Objet : Projet d'implantation du terminal méthanier RABASKA

Question de la Commission d'examen conjoint :

C71 : Transports Canada nous a fait part que vous leur avez fourni un avis sur l'analyse de risque au niveau maritime (incluant la jetée) présentée par le promoteur. Pourriez-vous déposer à la commission le contenu de cet avis (détails de l'analyse et les conclusions) sous forme écrite?

Réponse : Veuillez trouver en pièce jointe le rapport de Ressources Naturelles Canada, effectué dans le cadre du processus d'examen TERMPOL, pour donner un avis sur l'analyse de risque au niveau maritime. Transports Canada tient à préciser que ce rapport, en date de juin 2006, a été examiné par le Comité d'Examen TERMPOL. Suite à cet examen, le Comité a questionné le promoteur et obtenu les compléments d'information nécessaires pour répondre aux recommandations et préoccupations mentionnées dans ce rapport. Transports Canada a aussi noté que plusieurs des préoccupations soulevées dans ce rapport ont été soulevées lors des audiences publiques de la Commission. Lors de la rédaction du rapport TERMPOL, le Comité d'Examen TERMPOL tiendra compte des points soulevés dans le rapport de Ressources Naturelles Canada, et des réponses obtenues, dans l'élaboration de ses recommandations.

241 **DQ65.1**

Projet d'implantation du terminal méthanier Rabaska et des infrastructures connexes

Lévis **6211-04-004**

Primeau, Josée (BAPE)

De: Pagé, Lucie [PAGEL@tc.gc.ca]

Envoyé: 21 février 2007 13:27

À: Deziel, Annie: EC; Roy, Suzie: EC; Primeau, Josée (BAPE); Cliche, Dominic: EC

Cc: Boulianne, Michel; Duranceau, Danielle

Objet: TR: Projet RABASKA - Réponses aux questions de la Commission

Bonjour,
Vous trouverez ci-joint la réponse à la question C71.
Ainsi que le rapport de Ressources Naturelles Canada effectué dans le cadre du processus d'examen TERMPOL pour le projet Rabaska.

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Gouvernement du Canada | Government of Canada

-----Message d'origine-----
De : Boulianne, Michel
Envoyé : 17 février 2007 14:26
À : Duranceau, Danielle; Pagé, Lucie
Objet : Projet RABASKA - Réponses aux questions de la Commission

Ci-joint pour commentaire avant envoi, les réponses proposées aux questions C73 et C84 de la Commision d'examen conjoint pour le projet RABASKA.

Michel.

CANMET Canadian Explosives Research Laboratory

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Rabaska TERMPOL Review

B. von Rosen and P. Lightfoot

CERL Report 2006-04 (CF)

June 2006

No longer protected - P.D. Lightfoot, Manager CERL, 20/02/07

Natural Resources Canada   Ressources naturelles Canada

Canada

INTRODUCTION

The Canadian Explosives Research Laboratory (CERL) of Natural Resources Canada (NRCan) was approached in the fall of 2005 by Transport Canada (TC) for assistance in the review of a TERMPOL submission[1] regarding a proposed Liquefied Natural Gas (LNG) terminal to be located on the south shore of the St. Lawrence River just east of Lévis, Quebec. CERL has recently provided TC with two similar reviews[2,3] of submissions relating to an LNG terminal project at Gros Cacouna, QC.[4]

The scope of work was to review the submission which comprised five binders, including Studies 3.2 to 3.18, with associated appendices. The focus of the review performed by CERL was on Study 3.15, "General Risk Analysis and Intended Methods of Reducing the Risks". 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.

GENERAL COMMENTS

The technological risk assessment was carried out by Det Norske Veritas (DNV, http://www.dnv.com/) on behalf of Rabaska. 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 jetty and the region of the St. Lawrence out to the Cabot Strait. The methodology used by DNV to calculate risks follows and is well accepted:

- Perform a HAZID (hazard identification) study to identify potential hazards and accident scenarios (e.g., LNG carrier hitting jetty during approach).
- 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.
- For each scenario, determine the probability that an event will result in a hazardous situation by performing a fault tree analysis.
- Combine the frequency and consequence for each accident to estimate risk.

DETAILED COMMENTS

The following section is a review of the risk assessment section of the TERMPOL submission. The review points out only areas of concern, i.e., areas where the methodology or conclusions are either not complete, not convincing, lack substantiation or differ from what is contained in the literature.

HAZID Study

Fourteen hazard scenarios were generated in the HAZID study. A group of experts (see Page 42 of Study 3.15) was used to perform a qualitative evaluation of these hazards. The qualitative process was used to reduce the list of scenarios from fourteen to four: Grounding, Collision at Sea, Striking at Jetty and Unloading. These scenarios were then made the subject of a quantitative risk assessment. The remaining 10 scenarios were considered to be low risk and were not evaluated further.

Although the Qualitative Risk Assessment claims to have addressed the problem of terrorism, the HAZID sheets in the Appendix of Study 3.15 do not contain any typical scenarios relating to terrorism. Terrorism is ranked as low risk without any further justification and then set aside. While it is possible that the frequency of a terrorist attack may be low, the consequences could be very high. Since risk is usually described as the product of frequency and consequence, it could be that a low-frequency scenario can still result in a high risk when the consequences are severe.

While it may be correct that terrorist attacks may be low risk, the problem merits a more detailed analysis than was presented in the TERMPOL submission. Some effort should be made to justify the conclusion.

Another scenario which does not appear to have been addressed in the HAZID is that of a LNG carrier in a harbour other than the LNG terminal. For example, it is possible that a carrier which has lost some essential function, such as steering or propulsion may have to seek an alternate harbour to undergo repairs or just for refuge. The risk associated with harbouring a crippled carrier in a harbour which was not designed for such a vessel should be considered. The population density in the area, the emergency response equipment/personnel, the environmental conditions (tide, wind, waves, and ice) may differ considerably from those at the LNG terminal and may negatively impact the risk. This risk should be identified. Furthermore it would be useful to see mitigating options, contingency plans, and a list of acceptable harbours of refuge.

A review of the Appendix containing the HAZID study resulted in the following observations:

Hazard 3, Striking
- This section is not complete, no hazard rating is given
- Icebergs seem to have been ignored

Hazard 7, Terrorism
- This is very incomplete, no risk or consequence assigned, explosives not covered

A risk assessment was performed by six experts listed on Page 42 of Study 3.15. Résumés or statements of qualifications for each of these experts have not been included. Therefore, it is not clear whether any of these experts is familiar with conditions in the St. Lawrence or with LNG shipping in winter conditions. A statement of qualifications would be a useful addition to the appendices.

Chapter 6 of Study 3.15, Frequency Assessment

This section of the submission deals with the qualitative event frequency determination, (the events being the four scenarios identified in the HAZID). Because the nature of the shipping route changes along its length (population density, shipping lane width, current etc.), the route is divided into five sections or nodes. These nodes were selected because the basic characteristics in each node were relatively constant. Node 1 is from the Cabot Strait to Les Escoumins, Node 2 is from Les Escoumins to Traverse du Nord, Node 3 is from Traverse du Nord to Îles d'Orleans, Node 4 is from Îles d'Orleans to the Jetty at Ville Guay. The final node Node 5 is the area immediately surrounding the berth. The frequency assessment was made for each scenario in each node.

The event frequency assessment methodology employed by DNV is:

1. Identify the world average event frequency for the particular scenario
2. Determine the relevant modifying factors, "K-factors"
3. Assign values to the K-factors
4. Multiply the world average event frequency by the K-factors to obtain an event frequency specific to the Rabaska project

While this is a common and accepted approach to determining event frequency, determination of the appropriate modifiers can be problematic, since in many cases they are based on judgment. For example, when determining the frequency of grounding, a K-factor is used to account for the number of turns that the LNG carrier must make while navigating a particular channel. The more turns that are required, the more difficult the navigation is considered to be and the higher the K-factor must be. A K-factor of 1 indicates average navigating conditions, a K-factor lower than 1 indicates a wide channel with no obstacles, and a K-factor greater than 1 indicates that the channel is narrow or requires maneuvering to avoid obstacles.

In the submission, the K-factor for grounding events in Node 3 during the summer is set at 1.3; in the winter it is the same. Thus there is a 30% penalty due to the narrowness to the channel in Node 3. However the value of 1.3 is not supported with data. Thus we have no idea why 1.3 was selected and not 1.5 or 1.8. Furthermore, one would expect that the channel might be narrower and more difficult in the winter. This leads one to wonder why the K-factor is the same summer and winter.

In the section discussing ship collision it is stated that ship collisions increase with the square of the ship density. This formula does not seem to have been applied to the collision model K-factors. For example, in Node 2, which is considered wide, the K-factor is 0.4, while in Node 3, described as very narrow, the K-factor is 2. This is an increase by a factor of 5. According to the formula this means that the channel in Node 2 is only 2.2 times wider than the channel in Node 3, but this does not seem consistent with the descriptions, relatively wide and very narrow, respectively. On Page 18 of Study 3.15 the minimum width of Node 2 is given as 1 NM or 1850 m. On Page 19 the width of Node 3 is given as 300 m. This is a ratio of just over 6, which suggests that the K-factor for collision frequency should be 38 times higher in Node 3 than in Node 2.

As was stated before, one would expect the channel to be even narrower in the winter. Furthermore, the submission states that several buoys in Node 3 are removed in the winter due to problems caused by the ice. This makes it more difficult to see from one buoy to the next. For this reason the transition across this particular section is only made when the buoys are visible. What happens when they are not, does the carrier anchor and wait for clearance, does this not increase the hazard? This does not seem to be accounted for by an increase in the K-factor.

Throughout the submission the majority of K-factors are less than 1 indicating that conditions in the St Lawrence are better than the average condition around the world. This is difficult to believe, since the St. Lawrence has strong currents, high tides and relatively intense winter conditions. Therefore one must wonder whether the values are correct.

One method of determining the accuracy of the assumptions and the K-factors is to compare the predicted frequency of events with historical occurrences. According to Study 3.15 the frequency analysis for grounding indicates a much greater likelihood of grounding in Nodes 1, 2 and 3 than in 4, with return periods of as shown in Table 1.

Table 1 – Calculated return period for groundings by Node[1]

Node	Return period for groundings /yrs
Node 1	287
Node 2	125
Node 3	257
Node 4	18,253

However, a review performed by DNV, of the historical data, reveals that this predicted trend is not reflected in the accident history. Table 2 contains the accident history was for groundings of tankers and dry merchants as described in Figure 5.1 in Study 3.8 Page 16 and subsequent descriptions in the appendix.

Table 2 – Number of groundings in the St. Lawrence by Node[1] (1994-2002)

Node	Number of Groundings
Node 1	4
Node 2	1
Node 3	2
Node 4	3

Although the amount of data is limited, the number of groundings in Node 4 does not differ substantially from those in the other nodes, so the prediction of a very high return period for Node 4 needs to be explained.

The lack of substantiation of the K-factors is prevalent throughout the document. Some examples of this are given above along with some quick calculations which raise some concern with the assigned K-factors and frequency calculations. The examples given above do not represent all the areas of concern. Anywhere a K-factor is used it should be supported with data. If this is not possible, it must be demonstrated by some means that the supporting assumptions are valid. Alternatively, a sensitivity analysis could be used to demonstrate that significant variations in the assumed K-factors are not important.

Chapter 7 of Study 3.15, Consequence Evaluation

Determination of hole size due to collision or striking

A key part of evaluating the consequences of a ship striking an object or a ship-to-ship collision is the estimation of the size of the hole, since it is the size of the hole that will largely determine the extent of the leak. On Page 79 of Study 3.15 it is stated that for events that lead to leakage, hole sizes between 0 and 1.5 m (1.8 m^2) are almost equally likely. Based on this, DNV decided to continue the analysis using the average diameter, i.e. 0.75 m (0.44 m^2), as the maximum credible hole size from an accidental event. As the flow through an opening will depend on its area, an average area of 0.9 m^2 (1.3 m) would have been more appropriate Furthermore, in two separate reviews of the hazards posed by LNG spills over water Sandia[5] and ABS[6] used larger hole sizes (1.5 m^2 (1.38 m) for Sandia and at least 0.78 m^2 (1.0 m) for ABS). Furthermore, using 0.44 m^2 (0.75 m) is inconsistent with the risk assessment DNV performed for the Cacouna project, where DNV chose to use 1.5 m^2 (1.38 m) instead.[7]

Because terrorism was considered to be low risk in the initial qualitative risk assessment, consequence evaluation was not performed for any terrorist-based scenarios. However, the Sandia report states that hole sizes four to five times larger (5-7 m^2) may result from deliberate attacks than are likely to occur from accidents. Because the resulting hole is much larger, the leak and the consequences of ignition may be much higher as well.

Vapour dispersion distance calculation

While calculations are performed for three scenarios, a 0.25-m (0.05 m^2) hole, a 0.75-m (0.44 m^2) hole and a 1.5-m (1.8 m^2) hole. The results for the 1.5-m (1.8 m^2) hole are not used in the consequence assessment because it is considered a terrorist scenario and not credible. This is not consistent with the Sandia report which states that a 1.38- m (1.5 m^2)

hole is credible from an accidental event and that much larger holes are credible from a deliberate event, as discussed above.

Based on a 0.75-m (0.44 m^2) hole size DNV recommends a hazard area of 2000 m.

Pool Fire Calculations

In the pool fire calculations, DNV introduces a concept not apparently used in either the Sandia or the ABS reports, nor is it obvious that DNV uses this concept in another risk assessment it performed for a similar terminal at another site[7]. DNV proposes that the determination of a hazard zone due to thermal flux from pool fires be based on what they term as a "sustainable pool size" rather than a maximum pool size. The rationale is that the maximum pool size will only exist for a "few seconds" and then the pool will burn back to a sustainable size, which is based on an equilibrium between burn-back rate and pool replenishment from the hole or breach. This concept is not explicitly discussed in the Sandia reports, or in DNV's previous work. Introducing it essentially cuts the pool size in half, resulting in a corresponding 50% reduction in the radius of the hazard area (from 870 m to 450 m for a 0.75-m (0.44 m^2) hole). The 50% reduction is not important when the ship is out in the middle of a channel in Node 1, however may be very significant in Nodes 3, 4 or 5, (particularly Node 5, i.e., when the carrier is at the jetty) where the channel is narrow and the population relatively close to the shipping lane. If the 50% reduction is ignored, a pool fire at the jetty results in a thermal exposure of 5 kW/m^2 at 870 m (Page 92 of Study 3.15, 0.75-m (0.44 m^2) hole) a radius which encompasses as many as 27 buildings and just reaches the edge of Highway 132. When the 50% reduction is utilized the hazard radius does not reach the shore. Thus it is very important to justify this 50% reduction, particularly since it was not apparently used by other organizations in previous analyses, where larger thermal hazard distances were calculated. Furthermore, at high thermal fluxes, a "few seconds" is all it takes to cause burns and the the distance to 12.5 kW/m^2 for the initial pool is approximately the distance to the shore from the jetty (570 m). More data in support of this approach is needed

Both the pool fire and vapour dispersion calculations appear to assume a flat terrain, and no water flow. However, the escarpment rises up very steeply from the river to a height of approximately 60 m above the river at Highway 132. It would be interesting to know what effect the local topography would be expected to have on the results of the calculations. Similarly, there can be a strong downstream current at this location, which might have a significant effect on the same calculations.

Mooring Arm Failure

The risk from mooring arm failure is considered negligible because the mooring is too far from shore. However, on Page 90 it is stated that the hazard zone from an unloading arm failure and vapour cloud formation is 700 m (radius) and on Page 103 it is stated that the distance to shore is 500 m. A radius of 700 m encompasses at least nine buildings. Thus more evidence may be needed to support the conclusion that the hazard is negligible.

General Comments on Consequence Evaluation
The number of potential casualties from a given hazard is not calculated anywhere. Nor are hazard or risk templates placed over a map anywhere. It would be useful to have maps in the various nodes showing hazard zone templates.

The case of a carrier at the terminal is a special case because the carrier is at this location for a considerable time and because it is close to shore. However again no maps with hazard or risk contours are shown and no indication is given of the proximity of the nearest house or business. Therefore it is difficult to determine whether anyone is at risk.

Fault Tree Analysis
In the Fault Tree Analysis, the base event frequency is modified to determine how often an event (one of the four identified in the HAZID) may lead to a hazardous situation. For instance, the grounding of a ship may not necessarily lead to a dangerous release of LNG. There is a possibility that the grounding causes no damage to the carrier or that it causes insufficient damage to cause a release of gas. Table 3 shows the probabilities associated with each event in the grounding fault tree analysis.

Table 3 – Example of Fault Tree Analysis parameters

Grounding		
Event	**Probability**	**Comments**
Ship loaded	50%	Only loaded heading to terminal
Ship punctured in cargo area	70%	Report referenced
Rocky bottom	50%	Assumed values, no substantiation
Significant Damage, rocky bottom	50%	40% outer hull breach, 6% 250-mm hole, 4% 750-mm hole Assumed values, no substantiation
Significant Damage, sandy bottom	10%	Outer hull breach only Assumed values, no substantiation

What is significant in Table 3 is that three of the five assigned probabilities appear to be assumptions and are not supported with data or documentation. Similar assumptions are made in the fault tree analyses for the collision scenario, the striking of a ship at the jetty scenario and the mooring and unloading arm failure scenario.

Chapter 8 of Study 3.15, Risk Evaluation
Risk is generally the product of probability (or event frequency) and consequence. In this submission, it has been presented in a matrix with frequency on one axis and consequence, represented by fatalities, on the other axis. A risk matrix was generated for each of the four main scenarios. Risk is determined for various possibilities within each scenario by entering the matrix with an event frequency and a value reflecting the adjacent population density (number of possible casualties due to the event). The end result is not a number representing risk, rather risk is represented by high, medium (ALARP, As Low As Reasonability Practicable) and low designations. The disadvantage of this system is that it does not result in a risk value which can be compared to

acceptable norms. What is considered low risk to one person might be high to another. Hence it is preferable to be able to quantify the risk and compare it with industrial standards or societal norms.[8]

Another problem is that the consequences have not been well quantified in this submission. Risk radii have been calculated, but these have not been translated into casualties. However, the risk matrix requires a number of casualties as input and it is not made clear how the number of casualties that is used in the risk matrix is derived. An assumption has been made that the number of casualties can be related directly to the average population density along the river. Because Nodes 1, 2 and 3 are considered low-density areas, the numbers of casualties which may result from an event in these nodes is considered to be very low. There are two problems with this assumption. First, people tend to live in small pockets along the river, with a village every few kilometres. Thus the number of people exposed to the hazard fluctuates along the length of the river. Using an average population density results in an average value of risk, not the maximum risk.

The second problem arises from the fact that no attempt was made to determine the actual number of casualties from each scenario, however since the matrix uses column headings such as “no fatalities”, “some fatalities”, “several fatalities” and “multiple fatalities”, a number of casualties is required as input. To circumvent this problem, the assumption was made that events in a low population density will cause “no fatalities” or “some fatalities”, and that “several fatalities” and “multiple fatalities” arise only in medium or high population density areas. However no attempt has been made to define the terms “some”, “several” and “multiple” as they relate to the number of fatalities. Also no quantitative relationship has been established between the number of fatalities and the population density. Thus, how are we to know that an event in a low-density area would cause “some fatalities” instead of “several fatalities”?

A plot of frequency or risk contours would help resolve some of these issues. These plots, in strategic areas such as at the jetty, would allow the assessment of the potential impact on the public. Even more useful would be frequency contours which include some measurement of the potential error in the contours. This would allow us to assess the degree of certitude or the degree of conservatism in the contours. Knowing the potential impact on the public is important because of the large number of assumptions that have been made in calculating the event frequencies, especially since the risk associated with some of the accident scenarios has been calculated to fall within the ALARP region. A relatively small error in an assumption could push the risk into the high region. Therefore it is important that all the assumptions made in the determination of event frequencies are supported by data.

It is interesting to note that the four scenarios which were used in the quantitative assessment had been deemed medium and high risk in the initial qualitative assessment by the expert panel, but after the quantitative assessment were reduced to low and medium hazards.

DETERMINATION OF AN EXCLUSION ZONE RADIUS

The size of an exclusion zone around an accident scene should be based on the distance at which there is a substantial hazard to the public, the ability to put the exclusion zone in place in a timely manner and the consequences of maintaining the zone. There is little sense in requiring an exclusion zone that takes longer to establish than the duration of the hazardous event. Similarly, there is no sense in requiring an exclusion zone that causes more hardship to the public than is warranted by the severity of the event.

There are two major hazards from a release of natural gas: the first is a flash fire which occurs when a dispersed vapour cloud encounters an ignition source. This is a very short duration event but is very dangerous to anyone caught within the cloud. Natural gas, in vapour form is lighter than air, and as such eventually disperses. Once a vapour cloud has dispersed to the point of being below its lower flammability limit, there is no longer an ignition hazard. Therefore, the hazard from a flash fire is limited by the time it takes for the concentration of natural gas within the gas cloud to drop below the lower flammability limit.

The second hazard is a thermal exposure hazard due to thermal radiation from a pool fire. This event lasts substantially longer than a flash fire, but generally has a more limited range.

Table 1 summarizes the hazard radii and hazard durations as reported in four different sources from the literature (References 1, 5 and 6). The table shows that in worst case scenarios, vapour clouds may extend as far as 4 km from the source, but that this hazard exists for a very short time only, less than ½ an hour and only occurs under very specific conditions. It is unlikely that first responders could establish a secure perimeter around this area, evacuate personnel and eliminate any sources of ignition within the ½ hour during which there is a hazard. It is probably more reasonable to use a longer duration event (i.e. a smaller spill which remains hazardous for a longer period) as the basis of an evacuation distance. For example a 1.6-km evacuation distance would cover most of the hazardous scenarios, and it would be consistent with the Sandia report which states that beyond 1.6 km impacts on public safety should be considered low.

SUMMARY

Assessment of the frequency of an event can be made based on:

- Physics
- Statistics
- Experience/judgment

When based on physics or statistics (assuming that the reasoning is sound) it is relatively easy to have confidence in calculated event frequencies. However in this submission many of the factors used to determine event frequency appear to be based on experience and judgment. It would be preferable if these factors were supported by data or if reference was made to documents which could be reviewed.

The other key factor in determining risk, besides event frequency, is the consequence of an event. Usually consequences are determined in terms of financial impact or fatalities. In this submission consequences were evaluated in terms of fatalities. However, the submission did not convincingly link the predicted number of fatalities to the postulated event scenario or to the mechanism causing the fatalities. Thus the final evaluation of risk remains unconvincing. Event frequency contours would provide a useful tool to help establish the individual and societal risks.

Two possibly important scenarios were not addressed: harbours of refuge, and terrorist attacks. Both of these scenarios may affect the outcome of the risk assessment and as such should be considered.

There are several points in this submission which raise concern, the most prominent of these is that the method used to evaluate risk was not consistent with DNV's previous submission involving the Gros Cacouna project.

There is some question as to the validity some of the factors used by DNV to establish event frequency. The values assigned are particularly important when the risk of an event is determined to be in the ALARP region on the risk matrix.

Security measures and emergency response procedures should be put into place to deal with the worst-case scenarios. A part of an emergency response procedure would be to set up a secure perimeter around an accident site. A secure perimeter with a radius of 1.6 km should be sufficient to cover most credible accident scenarios.

Table 1 – Summary of Hazard Range Calculations

Scenario	Range to LFL /m	Time until hazard ignition hazard is removed /min	Pool Fire range to 12.5 kW/m² /m	Pool Fire range to 5 kW/m² /m	Pool duration /min	Source	Hole Size /mm
Ship Breach	1900 - 3200					Rabaska TERMPOL submission[1]	1500
Ship Breach	990 - 1500		310 - 585	450 - 870		Rabaska TERMPOL submission	750
Ship Breach	390 - 790		134 - 244	194 - 359		Rabaska TERMPOL submission	250
Loading Arm Failure	700					Rabaska TERMPOL submission	
Ship Breach				500		Lehr (Sandia Report)[5]	?
Ship Breach				1900	3.3	Fay (Sandia Report) [5]	5050
Ship Breach				490	28.6	Quest (Sandia Report) [5]	5050
Ship Breach				1290	9	Vallejo (Sandia Report) [5]	5050
Ship Breach				1300-2100	8.1	Sandia Report[5]	1380
Ship Breach				1920	3.4	Sandia Report	3900
Ship Breach	2450					Sandia Report	1380
Ship Breach	3614					Sandia Report	1380
Ship Breach	340 - 4000					Quest (Sandia Report)	
Ship Breach	1100-4500					Vallejo (Sandia Report)	1380
Ship Breach			600	760-900	33	ABS[6]	1000
Ship Breach	3300-3900	28-48				ABS	1000-5000
Ship Breach			980	1400	6.9	ABS	5000

RECOMMENDATIONS

We recommend that Transport Canada carry out the following actions:

1. Ask the federal security agencies for an assessment of the likelihood of a deliberate attack on a LNG carrier at Rabaska. If the intelligence assessment is that the probability of an attack is significant, request a risk assessment based on this worst-case scenario.
2. Ask the project coordinator to develop an emergency response plan that includes a secure perimeter with a radius of at least 1.6 km.
3. Request data to justify the key "factors" used in event frequency calculations.
4. Request details on Harbours of Refuge, locations, facilities, emergency response plans.
5. Request that event frequency contours be provided for key sites along the route.
6. Request a more complete justification for the use of the reduced pool radii.
7. Request that DNV provide a clearer link between the number of potential fatalities and the event scenarios.
8. Provide more complete justification for the selection of the small hole size (0.44 m^2, 0.75 m) as opposed to the larger hole size (1.5 m^2, 1.38 m) suggested by Sandia.

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