement (EIS). NRCan staff reviewed the TRA and asked for more information and posed a number of questions, as per the email messages included in Appendix C of this report. EC then provided Chapter 2 (Project Statement) and Appendices X – XIII of the EIS.

The remaining questions were addressed by EC and a representative of the risk consultant that produced the EIS (Det Norske Veritas (DNV)) at a meeting at CERL on November 22, 2005 (Appendix C).

Finally, an assessment was made of the potential effects of an explosive event at the TC port, arising from an accident during transhipment of explosives at the port, on the proposed LNG terminal. The details of the calculations can be found in Appendix D.

This report aims to summarise the results of the activities listed above.

## COMMENTS ON LNG HAZARDS IN GENERAL

LNG is mostly methane. Methane is lighter than air, so does eventually rise into the atmosphere when spilled. However, LNG is very cold, so a large spill results in the formation of a pool of evaporating liquid. The cold vapour above the liquid can form a large vapour cloud. The vapour cloud and evaporating liquid represent mostly a fire risk. There is a potential for a vapour cloud explosion, if the cloud can mix well with air before being ignited. The blast damage from explosion of unconfined hydrocarbon-air mixtures can be devastating (e.g. the cyclohexane-air explosion in Flixborough, UK). However, unconfined methane-air mixtures are difficult to detonate and it is not generally thought that there is a serious blast hazard from LNG spills.

There is a lot of literature on the subject of safety and siting of LNG facilities. Some of the literature can be found in the bibliography to this report. Very recently, there was a detailed study by Sandia National Laboratories in the US on the potential risks of a large-scale spill of LNG over water i.e. a large spill from a tanker; the study included a review of four recent modelling studies on LNG spills. All public studies of this kind create a lot of comment, both positive and negative, but Sandia is a very reputable scientific organization and their findings should be considered carefully. Some of the more important findings from the Sandia report that are relevant to the TC port operations follow:

- For a large accidental leak from a tanker, a pool of burning liquid approximately 200 m in diameter could be formed over water, with “high” thermal flux hazards up to 250 m from the centre of the spill and “moderate” thermal flux hazards over 750 m from the centre of the spill.
- Large LNG vapour cloud explosions were considered unlikely in the Sandia study, as they require the dispersion of a large amount of LNG before ignition. Most release scenarios would involve the prompt ignition of the escaping vapour. However, in the unlikely case of a vapour cloud explosion, the hazard range could extend up to 1700 m for an accidental spill.
- The Sandia report also raised the potential for deliberate i.e. terrorist breaching of a LNG vessel. For a large leak from a tanker caused by a deliberate attack, a pool of burning liquid approximately 400 m in diameter could be formed over water, with “high” thermal flux hazards up to 500 m from the centre of the spill and “moderate” thermal flux hazards up to 1600 m from the centre of the spill.
- The hazard range for a vapour cloud explosion as the result of a deliberate attack could extend to 2500 m i.e. as far as the town of Gros-Cacouna.

As the port of Gros-Cacouna is approximately 1500 m from the distance of nearest approach of a LNG carrier under normal circumstances, three of the scenarios described above could have an impact on the TC port.

## REVIEW OF TECHNOLOGICAL RISK ASSESSMENT

The main activity carried out by NRCan staff was to provide an overall review the technological risk assessment provided by Cacouna Energy. The aim was to establish whether the risk assessment was credible and whether the risks to the TC port from a potential accident at the proposed LNG facility are acceptable.

The technological risk assessment was carried out by Det Norske Veritas (DNV, http://www.dnv.com/) on behalf of Cacouna Energy. DNV is one of the world's leading ship classification societies with considerable experience in risk assessment and safety management associated with natural gas. In our opinion, DNV were qualified to carry out the technological risk assessment.

The risk assessment covers the proposed LNG terminal and the region of the St. Lawrence up to 1 km offshore of the berth. The methodology used by DNV to calculate risks follows is well accepted:

- Identify potential hazards and accident scenarios (e.g., LNG carrier hitting jetty during approach). Some 133 accident scenarios were developed.
- For each accident scenario, estimate the frequency, preferably based on historical data or generic failure frequencies. Accident frequency calculations are prone to considerable uncertainty.
- For each accident scenario, estimate the consequences, generally using DNV's in-house software.
- Combine the frequency and consequence for each accident to estimate individual risk (IR). IR is the probability of a fatality, per year of exposure, to an individual at a certain location. The IR from each accident scenario were combined to provide risk contours around the terminal.
- Combine the frequency and consequence for each accident to estimate societal risk (SR). SR is represented by a FN-curve that displays the frequency of an accident associated with a given number of fatalities (e.g. accidents causing X fatalities will occur with frequency Y).

Based on the methodology above and DNV's input probabilities, the largest contributors (>80%) to the individual risk from the proposed terminal involve LNG leaks from on-shore process equipment, such as compressors. Note that the individual risk is a product of the frequency and consequence and so a catastrophic accident leading to a large loss of life may not be considered a high risk, if the calculated frequency is very low.

One conclusion of the DNV technological risk assessment is that the individual risk at the TC port is less than $1 \times 10^{-5}$, i.e. there is less than a 10-in-a-million chance that a person situated permanently at the TC port would be killed in a given year. This risk is acceptable for commercial operations, such as the TC port at Gros-Cacouna, based on the criteria developed by the Major Industrial Accidents Council of Canada (MIACC). In broad terms, an accident at the onshore facility should have little effect on the TC port at Gros-Cacouna.

A second conclusion from the risk assessment is that the worst-case scenario related to accidental release of LNG from a carrier could produce hazardous heat radiation out to 1400 m and a flammable vapour cloud out to 1800 m. These distances are somewhat more conservative than those for accidental releases from the Sandia reports and indicate that the TC port could be affected in such an event. However, the cumulative frequency of all LNG carrier accident scenarios with leaks was calculated to be less then one in three million years and classified as "negligible".

Appendix C contains the substantive questions we had concerning the risk assessment and the responses from DNV in the form of a PowerPoint presentation.

## REMAINING ISSUES

While we consider that the risk assessment for the proposed LNG terminal is well done by a reputable company, there are a number of issues that were not fully addressed and which are listed in this section.

- The quantified risk assessment relies heavily on assumed frequencies for certain events, such as ship-to-ship collisions. Many of the frequencies used are internal to DNV, or based on statistics purchased by them from other companies, such as Lloyds. DNV were not prepared to share with us the derivation of their frequencies, as they consider them to be company confidential information. As these statistics are not in the public domain, it is not possible to verify them. Effectively, we are being asked to trust DNV that their base frequencies are valid. This is probably not a huge concern, given that DNV is a well-respected organization in the field of risk management, but it is incumbent upon us to point out that the core data used for the risk assessment is not verifiable.
- The proposed project includes only the LNG terminal. It does not address the pipeline that will be needed to transport the natural gas between Gros-Cacouna and the intended connection to main pipeline network near Quebec City. The pipeline will need to leave the terminal and may pass close to the TC port.
- The risk assessment deals only with accidental releases of LNG. No consideration is given to the possibility of deliberate (i.e. terrorist) attack on a LNG carrier. It is assumed that the probability of a deliberate attack is negligible. This omission could be important, as the consequences of a deliberate attack could be more severe than from an accidental spill. The maximum breach size in a carrier, whether from an accidental breach or deliberate attack, used in pool size calculations by DNV was limited to 1.38 m in diameter (1.5 $m^2$). This is equivalent to the maximum size for an accidental breach as calculated by Sandia. Calculations based on a breach of this size lead to the conclusion that an unignited vapour cloud dispersion and potential fireball reaching the TC port and surrounding area will not occur. However, according to the Sandia report, the breach size from a deliberate attack could be four to five times larger (5-7 $m^2$). Consequently the vapour cloud and resulting fireball would also be larger and have the potential to affect

both the TC port and the surrounding area. We should point out that the size of a breach in a LNG carrier that could be caused by a deliberate attack is the subject of debate. For example, DNV considers that the "maximum credible" hole size from a deliberate attack to be 1.5 m in diameter (1.8 $m^2$). An assessment of the probability and consequences of a deliberate attack should be carried out by security personnel and is beyond the scope of this report.

- We have not been provided with an emergency response plan: the EIS only contains the elements of a future emergency response plan, to be completed once the project is further advanced. A residual concern is that DNV recommends that the emergency response plan not include a large vapour cloud dispersion because they consider the risk too low. It is necessary to consider the TC port in the emergency response plan. We suggest that a scenario with a large vapour cloud dispersion be included in incident management strategies. Since this scenario might represent unacceptable consequences, regardless of the calculated risk, the availability of safe shelters and community education/awareness should be examined closely.

**EFFECT OF PORT OPERATIONS ON LNG TERMINAL**

Most of the discussion of the effect of the proposed LNG terminal has focussed on the potential effects of a hazardous even at the terminal on the TC port operations. However, consideration should be given to potentially hazardous operations at the TC port and the effect they may have on the proposed LNG terminal.

The one operation of potential concern that we are aware of is the transhipment of explosives that occurs a few times a year at the port. Up to 140 Tonnes of explosives can arrive on a ship. The explosives are unloaded into trucks, each of which can carry up to 20 Tonnes of product. Calculations were carried out on the potential effects of explosions involving either the a ship or a truck containing explosives. The details of the calculations can be found in Appendix D. The focus of the calculations was on whether an explosive event at the TC port could lead to a major event at the LNG terminal that could have an effect back at the port, such as the rupture of one of the LNG storage tanks. Potentially hazardous effects local to the proposed terminal, such as window breakage, were not considered.

The conclusion of the calculations was that overpressure from an explosion at the TC port was unlikely to damage the LNG storage tanks, but that the potential fragments from an explosion could. Of course, this finding does not mean that the presence of a LNG terminal would preclude explosives transhipment at the port, but it would be advisable to carry out a quantified risk assessment on the current explosives handling operations should the LNG terminal be approved.

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Liquefied natural gas – a primer http://www2.nrcan.gc.ca/es/erb/CMFiles/LNG_Web_A_Primer206NCG-04042005-706.pdf

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"Proceedings of the Martine Safety and Security Council", The Coast Guard Journal of Safety at Sea, Fall 2005

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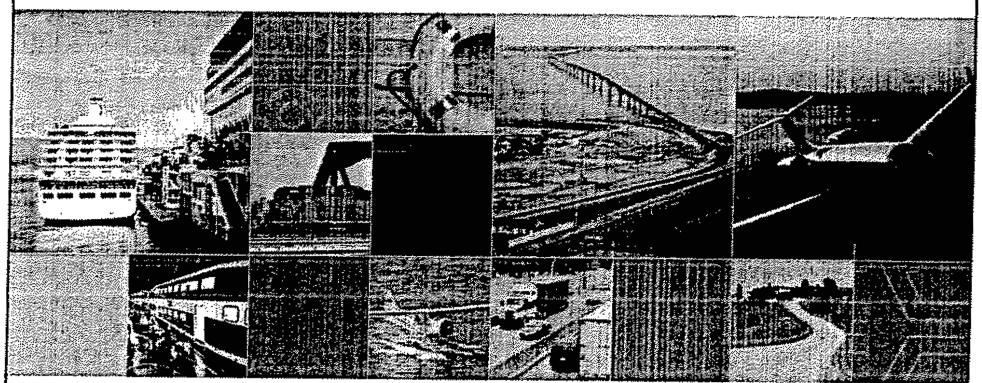
Staff Responses to "Consequence Assessment Methods for Incidents Involving Releases from Liquefied Natural Gas Carriers", Federal Energy Regulatory Commission, Docket No. AD04-6-00, June 2004

TERMPOL Review of the Cacouna Energy Project, Volumes 1 to 5

Transport Canada Termpol Process http://www.tc.gc.ca/MarineSafety/TP/Tp743/tp743e.pdf

# APPENDIX A: PRESENTATION FROM TRANSPORT CANADA TO NATURAL RESOURCES, 25 MAY 2005



# Cacouna Energy LNG carrier terminal project

TransCanada Pipeline – PetroCanada

Gros-Cacouna

A Natural Resources Canada Presentation

25 May 2005

Canada

# Presentation Objectives

- To outline the *Cacouna Energy* project;
- To introduce the roles of Transport Canada;
- To explain Transport Canada requirements;
- To present different strategic issues within the dossier;

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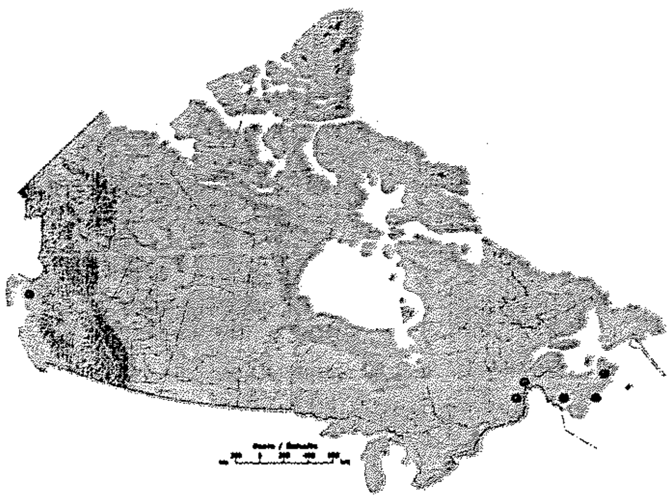
# Location of LNG carrier terminal projects in Canada



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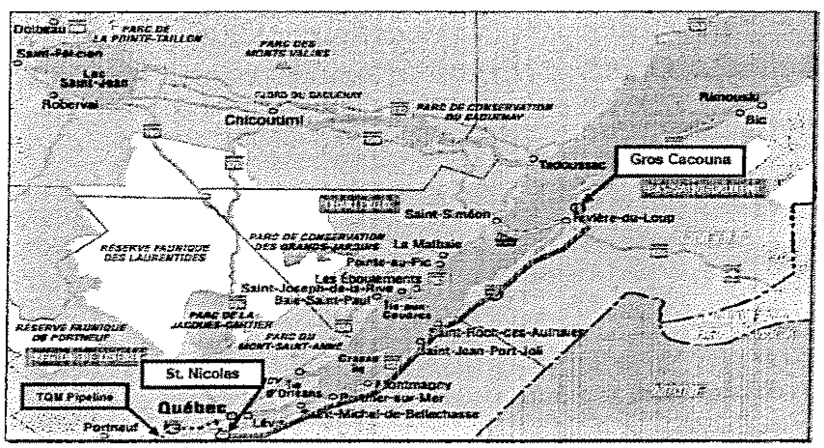
# Location of the Cacouna Energy project

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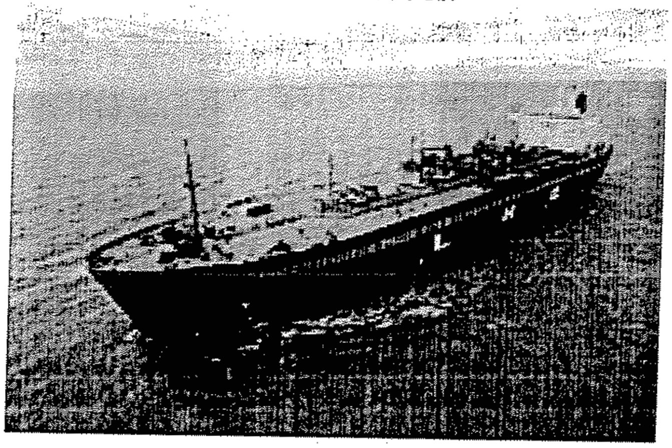
Project Goal : Carrier transportation of liquefied natural gas to Gros-Cacouna Port



Between 40 and 60 vessels per year

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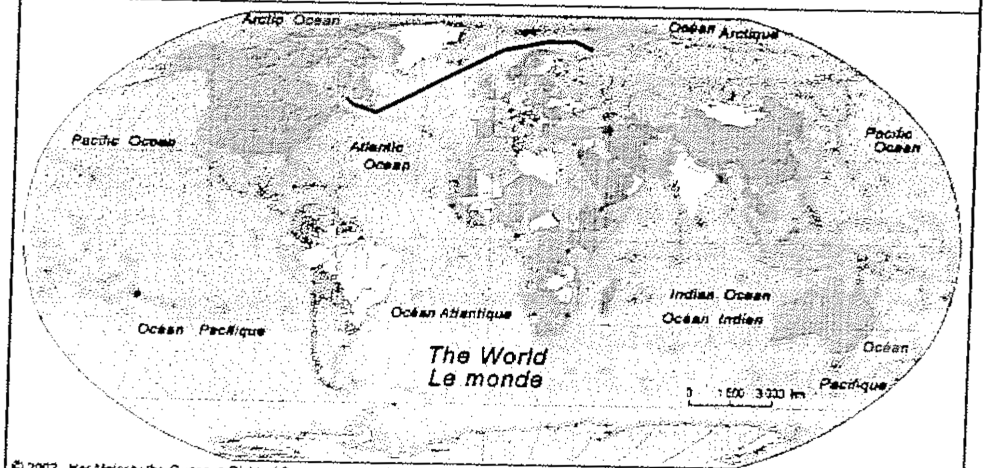
# Projected route between Russia and Gros-Cacouna



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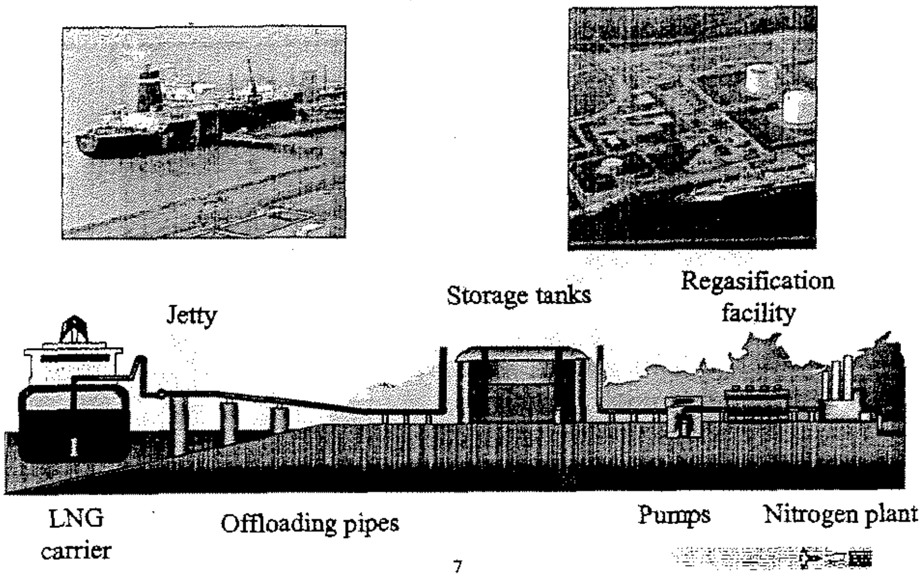
# Schematic view of a carrier terminal

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# Cacouna Energy project parameters

- The project includes :
  - Wharf that can accommodate vessels with a transport capacity of 140,000 $m^3$ to 230,000 $m^3$
  - Unloading equipment
  - Two Storage tanks (160 000 $m^3$ each)
  - Facility for the gasification of liquefied natural gas
  - Nitrogen injection unit
- 700 M$
- Employment for 1000 people over the three year construction period
- 40 permanent employees
- Currently excluding the gas pipeline

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## Environmental impact of the Cacouna Energy project

- As liquefied natural gas evaporates very quickly, it has practically no impact on the environment
- Vessels require ± 2 000 tonnes of fuel to operate
- Natural gas is flammable and requires a 1 to 2 km buffer zone, but it explodes with difficulty
- Visual impact
- Noise impact during construction

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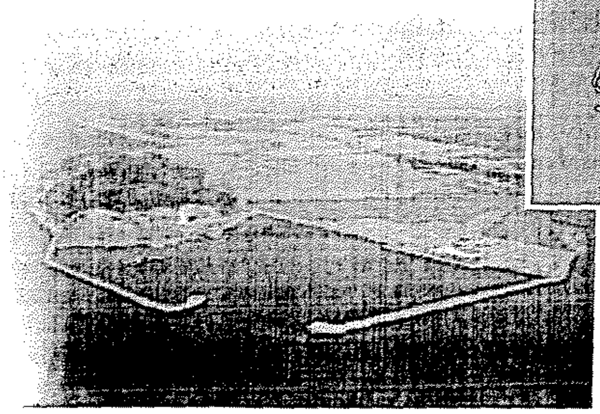
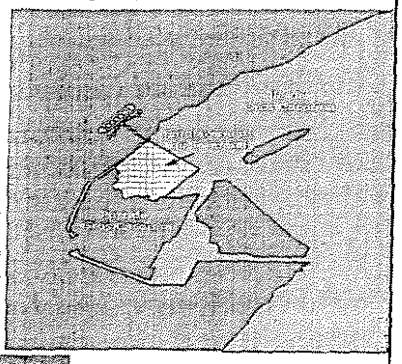
## Gros-Cacouna Port





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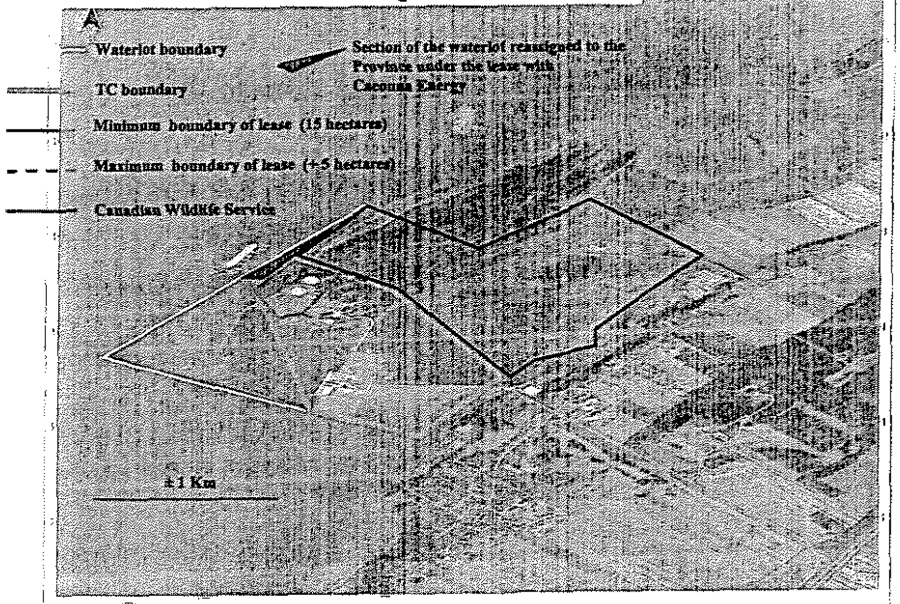
## Detail of Gros-Cacouna port boundaries

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# LNG – Safety dossier

According to the developer

- An exemplary record on safety for more than 45 yrs
  - 40,000 carrier journeys
  - 100 million kilometres travelled
  - No serious injuries or fatal accidents
- LNG is not flammable
- LNG is not explosive
- LNG equipment uses the best operating methods available
- Three levels of protection :
  - LNG storage
  - Detection and reduction of leaks
  - Safety zones

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# Safety Zones

According to the developer

- Safety distances are set up to conform with the Canadian Standards Association code CSA Z-276
- Protection area for the local community in the unlikely event of an LNG incident
  - Fire radiation limit within the terminal zone
  - Predictable limits for any vapour cloud resulting from specified LNG spillage
- Legal obligations based on conservative evaluation of the dangers
- Safety zone dimensions are dependent on site conditions
- Terminal concept takes safety distances into account
- Boundaries of safety zones will be far from neighbouring communities

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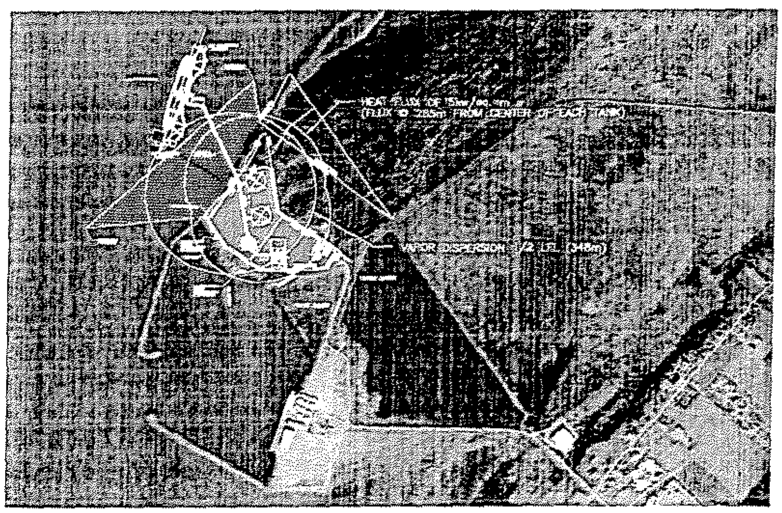
# Safety Zones

According to the developer

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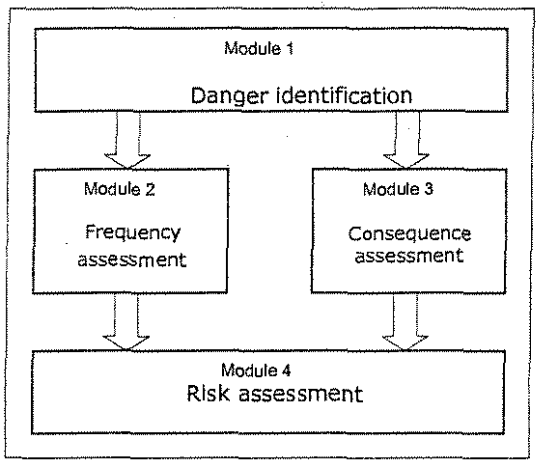
# Safety analysis – method

According to the developer

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# Safety analysis

According to the developer

- DNV confirm that the Cacouna Energy site will be able to receive and store LNG safely.
  - DNV: Awarded the distinction of "Best Classification Society in the World" by Lloyds List
  - DNV classified vessels have the lowest withholding rate
- Accident scenarios involving carriers, unloading operations, storage tanks, and treatment equipment have been examined
- The risks indicated for this project are significantly less than the DNV's recommended acceptance criteria, and they conform with the official criteria of numerous administrations worldwide
- The safety risks associated with even the worst carrier scenarios are negligible
  - The cumulative frequency of accidents involving LNG carriers is less than one in three million years.
- The most serious potential accident involves storage tanks, and does not pose any risk to people outside the terminal

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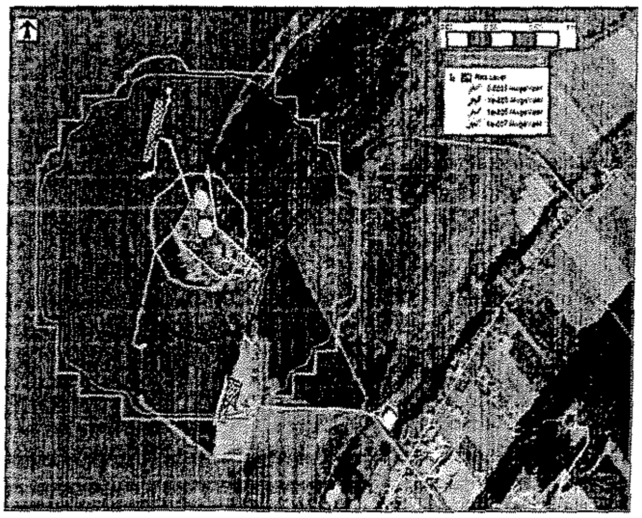
# Safety analysis – results

According to the developer



# Transport Canada Roles

- Owner and operator of Gros-Cacouna port :
  - Canada Marine Act
- Regulatory role under the :
  - Navigable Waters Protection Act
  - Canada Shipping Act
  - Canadian Environmental Assessment Act
  - Marine Transportation Security Act

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# Role of the Port owner

- Responsibility for the security and safety of port operations;
- To ensure that carrier terminal activity can operate safely side by side with existing port operations, as well as with any development projects of the latter, for example; for cabotage;
- To ensure close cooperation in the area

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# Requirements of Transport Canada

Transport Canada requires counter-expertise to validate the results presented by the developer in order to:

- Update our emergency plan for the port
- Ensure the validity of the developers activities
- Prepare Transport Canada for public consultations on the environmental assessment
- Improve a « cohabitation » study between the LNG carrier terminal and a cabotage project

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# ISSUES :

- Transport Canada must carry out all of its roles in complete transparency to:
  - ➢ Avoid any perceived conflict of interest;
  - ➢ Take into account the sensitivity of public opinion.
- Cabotage project : Feasibility study for a link north-south Gros-Cacouna – Baie-Comeau (initiated by the Gros-Cacouna Port Facilities Development Commission - December 2004) :
  - ➢ 222 trailer trucks/week at the port ;
  - ➢ Vessel presence to secure the north-south link: 2x/day at the port;
  - ➢ Transport Canada must ensure that the 2 projects (Cacouna Energy Project, and the north-south link project) do not conflict with physical installations or current and future maritime traffic.

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# ISSUES (continued) :

- – Project timeline is a major issue for the developer and the Ministry must take this into account;
- Malécite-de-Viger and Mi'gmak First Nations land claims;
  - – A feasibility study for a recreational-tourist project has been financed by the Ministry for Indian and Northern Affairs
- The Department has teamed up with the port company to carry out a cohabitation study for the carrier terminal and other port projects;
- Transport Canada is on call for other similar projects throughout the country.

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## *QUESTIONS ?*

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## Regulatory Role : Navigable Waters Protection Act

- To ensure that the new carrier terminal does not hinder navigation or maritime safety.
- A permit must be granted to set up the terminal;
- Issuance of the permit must comply with the Canadian Environmental Assessment Act;
- The TERMPOL process applies for the assessment of this project

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# Regulatory role : TERMPOL process

- The arrival of this type of vessel requires a risk assessment for maritime operations and for the port;
- The assessment is carried out in consultation with the Canadian coast guard, Environment Canada, and Quebec Civil Security.
- The criteria of the Termpol process aim to determine whether any rules or precautions should be adopted in respect of the project;
- Examples :
  - Tug usage
  - Restrictions on other vessels wishing to use the port
  - Restrictions that take the ice regime into account

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# Regulatory role : Canadian Environmental Assessment Act

- The responsible authorities, Transport Canada and Fisheries and Oceans Canada, will ensure compliance with the Canadian Environmental Assessment Act (CEAA).
- After public consultation, and following the recommendations of the Canadian Minister of the Environment, Transport Canada, and Fisheries and Oceans Canada shall issue or withhold the required authorisations.
  - The federal process runs in parallel with that of the province of Québec within the framework of federal-provincial agreement on environmental assessment.
  - Federal and provincial processes will not be completed until the end of summer 2006.

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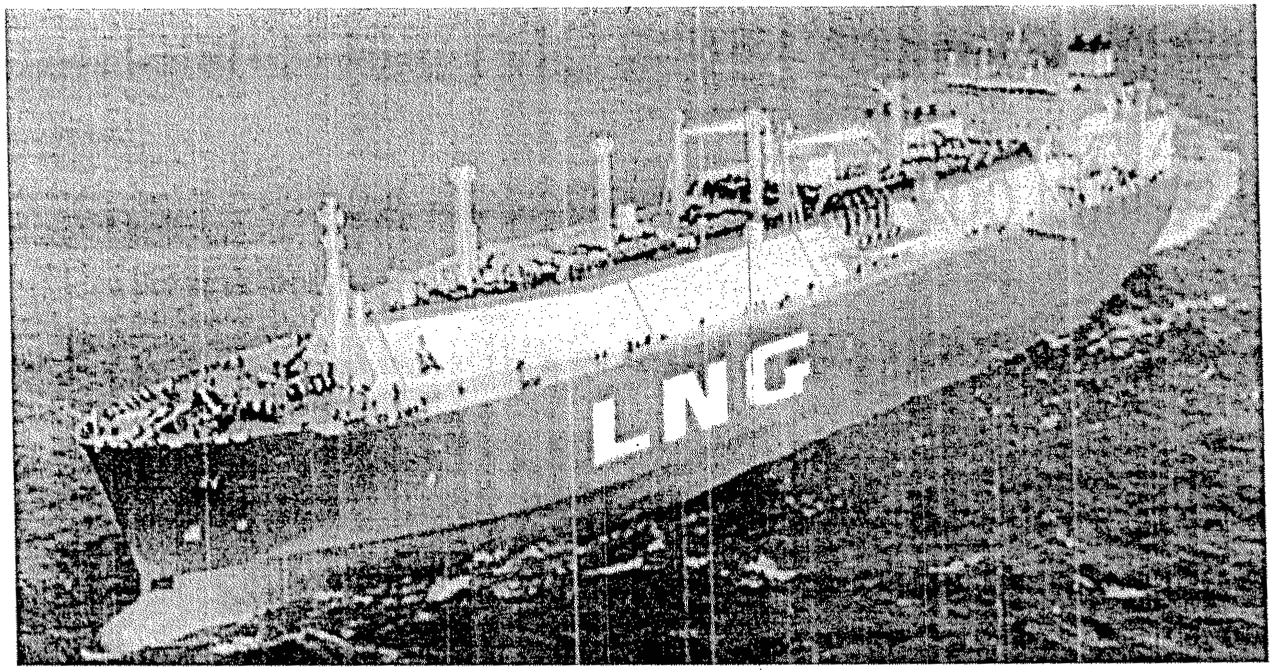
## APPENDIX B: PRESENTATION FROM ENERGY CACOUNA TO NATURAL RESOURCES CANADA, AUGUST 24, 2005

# Cacouna Energy Project

## Presentation to Natural Resources Canada

**August 24, 2005**




ÉNERGIE
cacouna
ENERGY

The information contained herein is confidential, commercial and technical information and is provided on that basis. We believe that the information also contains trade secrets and that its disclosure could reasonably be expected to cause material financial loss to us. In the event that you intend to disclose all or any part of the information, we should be so advised so that we can make appropriate detailed representations to you about the nature of the information.

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# Project Overview

- A partnership between TransCanada and Petro-Canada
- LNG import terminal with capacity for regasification of 500 Million cubic feet per day
- Two LNG storage tanks with total capacity for 320,000 cubic metres of LNG
- Estimated capital cost of about C$ 700 Million for the terminal
- Approximately one LNG carrier visit each week
- The terminal will be designed to accommodate LNG carriers with capacities up to 216,000 cubic metres of LNG

# Project Schedule

- Regulatory process initiated in September 2004
- EIS filed with provincial regulators in May, 2005
- Public hearing expected in early 2006
- Receipt of regulatory approvals by the end of 2006
- Construction between 2007 and 2009
- Start-up of terminal operations anticipated by the end of 2009 or early 2010

# Partner Roles

- Terminal construction and operation: TransCanada
- LNG supply and shipping: Petro-Canada
- Contract downstream pipeline capacity: Petro-Canada
- Construction and operation of the connecting pipeline: TransCanada or TQ&M

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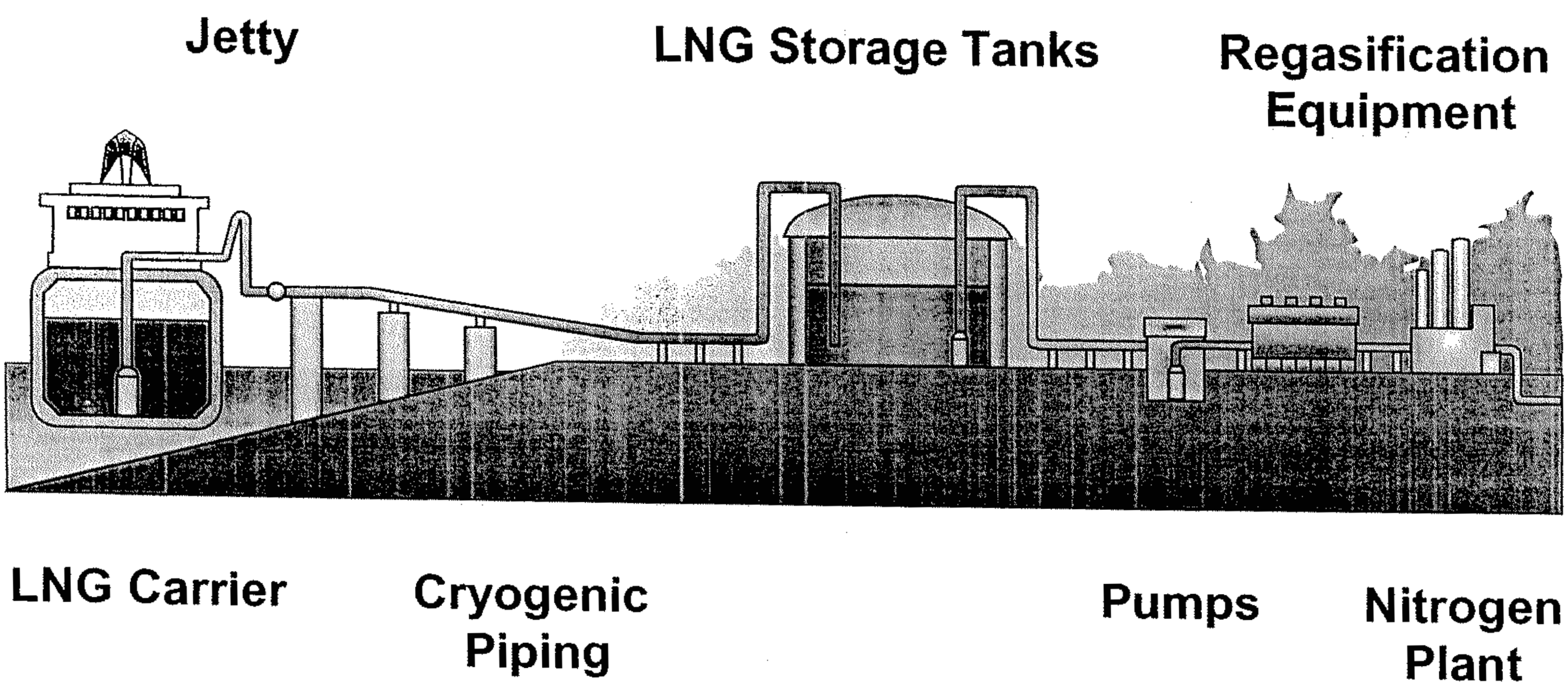
# Overview of an LNG Terminal



Boston.

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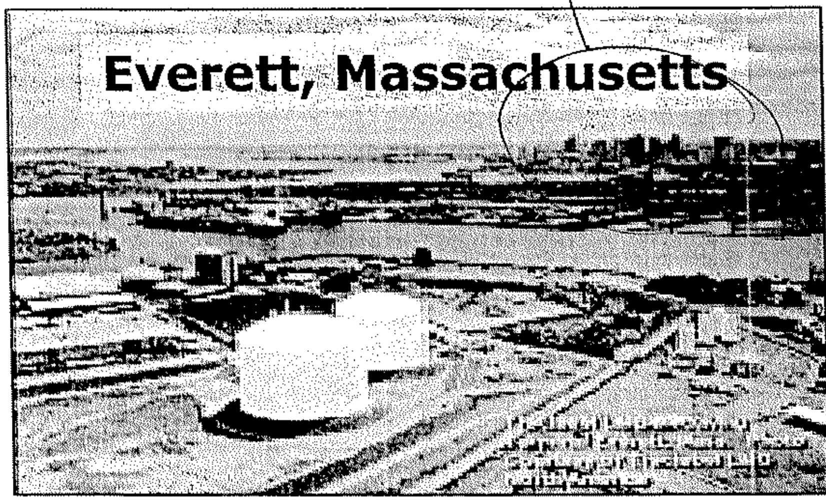
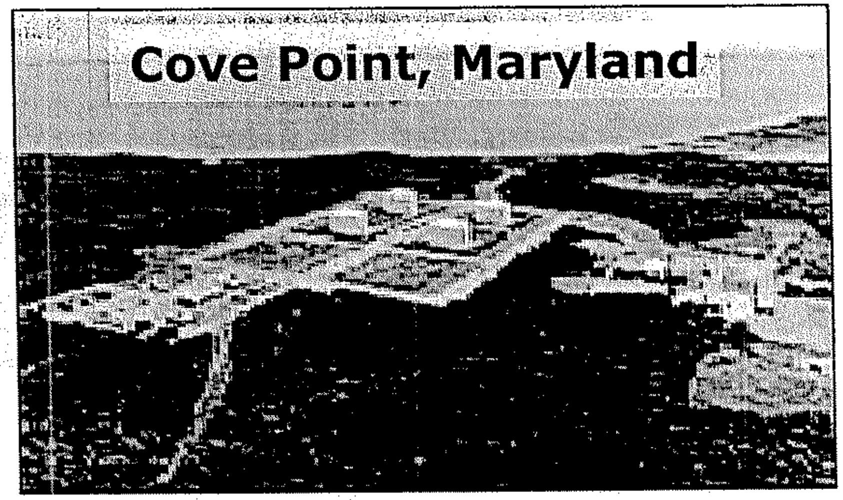
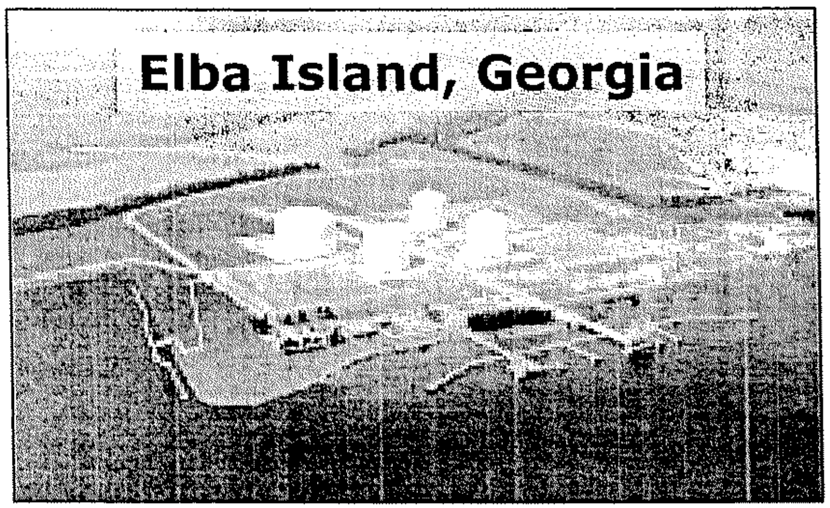
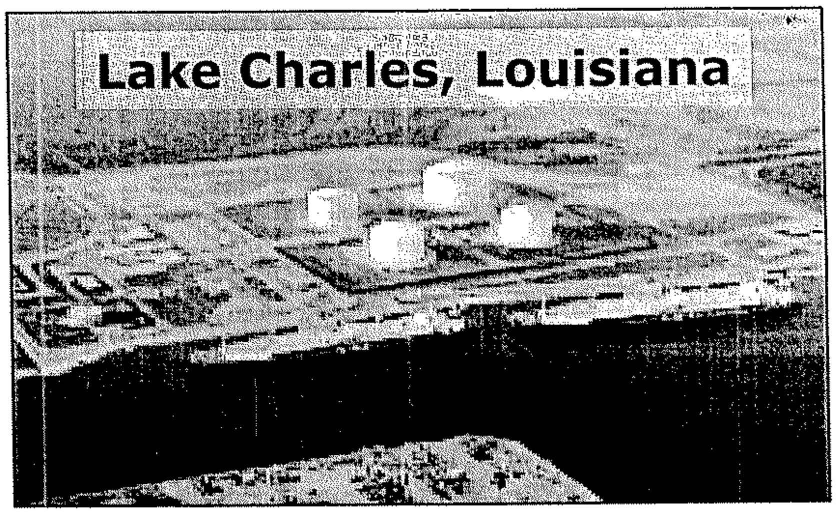
# LNG Terminals in the United States


Everett, Massachusetts


Cove Point, Maryland


Elba Island, Georgia


Lake Charles, Louisiana

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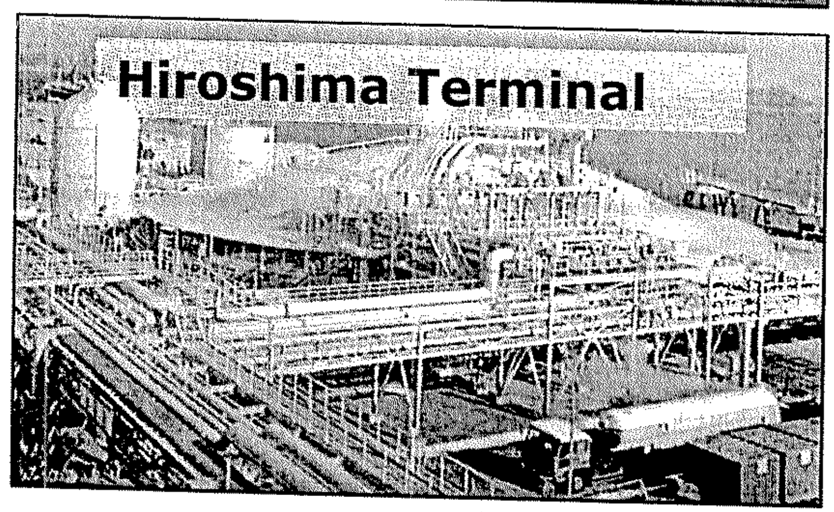
# LNG Terminals in Japan



# Rationale for Selection of the Gros-Cacouna Site

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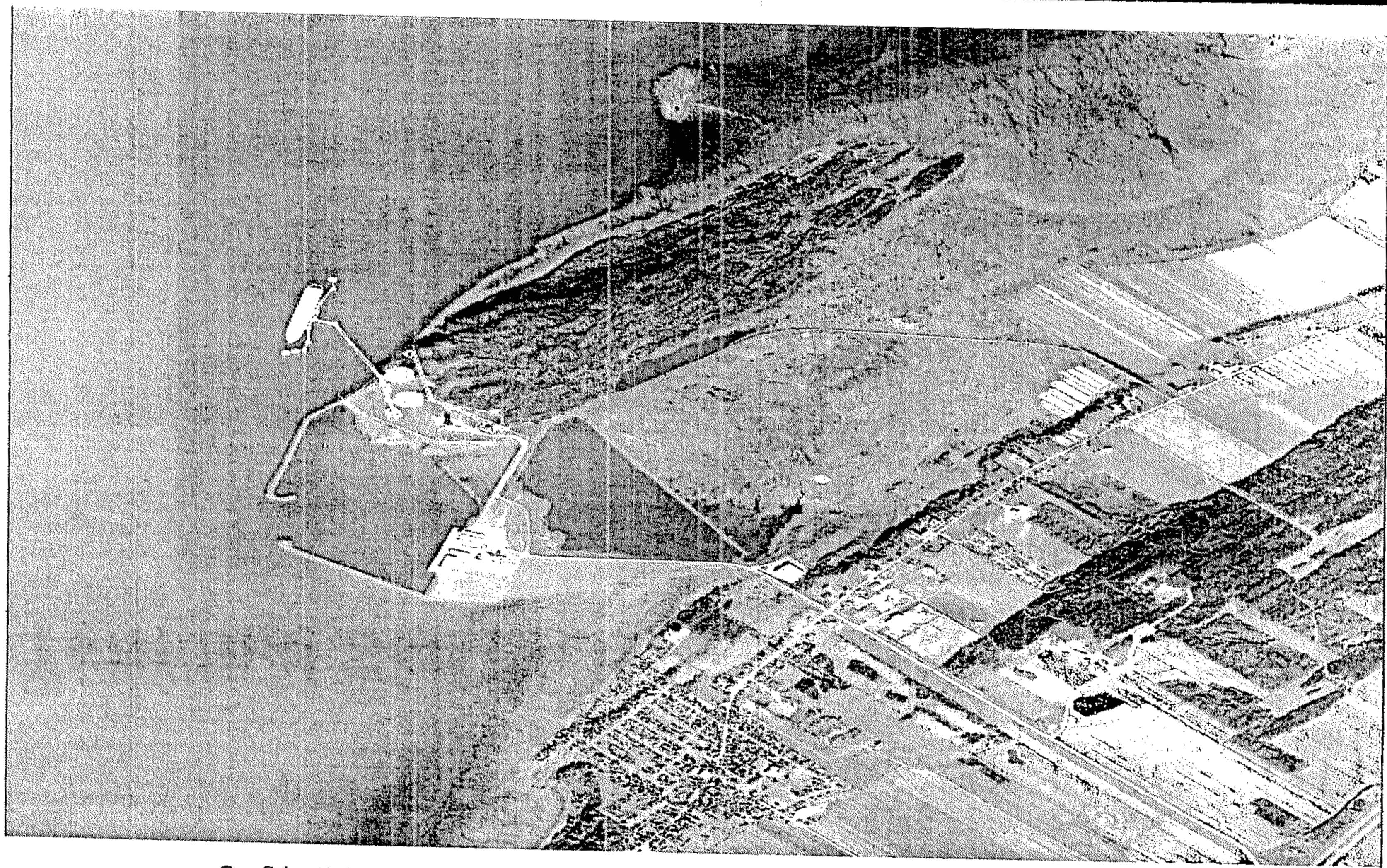
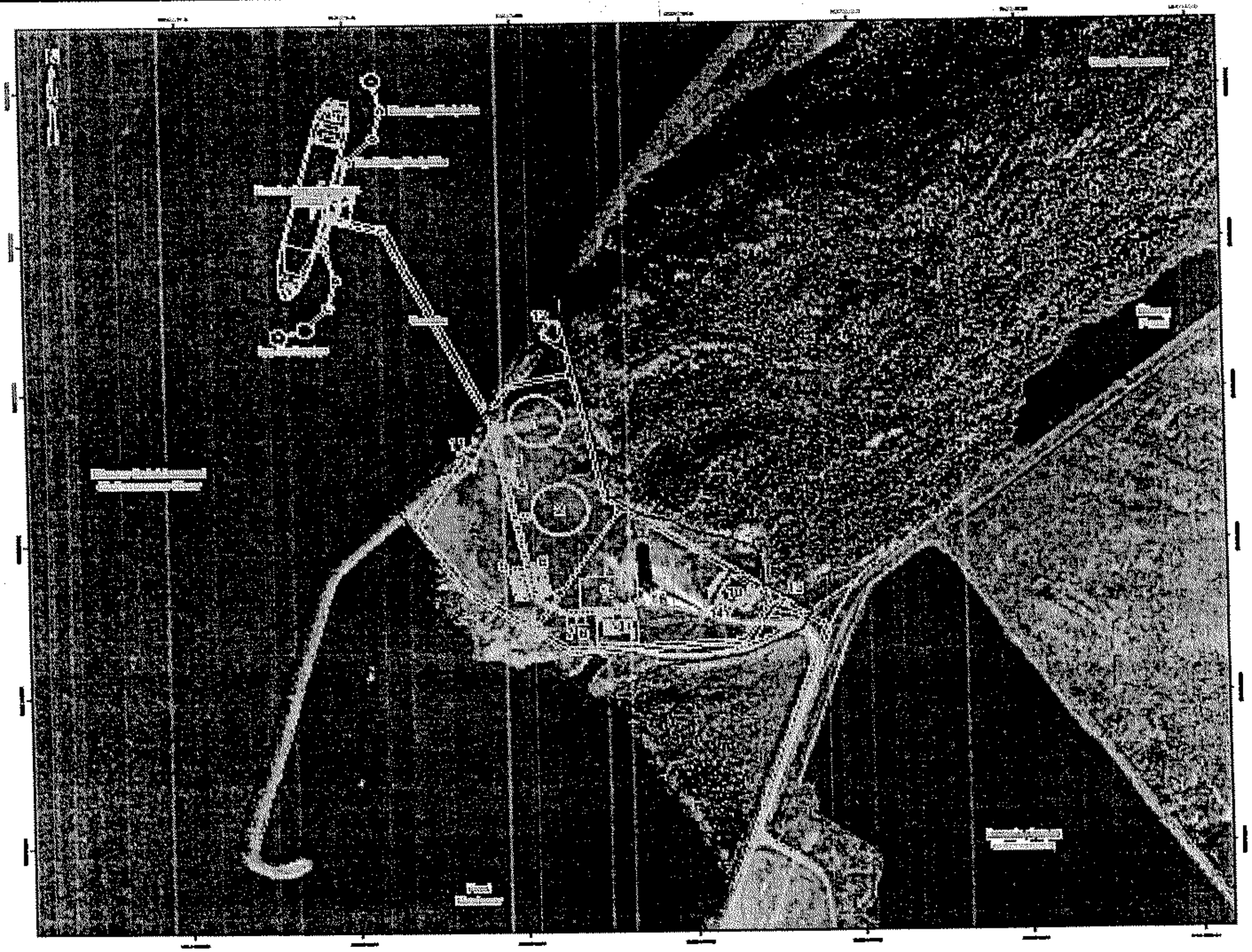
- Ideal location for siting an LNG import terminal
- Deep water for berthing of LNG carriers
- Existing industrial development on the site
- Limited ship traffic in the area
- Tidal currents benign
- The natural topography of Gros-Cacouna island can help reduce the visual impact of the LNG storage tanks

# Location of the Terminal



# Terminal Site Plan



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# Artist's Rendition of the Cacouna Energy LNG Terminal – View from the River

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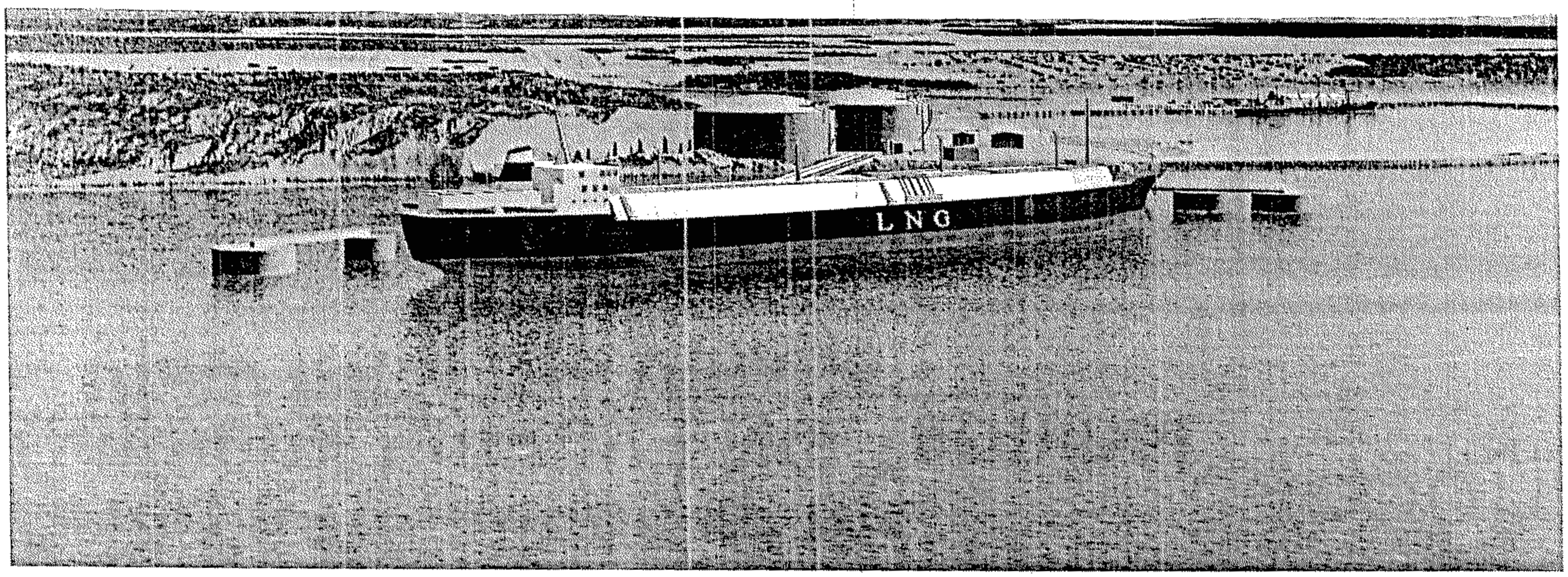

# Artist's Rendition of the Cacouna Energy LNG Terminal – View from the Village

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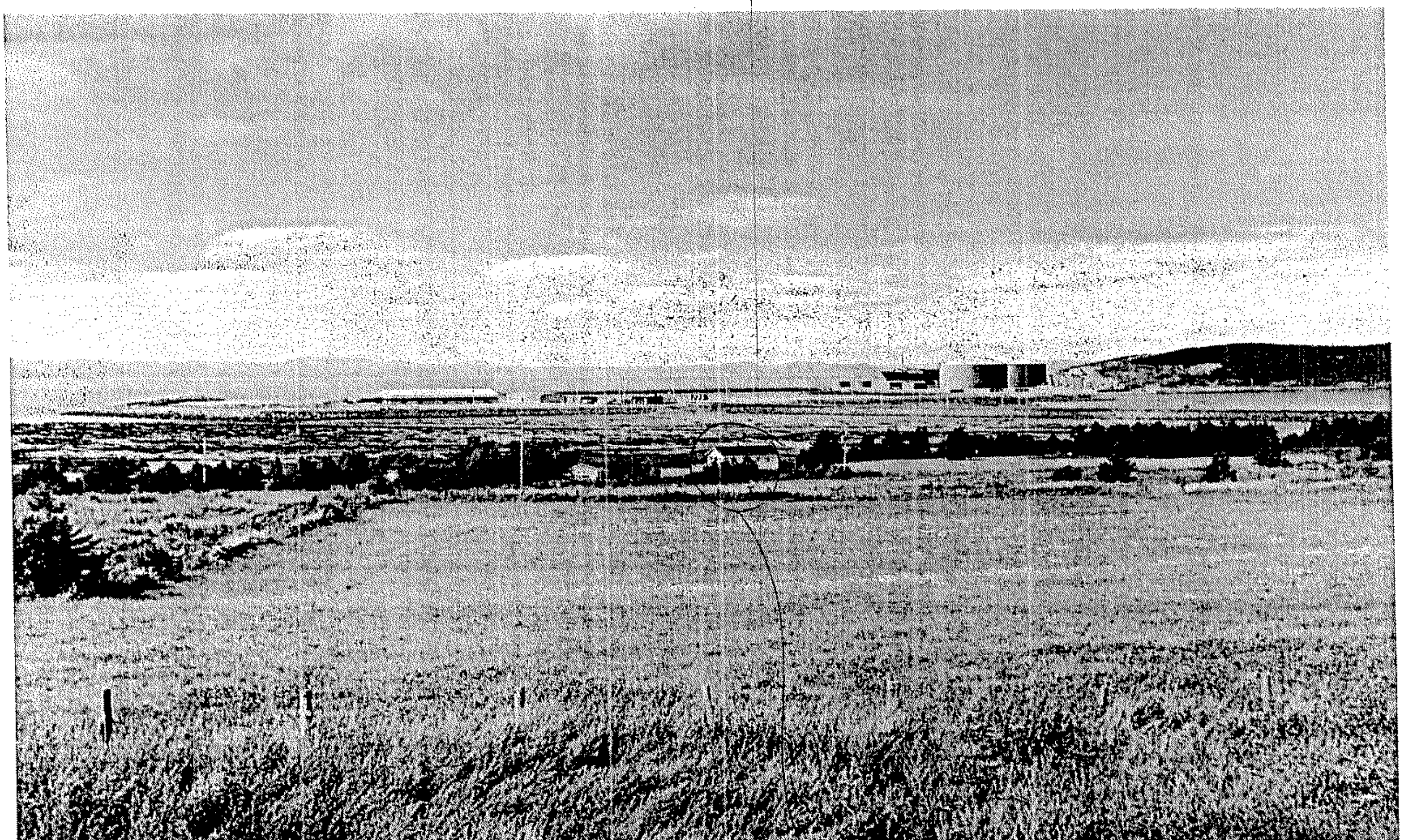

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Closest home. 1500 m from tanks
>2050 m from ier.

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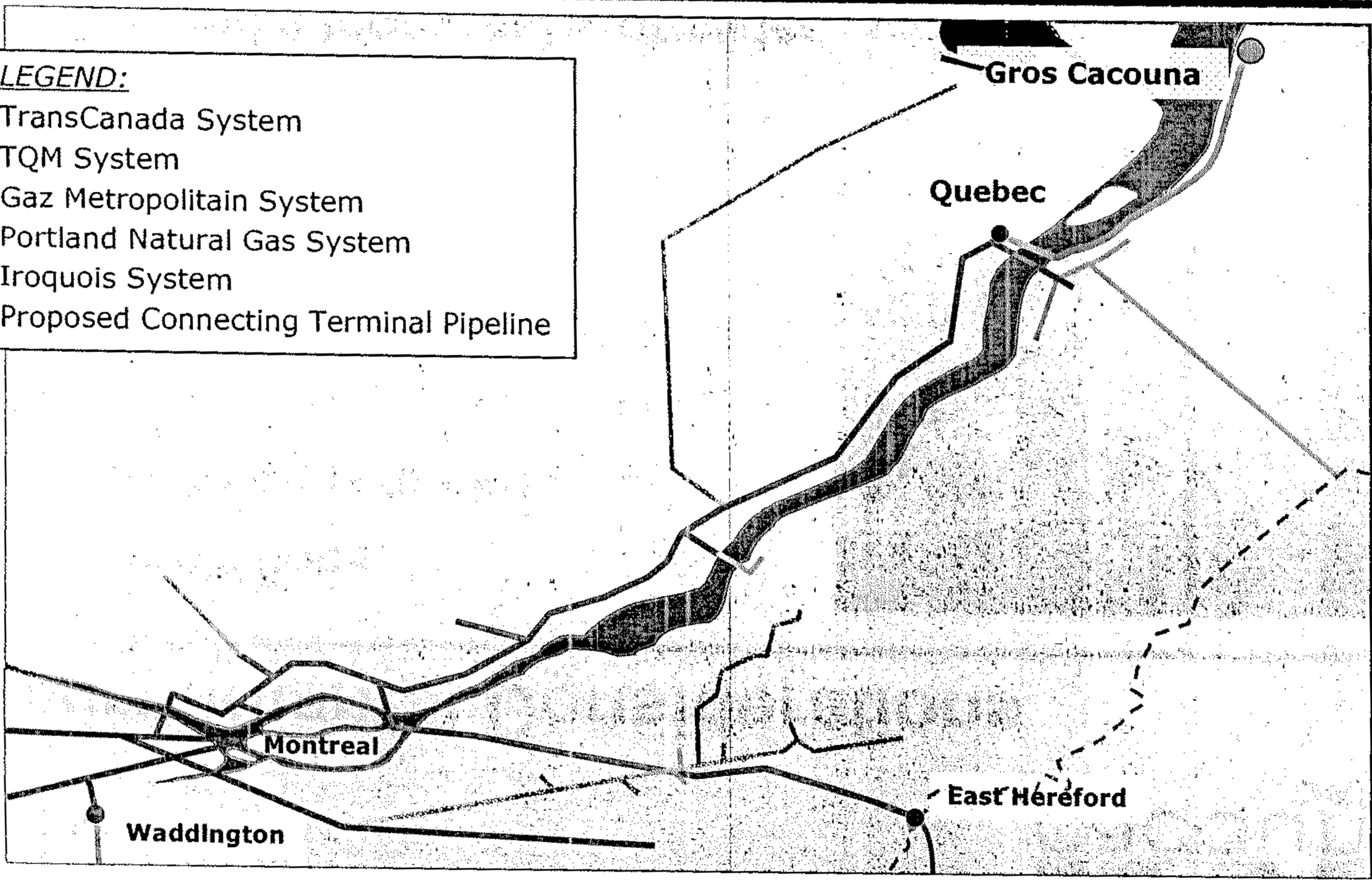
# Natural Gas Access to Market

*LEGEND:*

- TransCanada System
- TQM System
- Gaz Metropolitain System
- Portland Natural Gas System
- Iroquois System
- Proposed Connecting Terminal Pipeline



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# Environmental Considerations

- Low emissions
- No dredging required
- Minimal increase in maritime traffic (45 to 65 carrier visits per year)
- No subsea pipeline
- Compatible land use
- The island's topography provides a barrier between the proposed terminal and the marsh

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# Economic Benefits

Impacts économiques dans le Bas-Saint-Laurent, au Québec et au Canada

| | Bas-Saint-Laurent | Québec (incluant Bas-Saint-Laurent) | Gouvernement fédéral |
|---|---|---|---|
| **Phase de construction** | | | |
| PIB (millions $) | 134 | 236,6 | non disponible |
| Emplois directs | 1965 | 1965 | non disponible |
| Emplois indirects | 725 | 1730 | non disponible |
| Revenus en taxes et impôts (millions $) | non disponible | 16,7 | 11,9 |
| **Phase d'exploitation** | | | |
| PIB (millions $) | 18 | 21,3 | non disponible |
| Emplois directs | 35 | 35 | non disponible |
| Emplois indirects | 11 | 73 | non disponible |
| Revenus en taxes et impôts (millions $) | non disponible | 0,9 | 0,5 |

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# Regulatory Process

- Québec Environmental Review Process
  - Project Notice filed with the MENV on Sept. 13, 2004 and Project Directive issued by the MENV on Oct. 13, 2004
  - Environmental Impact Assessment filed in May, 2005
  - BAPE hearings anticipated in the first quarter of 2006
- Canadian Environmental Assessment Agency (CEAA) Review
  - Project Description filed with CEAA on Sept. 13, 2004
  - Panel Review decision issued August 18, 2005
- Project subject to formal approval under the Navigable Waters Protection Act
  - Marine terminal technical review process (TERMPOL)

# Public Consultation Process

- The community is the project's third partner
- Open houses were held on Oct. 5th & 7th of 2004, January 26th, April 14th & 15th, and June 15nd of 2005
- Pre-consultation process with workshops held on January 25th, March 16th , April 13th, June 1st , and July 4th of 2005
- Town Hall meeting in Cacouna on June 13th of 2005
- A project website is available
  - www.energiecacouna.ca
- The project has a toll-free number (1 877 744-2113) and an e-mail address (info@energiecacouna.ca)

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# LNG - An Exemplary Safety Record

- 45 Years of safe transportation of LNG on the water
  - 40,000 voyages over more than 100 million kilometres without a major incident
  - Only two serious groundings and no loss of cargo
- Over 60 years of safe operations in LNG facilities
  - Only 5 serious accidents (3 in the U.S., 1 in the U.K., and 1 in Algeria)
  - Last serious accident in an LNG terminal was in 1979 at Cove Point
  - Last LNG facility accident affecting the public was in 1944 in Cleveland, Ohio

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# Separation Distances and Land Requirements

- Terminal site footprint determined by facilities layout requirements
- Terminal zone of control  to encompass exclusion zones per CSA Z-276
- Overall zone of control encompassing trestle and dock specified by:
  - CSA Z-276
  - Cacouna Energy for security purposes
  - Canadian Coast Guard (TERMPOL process)
- Temporary work space during construction to be identified by Cacouna Energy

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# CSA Z-276 Standard

- CSA standard for LNG production, storage, and handling
  - First published in 1972; current revision published in 2001
  - Next revision expected by late 2006; will harmonize with new version of NFPA 59A being issued in the Fall of 2005
    - Public review period in November/December 2005
- Technical Committee membership includes regulators (incl. NEB), operators (incl. TC), suppliers, and service providers
- Standard specifies definition of exclusion zones for LNG facilities
- The determination of exclusion zones is based on credible worst-case scenarios
- The size of each exclusion zone is site-specific

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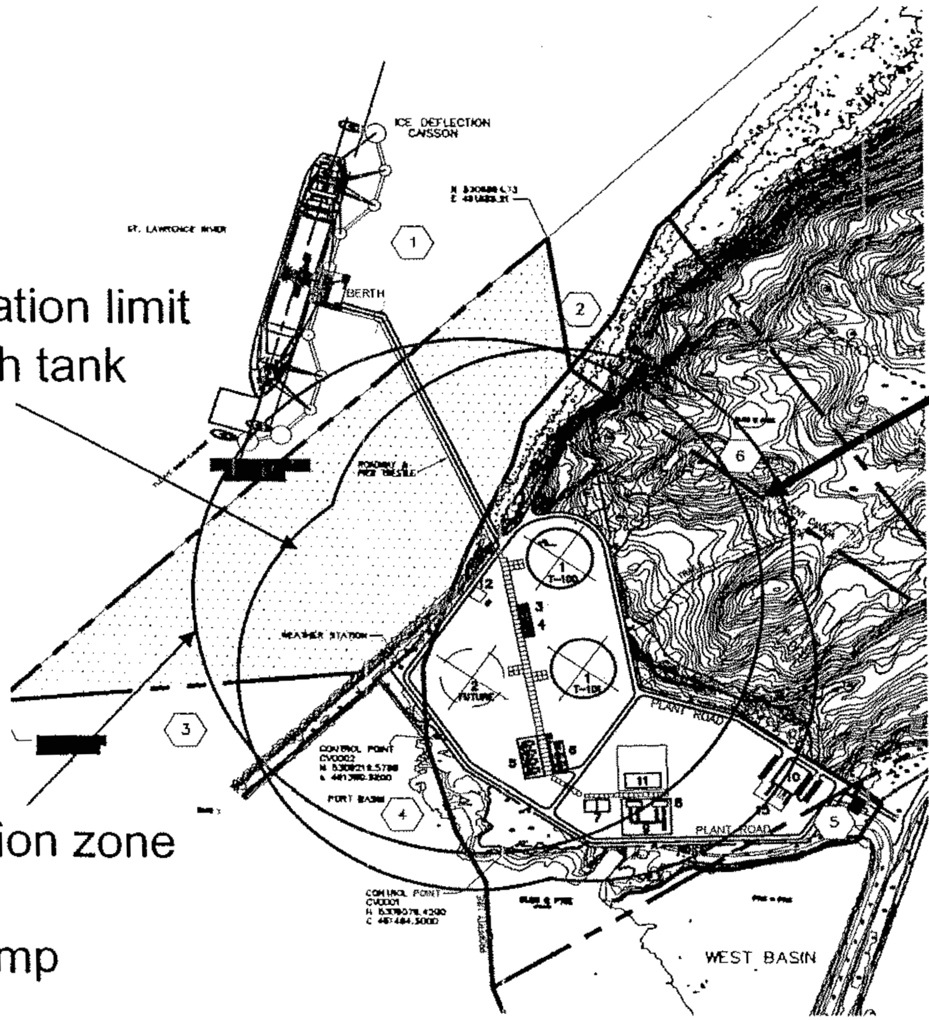
# Terminal Zone of Control

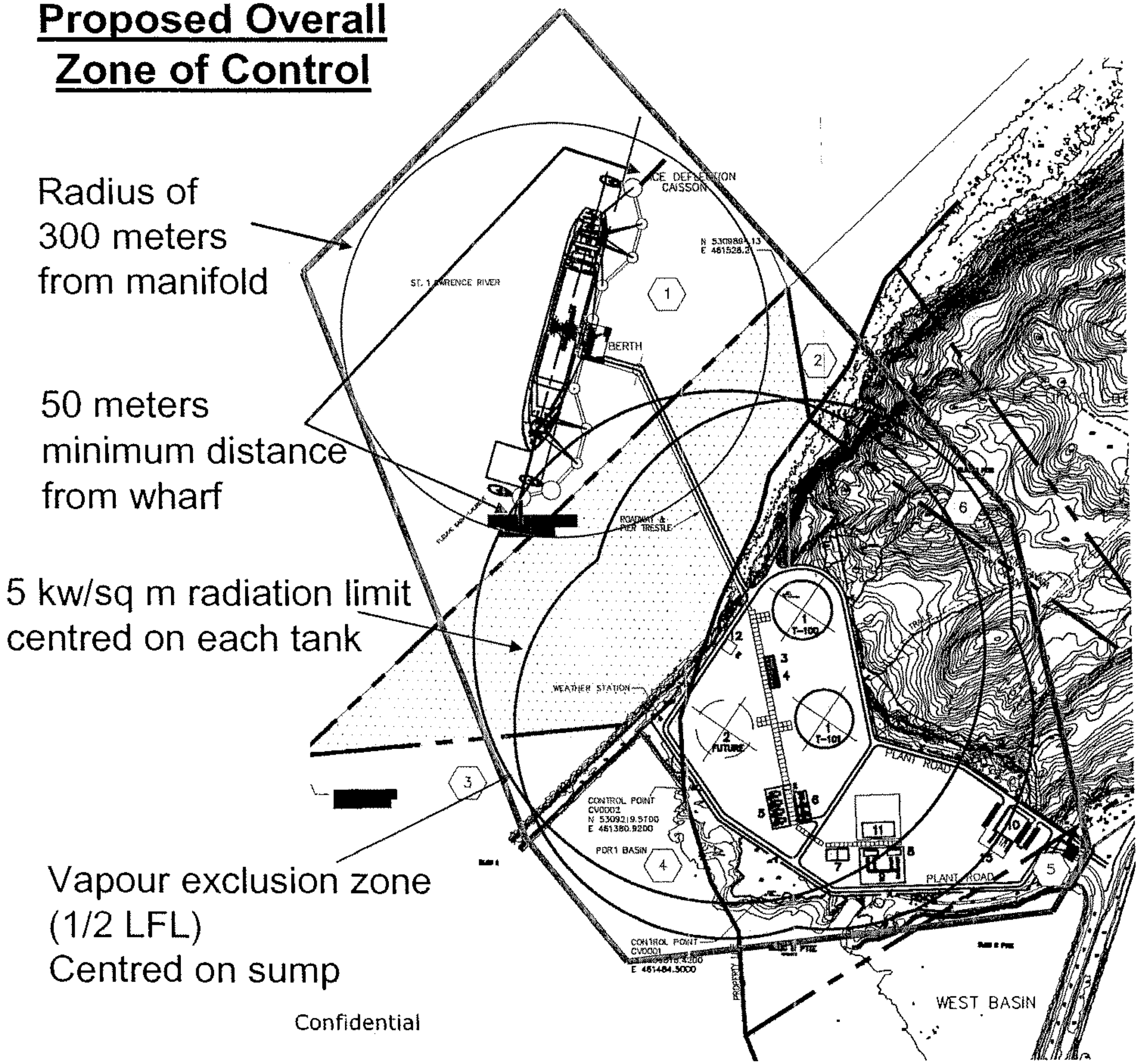
5 kw/sq m radiation limit centred on each tank (284 m radius)

Transport Canada/ Environment Canada Boundary



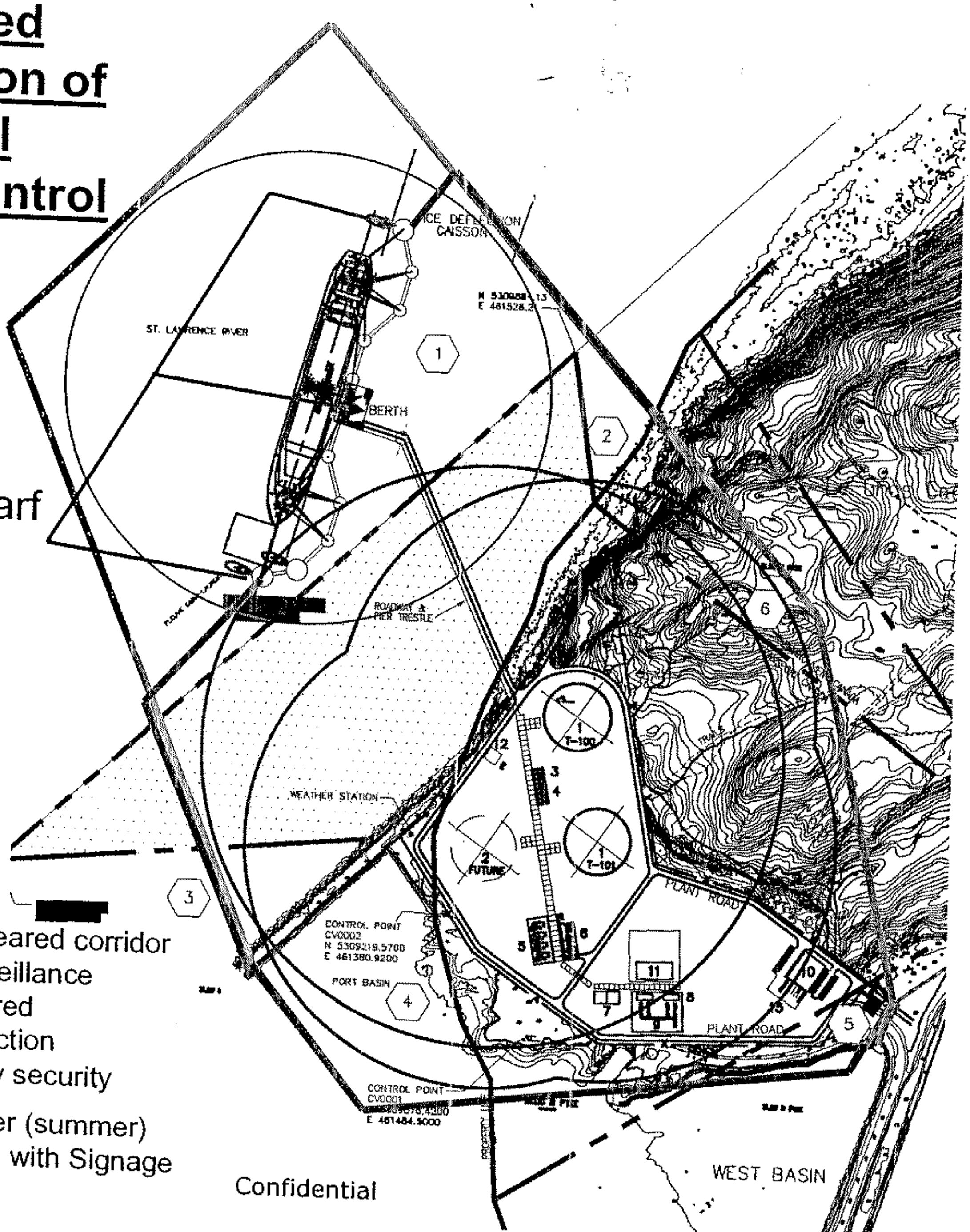

Vapour exclusion zone (1/2 LFL)
Centred on sump
(346 m radius)

# Proposed Overall Zone of Control



# Proposed Demarcation of Overall Zone of Control

Signage on wharf warning of exclusion zone




Fence with cleared corridor for video surveillance and / or infrared intrusion detection and access by security

Floating Barrier (summer) and / or buoys with Signage

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# Quantitative Risk Assessment

- Assess probabilities and consequences associated with wide variety of potential incident scenarios
- Comply with safety standards established by the responsible provincial and federal government agencies and international safety standards societies
- Develop emergency response plans to ensure public safety and prevent damages in the event of an incident

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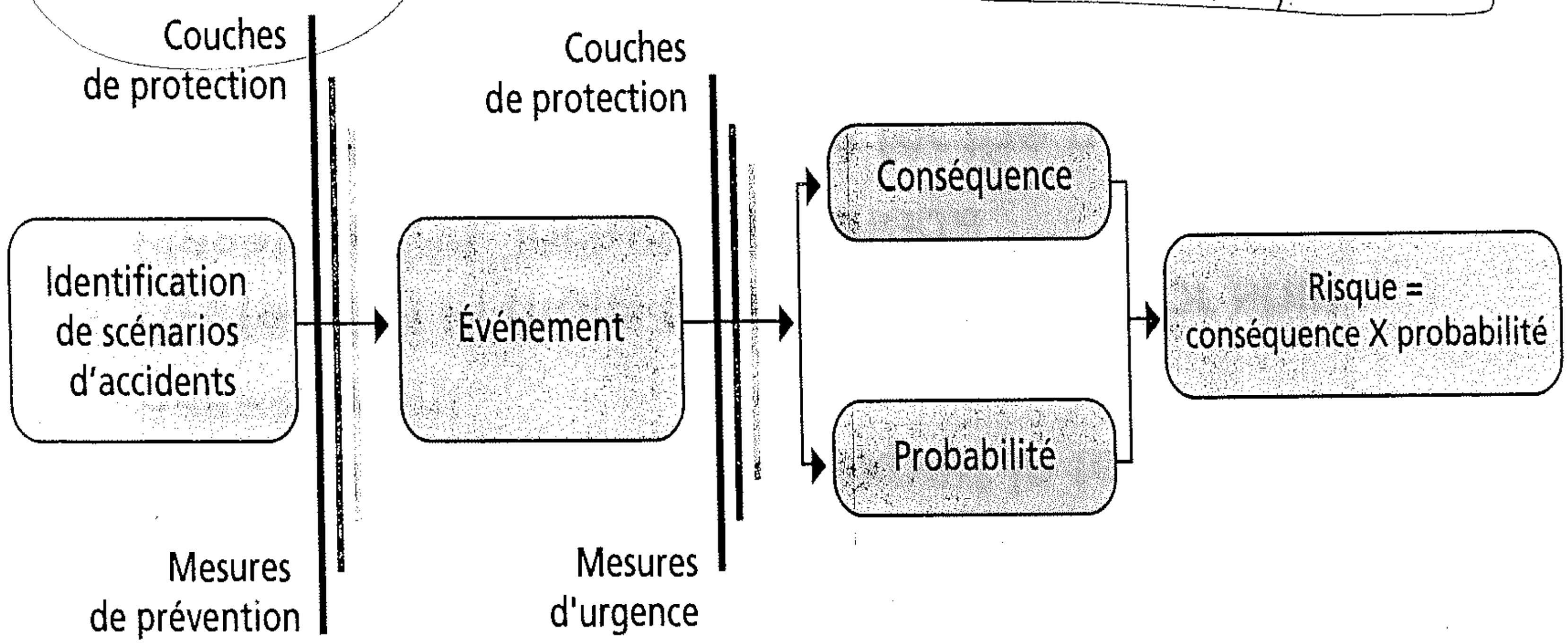
# DNV Selected to Conduct QRA

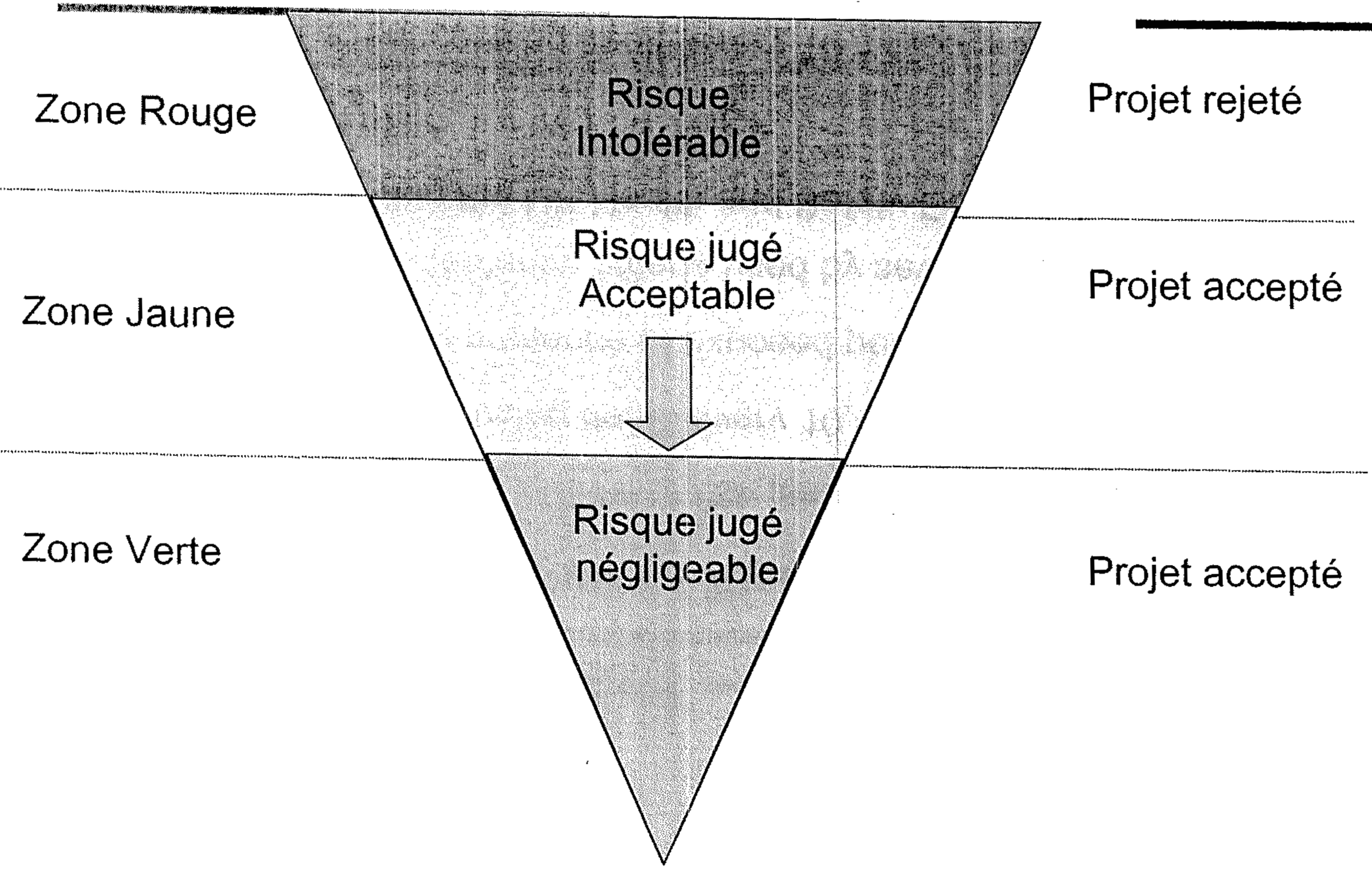
- World class independent expert in technological risk assessment
- Accredited in more than 80 countries for ship classification, including Canada
- Involved in risk evaluations for the natural gas industry for more than 50 years
- In recent years, performed risk assessments for about 10 North American LNG terminal development projects
- In 2004 was recognized by Lloyd's List as « Best Ship Classification Society in the World »

# Risk Assessment - Methodology

Should be in Environmental Impact Study



# Risk Assessment – Levels of Risk

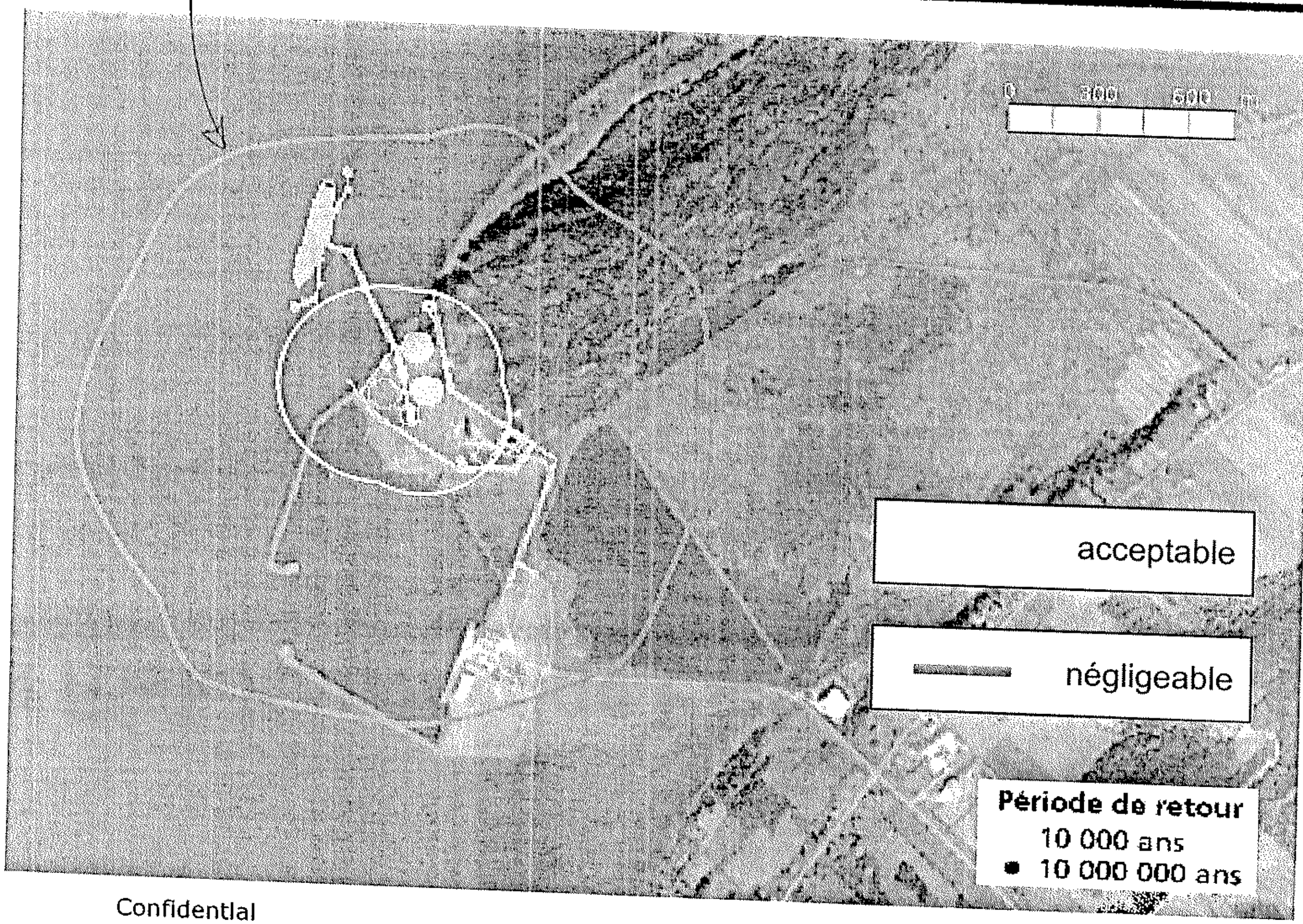


# Risk Assessment – Levels of Risk

- Acceptable Level of Risk
  - No increase in level of risk people accept in their daily lives
  - 1 event causing death every 10,000 years
  - Assumes presence of exposed personnel 100% of time
  - Risk acceptance criteria used by several authorities worldwide, including the UK Health and Safety Executive Board
- Negligible Level of Risk
  - 1 event causing death every 10 million years
  - Criteria used by the most stringent of authorities (e.g. Santa Barbara County, California)
    - UK HSE uses return period of 1 million years

# Risk Assessment - Results

Composite risk contours, built from many different scenarios.

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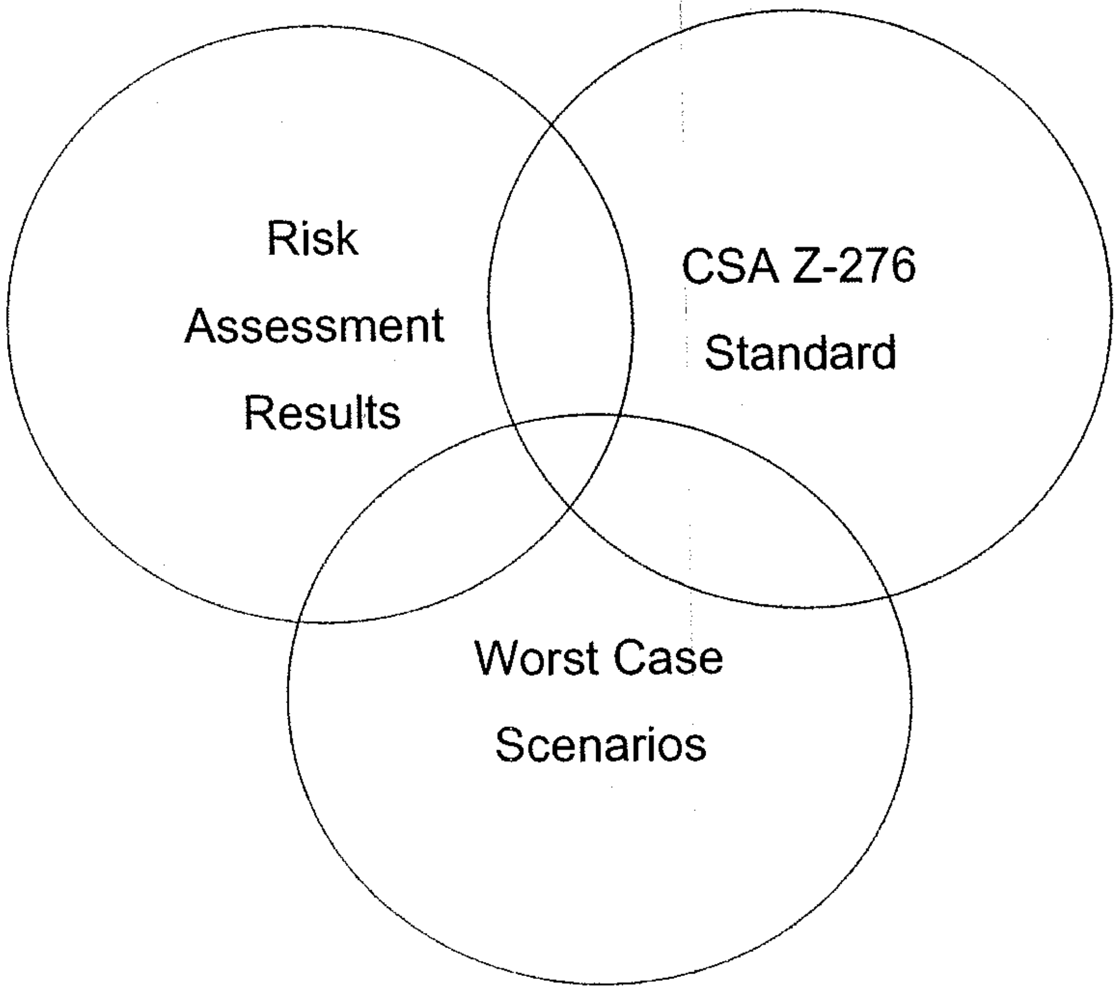
# The Risk Knowledge Picture



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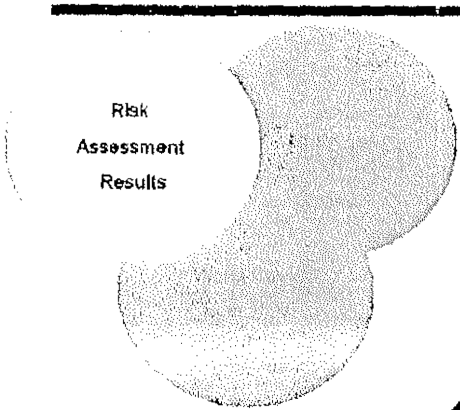
# Risk Assessment Results

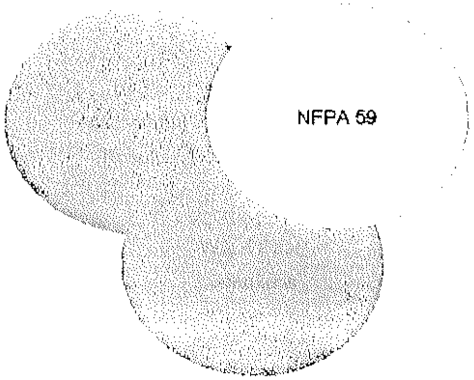


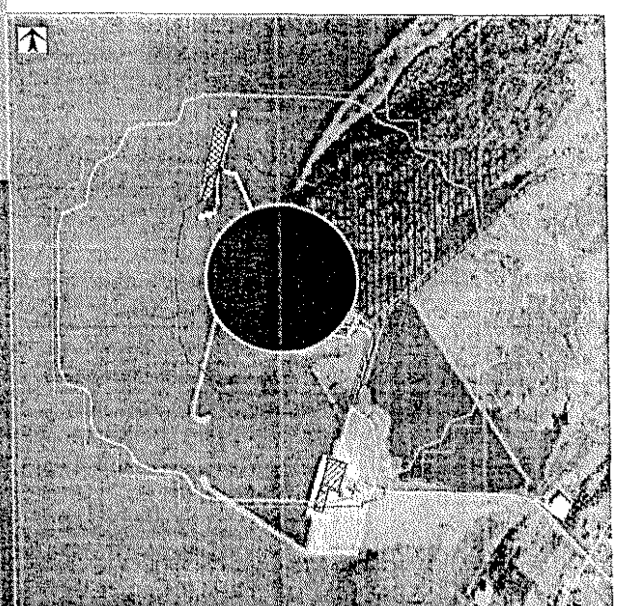

- Tell if risk posed by terminal to public is acceptable.
- Rank the risks to enable prioritized risk mitigation.
- The $10^{-4}$ risk contour: allows public access
- The $10^{-5}$ risk contour: allows public residential
- The $10^{-6}$ risk contour: allows dense public population
- The $10^{-7}$ risk contour: negligible risk

Worst case scenarios can impact the negligible risk area.

CSA Z-276 will not impact areas with public access → Exclusion zone

# The CSA Z-276 Requirement



- Dictates exclusion zones based on a pre-defined set of severe accident scenarios.
- Not meant to eliminate public risk but meant to reduce public risk to an acceptable level.
- Worker risk is acceptable inside the $10^{-4}$ contour
- The exclusion zone defined by CSA Z-276 is sufficient if it covers the $10^{-4}$ contour.
- It is not required to introduce exclusion zones to protect public from the terminal beyond the CSA Z-276 requirements.
- There may be reasons to introduce exclusion zones around the LNG Carrier to avoid operational disturbances and accidents caused by unauthorized personnel.

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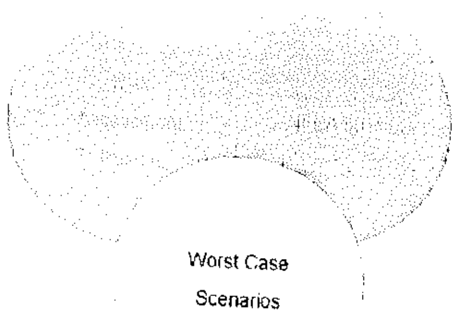
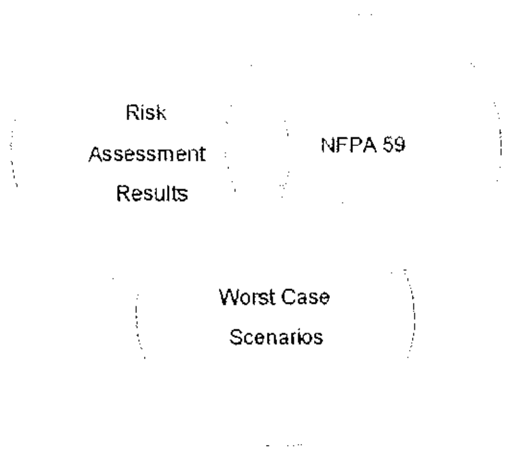
# Worst Case Scenario Knowledge




- Worst case scenario knowledge is coming from the risk assessment which includes all controllable and not controllable accidents.
- A worst case scenario can in principle impact densely populated areas and still pose acceptable risk if the probability is sufficiently low. An example would be an airplane crashing into a city.
- Worst case scenario knowledge shall be used for emergency response purposes:
  - Evacuation plans
  - Alert plans
  - Large scale accident risk reduction
- Worst case scenario hazard zones must not be confused with exclusion zones.

# The overlap




- Scenarios defined by CSA Z-276 and worst case scenarios are included in the risk assessment.
- The risk assessment comprise all accident scenarios beyond CSA Z-276 and worst case scenarios.
- The CSA Z-276 scenarios enforce the exclusion zone and thereby public risk exposure.
- Worst case scenarios are negligible meaning that an exclusion zone enforcing personnel to keep out from any remote but potential hazard zone will have negligible risk reduction impact.

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# Multiple Layers of Protection

## Land-based Facilities:

- Full-containment LNG storage tanks
- Leak detection and mitigation
- Exclusion zones

## LNG carriers:

- Double-hulled design
- Double-walled LNG storage tanks
- Ice reinforcement
- Closest point of approach designation around carriers

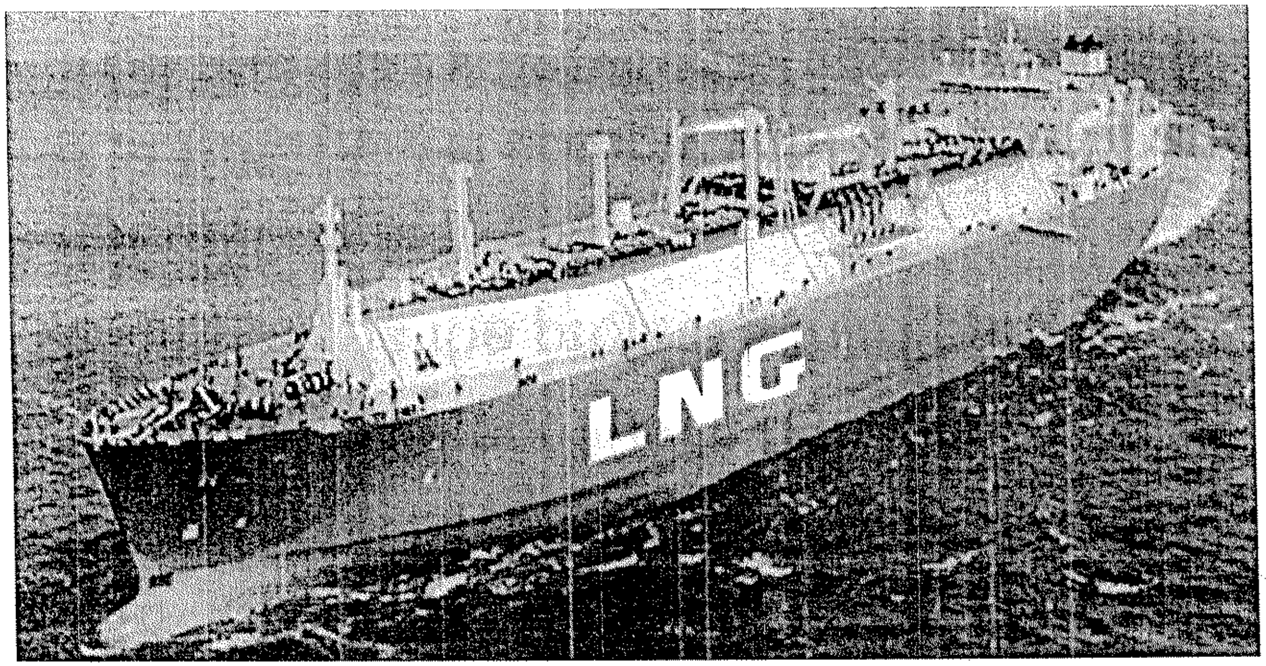
# Prevention and Mitigation Measures

- Prevention
  - Stringent internal safety policies
  - Government regulations
  - Site access control
- Mitigation
  - Incident detection and alarm systems
  - Safety equipment inspection program
  - Site personnel trained in emergency response
  - Emergency response plans
  - Emergency shutdown systems
  - Coordination with municipal emergency response resources

# Summary

- Gros-Cacouna is the ideal site for an LNG terminal on the St. Lawrence River
- Significant regional economic benefits
- The community is the project's third partner
- LNG operations are safe
- Cacouna Energy will comply with all federal and provincial regulatory requirements

# Thankyou

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# APPENDIX C: QUESTIONS FROM NATURAL RESOURCES TO CACOUNA ENERGY AND ANSWERS IN THE FORM OF A PRESENTATION FROM DNV TO NATURAL RESOURCES CANADA, 22 NOVEMBER 2005

## Lightfoot, Phil

**From:** Lightfoot, Phil
**Sent:** Thursday, September 22, 2005 2:39 PM
**To:** Vincent Jarry (E-mail)
**Cc:** Von Rosen, Bert; Buszard, John; Kwamena, Felix
**Subject:** Further information requested from Cacouna Energy

Vincent,

As agreed, we have carried out a preliminary review of the technical risk assessment provided by Cacouna Energy, with an aim to identifying any further information that we think we need to provide a detailed review. A list of information we would like follows. Some of the information is available in French on the Cacouna Energy website, but it would really speed things up if we could have English versions, as most of our technical staff are not bilingual. If English versions are not available, we will manage, but it might be a bit slow.

English versions needed of:

- Appendix X of the Environmental Impact Assessment (Feuilles de travail d'identification des dangers)
- Appendix XI of the Environmental Impact Assessment (Scénarios d'accidents)
- Appendix XII of the Environmental Impact Assessment (Fréquence des scénarios d'accidents)
- Project description (Section 2 of the Environmental Impact Assessment)

Any information on the following would be helpful:

- Consideration of threats from terrorist activities
- How safety zones would be enforced
- Security around the terminal either on the water or on land
- More detail on the proposed layout of the site and how everything fits together, such as a P&ID, a detailed site plan, or a flow diagram
- Consideration of snowmobile routes
- Are there any flare systems or gas release systems except for the condenser to collect leaks and evaporation?

As the point of contact with Cacouna Energy, could you please pass this request to them.

As mentioned, this is just a preliminary request for additional information. We already have number of detailed questions about how the study was done and the assumptions made. Some of the questions might be answered once we receive the additional information, but others will no doubt come up. We will meet early next week to compile the questions that have arisen already, at which point we could pass them on the Cacouna Energy, on the understanding that there will probably be more.

Thanks,

Phil

Dr. Phil Lightfoot
Manager, Canadian Explosives Research Laboratory
Explosives Branch, Natural Resources Canada
555 Booth Street, Ottawa, Ontario, Canada K1A 0G1
Tel: 613-947-7534, Fax: 613-995-1230
email: plightfo@nrcan.gc.ca

## Lightfoot, Phil

**From:** Lightfoot, Phil
**Sent:** Monday, September 26, 2005 5:02 PM
**To:** Vincent Jarry (E-mail)
**Cc:** Von Rosen, Bert; Buszard, John; Kwamena, Felix
**Subject:** Questions on Cacouna Energy Risk Assessment

Vincent,

To follow up on my email of last week, we now have a detailed list of questions for Cacouna Energy about how their risk assessment was done. The additional information we asked for last week may answer some of these questions and raise others. We decided to send the questions now and not wait for the additional information so that we could keep things moving along.

Could you please pass these questions along to Cacouna Energy. They could reply by email, or we could set up a meeting in Ottawa in mid-October, as originally planned when we visited Gros-Cacouna.

In addition to the questions on the details of the risk assessment, we realised that there were a couple of pieces of information that we forgot to ask for last week. They are detailed below.

**Further information we seek**

- The Emergency Response Plan. This is mentioned in the risk assessment, but not detailed. Apparently it was to form part of the TERMPOL submission that you should have by now (I think).
- Appendix XIII Conséquences des scénarios d'accidents (in English)

**Questions and comments on risk assessment**

The page numbers below refer to the English version of the technical risk assessment.

- Frequency analysis. We have a number of related questions in this area. Most importantly, it is not obvious to us that frequency modifiers used have not been double-counted. For example, on 9-38, the risk of LNG release following a collision of a LNG tanker with an errant vessel is reduced by 50%, as tug boats would always be present. It is not clear that the base frequency for ship-to-ship collisions was not calculated on global statistics where tug boats may well have been present anyway. There are five similar examples on 9-39 and 9-40. For example, it is claimed that the crew would be able to avoid a collision in 70% of cases by "last minute actions..". We assume that the crews of every vessel would do their best to avoid a collision and that such behaviour should be already accounted for in the base collision frequency. The frequency modifiers are generally attributed to internal DNV numbers. We would like to know how these numbers can be justified and how the effects of tugs, emergency action and equipment to control speed can be separated out. Changing the frequency modifiers significantly could affect the risk contours for the project.
- On 9-44, the frequency for LNG spills seems low compared to crude oil and other chemicals. Could this be related to the volatility of LNG i.e. a lot of spills don't get reported because they don't last?
- 9-45. Does the base leak frequency include the acts of connecting and disconnecting the loading arms, or just when LNG is flowing?
- 9-48. Leakage of LNG into the secondary containment of the storage tanks has been considered, as has a subsequent fire. Has explosion in the confined space between the inner and outer walls been considered?
- The results of the consequence analysis (9-53 onwards) are consistent with other studies carried out by Sandia Laboratories and ABS Consulting. However, the worst-case scenario (9-61) is different in that the maximum LNG release rate from the carrier vessel is based on an accidental breach of the vessel, whereas the Sandia study uses a deliberate attack as a worst-case scenario, leading to a much larger LNG release rate and a vapour cloud that could reach the village of Gros-Cacouna. The risk assessment does not address deliberate attack on the carrier or the terminal. Has deliberate attack been considered by Energy Cacouna?
- 9-61. Where do the numbers for the effects of heat radiation come from? Which number was used for the risk calculations? If 37.5 kW/m2 (immediate fatality) were used, this might not be conservative. Lower levels could lead to fatalities, dependent on the exposure. The use of 5.4 kW/m2 (escape should always be possible) would be conservative.

  In general terms, what happens to the LNG that evaporates? Where does it go under normal operating conditions? Where does it go if the pipeline is not operational?
- What would happen if a ship were not available for a long period of time e.g. a few weeks? There will no doubt be

Standard Operating Procedures (SOP) which forbid docking operations in foul weather. However, what happens if there is a week of foul weather starting just when a shipment is expected. Will there be pressure to disregard SOP after 5 days because of a shortage of LNG? Can the system be closed down and started up again without much difficulty?

- How is the sump kept clear of snow, ice, water and other things that might reduce its volume?
- There is a lot of snow and ice around Gros-Cacouna in the winter. Do Energy Cacouna know how LNG spills on ice would behave?
- We are concerned about the individual risk estimates on 9-66. For example, the individual risk for the process areas is 1x10-3 per year, which is at the limit of what is tolerable for worker safety according to the UK HSE. This means that there is no room for error in the frequency calculations, which are notoriously difficult to calculate with any accuracy. We like to see at least an order of magnitude better than "intolerable". For example, the explosives industry works towards an individual risk of 2x10-5 per year i.e. a factor of 50 lower. Our question here is whether an individual risk of 1x10-3 is unusual for the LNG industry. We would also comment that, in our experience, it is often suspicious when the sum of the risks add up to exactly the "tolerable" limit. The maximum public risk is calculated to be 3x10-5. This is close to the "intolerable" limit of 1x10-4, so the same comments apply as to the low margin of error required for the calculations.

Yours,

Phil

Dr. Phil Lightfoot
Manager, Canadian Explosives Research Laboratory
Explosives Branch, Natural Resources Canada
555 Booth Street, Ottawa, Ontario, Canada K1A 0G1
Tel: 613-947-7534, Fax: 613-995-1230
email: plightfo@nrcan.gc.ca

(phi)

MANAGING RISK DNV

# Response to NRCAN Queries

## Cacouna Energy LNG Terminal

Ernst Meyer, Det Norske Veritas
22. November, 2005

# Background

MANAGING RISK DNV

- Queries from Dr. Lightfoot in e-mail dated September 26th, 2005 from NRCAN to TransCanada.
- Queries divided into 15 questions by DNV in order to achieve distinct addressability.
- Answers have been provided to each question and given on dedicated slides
- Answers are mostly provided by DNV
- DNV conducted the Risk Assessment presented in Section 9 of the EIS.

Internal DNV stats.
Some purchased from Lloyds.
Not in public domain

# 1 - Frequency Discounting I

MANAGING RISK DNV

| Q1 | On page 9-38, the risk of LNG release following a collision of a LNG tanker with an errant vessel is reduced by 50%, as tug boats would always be present. It is not clear that the base frequency for ship-to-ship collisions was not calculated on global statistics where tug boats may well have been present anyway. |
|---|---|
| **A1** | Failure frequency is estimated from generic statistics. Failures may be wrong course due to human factors, engine break-down or rudder failure. Its only the initiating event which are derived from statistics.<br>The frequency of LNG release is estimated by combining the frequency of failure with the probability of all conditions necessary to cause release of LNG. Examples are:<br>- Wrong course must be collision course<br>- Failure is not corrected before collision occur<br>- Local specific safeguards such as tugs has to fail<br>- Cargo tank has to be hit with sufficient energy |

# 2 - Frequency Discounting II

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| Q2 | There are five similar examples on 9-39 and 9-40. For example, it is claimed that the crew would be able to avoid a collision in 70% of cases by "last minute actions..". We assume that the crews of every vessel would do their best to avoid a collision and that such behavior should be already accounted for in the base collision frequency. |
|---|---|
| A2 | The same principles apply as for the effect of tugs. Reference is hence made to previous slide for explanation. |

# 3 - Justification of conditional probabilities

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**Q3**

The frequency modifiers are generally attributed to internal DNV numbers. We would like to know how these numbers can be justified and how the effects of tugs, emergency action and equipment to control speed can be separated out.

**A3**

Conditional probabilities are hard to prove in exact terms but are known to have effect. The principles behind a risk analysis is to attribute conservative numbers to probabilities that can not be documented with basis in data of statistical significance. DNV has performed a high number of similar risk assessments and has gathered probability numbers by interviewing operational personnel in various ports. DNV has guidelines that ensure consistent attribution of numbers. However, specific parameters apply for each project requiring individual judgments. For example, the probability of a successful emergency anchoring procedure is dependent on speed, water depth and bottom conditions which may vary significantly between locations.



[Numbers depend on local conditions — judgement call.]

Again DNV numbers

# 4 – Parameter sensitivities



| Q4 | Changing the frequency modifiers significantly could affect the risk contours for the project. |
|---|---|

| A4 | Use of conditional probabilities to estimate the frequency of an end event following an initial event can have significant impact on the numbers. DNV has therefore applied conservative numbers.<br><br>However, it should be noted that release frequencies will remain in the negligible risk region even if the conditional probabilities are reduced significantly. In other words, the numbers may change significantly but not the conclusions. DNV is of the opinion that the estimated risk numbers are conservative and the conclusions that can be drawn are robust. |
|---|---|

# 5 - LNG spills versus oil spills

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**Q5**

On 9-44, the frequency for LNG spills seems low compared to crude oil and other chemicals. Could this be related to the volatility of LNG i.e. a lot of spills don't get reported because they don't last?

**A5**

Standard of technical conditions, equipment and crew associated with crude oil and chemical tankers are in average of lower standard than for LPG and LNG Carriers. This could explain the difference.

There have been very few incidents where LNG has been spilled. The LNG industry has also in fact a better reporting record than conventional crude oil and chemical industries. The diversity in standard and quality is much more appear ant for oil and chemical terminals.

However, the reporting culture has improved for all industry segments over the last 5-10 years.

# 6 - Loading arm leaks



| | |
|---|---|
| Q6 | Does the base leak frequency include the acts of connecting and disconnecting the loading arms, or just when LNG is flowing? |
| A6 | The base leak frequency includes the connection and disconnections phases. |

# 7 - LNG Carrier explosion

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Q7

Leakage of LNG into the secondary containment of the storage tanks has been considered, as has a subsequent fire. Has explosion in the confined space between the inner and outer walls been considered?

A7

Yes, explosion has been considered. It would require an internal leak and presence of at least 85% air in the secondary containment area. This area is inerted and monitored at all times. The scenario has never occurred and would require:

1) long lasting undetected failure of the inert system allowing sufficient amount of air to migrate into the space, followed by
2) a significant leak of gas from cargo tank to same space, followed by
3) ignition in a space without ignition sources

The event tree developed for this scenario shows negligible risk.

# 8 – Deliberate attacks



| | |
|---|---|
| Q8 | The results of the consequence analysis (9-53 onwards) are consistent with other studies carried out by Sandia Laboratories and ABS Consulting. However, the worst-case scenario (9-61) is different in that the maximum LNG release rate from the carrier vessel is based on an accidental breach of the vessel, whereas the Sandia study uses a deliberate attack as a worst-case scenario, leading to a much larger LNG release rate and a vapour cloud that could reach the village of Gros-Cacouna. The risk assessment does not address deliberate attack on the carrier or the terminal. Has deliberate attack been considered by Energy Cacouna? |
| A8 | Deliberate attacks has not been considered by Energy Cacouna. However, the applied release rate is in accordance with what DNV reported to be worst case from intentional acts in their Marine Consequence assessment which is referenced in the EIS. In addition, due to prevailing wind directions, it should be noticed that the Village of Cacouna would be exposed to only 7% of such accident scenarios. In addition, the scenario would require ideal atmospheric stability conditions which are rare (3% of the time) to have such potential in dispersion ranges. |

# 9 – Heat radiation

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Q9

Where do the numbers for the effects of heat radiation come from? Which number was used for the risk calculations? If 37.5 kW/m² (immediate fatality) were used, this might not be conservative. Lower levels could lead to fatalities, dependent on the exposure. The use of 5.4 kW/m² (escape should always be possible) would be conservative.

A9

A single fatality criteria is used in the risk analysis and is 12.5 kW/m². It is conservatively assumed that fatality rate of personnel within this radiation contour is 100%. No fatalities are counted outside this contour which may be optimistic. However, conservative effect will supersede optimistic effects by far and ensure an overall conservative result.

The 12.5 kW/m² criteria is the default criteria applied in SAFETI which is the consequence tool used in the risk assessment.

# 10 - Operational LNG evaporation

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| | |
|---|---|
| Q10 | In general terms, what happens to the LNG that evaporates? Where does it go under normal operating conditions? Where does it go if the pipeline is not operational? What would happen if a ship were not available for a long period of time e.g. a few weeks? |
| A10 | Under normal operating conditions, LNG, in liquid state, is pumped at pipeline pressure to the vaporizers. The vaporizers add sufficient heat to convert the LNG from a liquid to gaseous state. From the vaporizers, the gas flows directly into the pipeline.<br><br>If the pipeline is not operational, the LNG pumps and vaporizers are shutdown.<br><br>Reference is made to next slide with regard to shipping delays. |

# 11 - Terminal shut-down

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**Q11** There will no doubt be Standard Operating Procedures (SOP) which forbid docking operations in foul weather. However, what happens if there is a week of foul weather starting just when a shipment is expected. Will there be pressure to disregard SOP after 5 days because of a shortage of LNG? Can the system be closed down and started up again without much difficulty?

**A11** The flow to the pipeline can be maintained at lower rates as needed until the next cargo arrives. If needed, the system can be shut down and started up again without much difficulty.

Such a significant delay in the arrival of a ship, however, would be extremely rare. The shipper would likely divert a cargo from another source to meet its market obligations at Gros-Cacouna if the scheduled cargo were delayed for a significant period of time.

The storage tanks would typically have 6-7 days of buffer LNG inventory available to bridge a significant delay in the arrival of the next cargo.

# 12 - Sump maintenance



| | |
|---|---|
| Q12 | How is the sump kept clear of snow, ice, water and other things that might reduce its volume? |
| A12 | Snow and ice will be melted with heat tracing and pumped outside the sump. Rain water will be pumped by the same pumping system. These systems are automatically shutdown when LNG release is detected. |

# 13 - LNG spill on ice



| | |
|---|---|
| Q13 | There is a lot of snow and ice around Gros-Cacouna in the winter. Do Energy Cacouna know how LNG spills on ice would behave? |
| A13 | A spill on ice will evaporate similar spills on other surfaces. A vapor cloud may travel farther on ice due to less roughness. |

# 14 - Worker risk



| | |
|---|---|
| Q14 | We are concerned about the individual risk estimates on 9-66. For example, the individual risk for the process areas is $1\times10^{-3}$ per year, which is at the limit of what is tolerable for worker safety according to the UK HSE. This means that there is no room for error in the frequency calculations, which are notoriously difficult to calculate with any accuracy. We like to see at least an order of magnitude better than "intolerable". For example, the explosives industry works towards an individual risk of $2\times10^{-5}$ per year i.e. a factor of 50 lower. Our question here is whether an individual risk of $1\times10^{-3}$ is unusual for the LNG industry. We would also comment that, in our experience, it is often suspicious when the sum of the risks add up to exactly the "tolerable" limit. |
| A14 | The values are maximum individual risk meaning 100% presence time. The number should approach $1 \times 10^{-4}$ if presence time is considered. The estimated number is typical for a process area and in line with other risk analyses DNV has carried out for LNG import terminals.<br><br>DNV is never adjusting numbers to acceptance criteria. However, as a principle conservatism is used when input is uncertain. All numbers presented in the EIS are therefore conservative. |

# 15 - Public risk

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Q15

The maximum public risk is calculated to be $3x10^{-5}$. This is close to the "intolerable" limit of $1x10^{-4}$, so the same comments apply as to the low margin of error required for the calculations.

A15

DNV is of the opinion that there is significant difference between the individual risk numbers $3x10^{-5}$ and $1x10^{-4}$ . As for the previous question, the number is the maximum individual risk assuming 100% presence time. An average person would typically spend less than 1% of his time at this location unless he is a very frequent user. Most individuals using the trials would therefore have exposures in the $10^{-5}$ and $10^{-6}$ region.

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## APPENDIX C: QUESTIONS FROM NATURAL RESOURCES TO CACOUNA ENERGY AND ANSWERS IN THE FORM OF A PRESENTATION FROM DNV TO NATURAL RESOURCES CANADA, 22 NOVEMBER 2005

## APPENDIX D: THREAT TO LNG TERMINAL BASED ON EXPLOSIVES AT DOCK

This section outlines CERL's assessment of the threat to the proposed LNG terminal from the accidental or deliberate detonation of explosives being unloaded at the TC port. The port is currently being used for the transport of explosives and the question arose as to whether the two activities were compatible. Two threats are considered, fragments and overpressure.

### Assumptions

Distance from Storage tank to near end of terminal dock: 750 m
Distance from storage tank to access gate: 300 m
Estimated maximum quantity of explosives at port at any one time: 140 tonnes.
Assumed wall thickness of storage tank wall, 18" concrete, steel thickness ignored

### Calculations

**Table 1 - Pressure and impulse acting on storage tanks based on various masses of TNT**

| Mass /kg | Range /m | $P_i$ /kPa | $I_i$ /kPa-ms | $P_r$ /kPa | $I_r$ /kPa-ms |
|---|---|---|---|---|---|
| 20,000 | 750 | 4.0 | 315 | 8.1 | 555 |
| 40,000 | 750 | 5.4 | 500 | 11.0 | 890 |
| 60,000 | 750 | 6.4 | 650 | 13.1 | 1175 |
| 100,000 | 750 | 8.0 | 910 | 16.4 | 1660 |
| 140,000 | 750 | 9.2 | 1130 | 19.0 | 2100 |

**Table 2 - Estimated flight range and residual velocity of various fragments from the detonation of a large mass of explosives in either a ship or on a truck**

| vo /m/s | mass /kg | area /m2 | thick /cm | cd | range /m | vel /m/s |
|---|---|---|---|---|---|---|
| 1000 | 50 | 0.25 | 2.5 | 1 | 1125 | 51 |
| 1000 | 50 | 0.25 | 2.5 | 2 | 620 | 36 |
| 1000 | 100 | 0.50 | 2.5 | 1 | 1123 | 51 |
| 1000 | 100 | 0.50 | 2.5 | 2 | 619 | 36 |
| 1000 | 500 | 2.50 | 2.5 | 1 | 1123 | 51 |
| 1000 | 500 | 2.50 | 2.5 | 2 | 619 | 36 |
| 600 | 500 | 2.50 | 2.5 | 1 | 947 | 49 |
| 1000 | 100 | 0.04 | 30.5 | 1 | 7376 | 157 |
| 1000 | 500 | 0.21 | 30.5 | 1 | 7407 | 157 |

The pressure and impulse values in Table 1 were calculated using the Kingery Bulmash Equations for Hemi-spherical charges of TNT.

The fragment flight parameters were calculated assuming an initial velocity of either 1000 m/s or 600 m/s. Since determining the appropriate drag coefficient (cd) can be difficult the problem was bracketed by using values of 1 and 2. The initial launch angle of the fragment was assumed to be 20 degrees.

**Discussion**

The pressure and impulse from even the larges charge appears to be too low to seriously damage the storage tanks. A truck containing 20 tonnes of TNT detonated at the access gate would be even less likely to damage the tank (based on overpressure). Therefore, unless a truck is hijacked and driven through the gate, or a ship carrying explosives is hijacked and moved closer to the terminal, overpressure is not a serious threat to the facility.

However, the detonation of either the truck or the ship would result in a large number of high velocity high energy fragments. Several potential fragments are shown in Table 2. The size of the fragments shown in the table are hypothetical, however, they are not unreasonable given that a 70 kg axle was recovered after the Walden Accident in 1998, 1050 m from ground zero. Using the computer code ConWep it was determined that even the smallest of these fragments with an impact velocity of 33 m/s is likely to perforate 45 cm of concrete. Table 2 also indicates that the port is well within range of the fragments. Thus the possibility exists that the detonation of a truck at the port site could produce fragments which would perforate a LNG storage tank resulting in a leak.

**References**

1. Hyde, D.W., User Guide for Microcomputer Code ConWep, Instruction Report SL-88-1, US Army, Waterways Experiment Station, April 1988 (Revised 22 February 1993).
2. Natural Resources Canada and Transport Canada, "Report of an Investigation into the Explosion During Transport of Blasting Explosives that occurred in Walden, Ontario on August 5, 1998."