Le 8 juin 2006

Madame Monique Gélinas
Coordonnatrice du secrétariat de la commission
Édifice Lomer-Gouin
575, rue Saint-Amable, bureau 2.10
Québec (Québec) G1R 6A6

Objet: Avis de Ressources naturelles Canada sur la sismicité régionale ainsi que les risques sismiques associés à la zone d'étude du projet de terminal méthanier Énergie Cacouna

Madame,

Suite à votre demande du 19 mai dernier, veuillez trouver ci-joint un avis écrit de Ressources naturelles Canada (RNCan) concernant la sismicité régionale ainsi que les risques sismiques associés à la zone d'étude du projet de terminal méthanier Énergie Cacouna.

Nous avons aussi joint les commentaires de RNCan sur le document intitulé « Earthquake Hazard Analysis : Gros Cacouna, Quebec for Sandwell Engineering Inc. » produit par Gail M. Atkinson, février 2006.

Veuillez prendre note que l'avis et les commentaires sont en anglais et que nous vous ferons parvenir la version française dès que la traduction sera complétée.

N'hésitez pas à communiquer avec moi au (613) 995-2848 ou par courriel à lmichaud@rncan.gc.ca si vous avez des questions.

Veuillez agréer, Madame, l'expression de mes sentiments les meilleurs.

Livain Michaud
Agent principal d'évaluation environnementale
Développement durable et affaires internationales
Ressources naturelles Canada
580, rue Booth
Ottawa (Ontario) K1A 0E4

p.j.

Développement durable et Affaires internationales
Direction de la Politique stratégique
580, rue Booth, Ottawa ON K1A 0E4
Tél: (613) 995-2848 | Fax (613) 995-5719
Courriel : lmichaud@rncan.gc.ca

Advice from NRCan on Seismic Aspects of the Energie Cacouna Project

Regional Seismicity

The Cacouna site is within 25 km of the Charlevoix seismic zone which has generated five magnitude 6+ events in the past 350 years (http://earthquakescanada.nrcan.gc.ca/zones/eastcan_e.php#CSZ). These large earthquakes and the almost daily occurrence of earthquakes too small to be felt (http://earthquakescanada.nrcan.gc.ca/recent_eq/maps/index_e.php?tpl_region=charlevoix) are an indication that the seismic hazard is one of the highest in eastern Canada and deserves careful consideration.

Seismic Hazard (1)

NRCan in its August and November 2005 comments indicated that a site-specific seismic hazard assessment was necessary. That assessment has now been submitted for the proponent and evaluated by NRCan (see below). The report appears to be a fair assessment of the seismic hazard level, and while it is possible that the values are slightly on the low side, this does not significantly change the design issue, i.e. that the LNG plant will need to be designed to safely survive a magnitude 7 earthquake "near" the plant.

Seismic Hazard (2)

The issue of how "near" the M7 earthquake should be is tied in with the design standard adopted and the consequent choice of the probability level for the "Safe-Shutdown Earthquake" (SSE). As set out below, NRCan finds convincing the arguments made for contemporary Canadian LNG projects that the SSE design should be to the 0.0002 p.a. probabilistic ground motions, even though this significantly exceeds the current Canadian standard Z276 minimum requirement, slightly exceeds the NFPA59A (2001 version), and exceeds the NFPA59A (2006 version). According to the seismic hazard report, the 0.0002 p.a. probabilistic ground motions are equivalent to those from an earthquake of approximate magnitude 7, generating median plus 1 sigma ground motions, and occurring about 25 km from the site.

Anti-seismic Design

While care needs to be taken to ensure that a LNG plant is designed and operated correctly, LNG plant have already been constructed and operated in high-seismicity areas (Japan, Algeria, etc). Also, while the seismic hazard at the Cacouna site is one of the highest in eastern Canada, it is comparable to, or below, many other high-seismicity places such as San Francisco. NRCan thus considers that engineering practitioners should be able to demonstrate that a LNG plant can be constructed at Cacouna that will safely resist the 0.0002 p.a. design earthquake forces satisfactorily.

Emergency Response Plans

Earthquake shaking stronger than the design level may occur (but is expected to be rare), in such a case it is the secondary safety systems and the emergency response that will determine the consequences. There needs to be consideration of the accident response in the case where multiple incidents (pipe leakage, electrical power failure, diesel fuel spill, tank crack) occur, as such simultaneous occurrences are inevitable during a large earthquake. NRCan considered the proponent's response to C-027 shows a good appreciation of the issues. NRCan has little specific expertise in devising emergency plans, other than the incidental insight that has come from post-earthquake disaster visits. It is possible that foreign earthquake experience from high-seismicity regions will be more beneficial, as no modern Canadian industrial plant has yet suffered very strong earthquake shaking.

Other Comments
NRCan recommends that a regulator be clearly assigned to take responsibility for ensuring that the proponent follows standards, accident plans, and other panel recommendations as promised in the EIS and in the subsequent review process. To this end, the proponent's recommendations on the regulator deserve consideration (C-072).

Review of "Earthquake Hazard Analysis: Gros-Cacouna, Quebec for Sandwell Engineering Inc" by Gail Atkinson, Feb 2006, 33 pp.

The report indicates that the LNG plant will need to be designed to safely survive a magnitude 7 at a distance of circa 25-30 km.

The report cites the geotechnical report "Journeaux Bedard and Associates (2005). Report S-05-1743 Preliminary geotechnical investigation LNG Terminal - Cacouna Energy, Gros-Cacouna Que. For Sandwell EPC Inc., Nov. 28, 2005". The geotechnical report indicates that the tank foundations will be hard rock, and thus removes concern about ground amplification of the design ground motions. The work also reduces the likelihood there is young faulting on the site.

The chief issue with the seismic hazard assessment is whether the rate of earthquakes close to the site is comparable to that of the very-active Charlevoix seismic zone or to the less-active region under the St. Lawrence river in the downstream direction (i.e. to the north and northeast of the site). The Charlevoix seismic zone is modelled as a "confined" source model, with its boundaries based on the pattern of small earthquakes. To address the uncertainty in the rate, the report also defines an enlarged "broad" source for Charlevoix earthquakes which extends under the Cacouna site. The seismic hazard at the site from this "broad" zone is approximately 40% higher than from the "confined" zone (see Fig. 8). However the final "weighted" model gives only a 10% weight to the "broad" versus 90% weight for the "confined". This is tantamount to ignoring the "broad" model, as the test in the Appendix indicates.

For this reason, the decision to use a 10% weight for the "broad" zone is essentially a decision to go with the "confined" zone model (i.e. it assumes that the northeast boundary of the Charlevoix activity is fixed and correct), and it thus reduces the chance that M7 earthquakes will occur close to the plant relative to some other weighting scheme (such as 0.5 & 0.5).

Because of the choice for the weights, the calculated ground motions should be expected to resemble the GSC's NBCC values; indeed Figure 7 shows that when the same ground motion relation (AB95) is used, the report's values are very similar to the GSC's.

In light of the above it is very surprising that the report's *mean* values are for the most part lower than the GSC's *median* values (compare in Figure 10 and Table 2), except for longer periods where the effect of the Campbell relationship begins to show. It is possible that this is due to using a lower magnitude cut-off at Mw=5.0 whereas the GSC used Mw~4.4, but this may not be the case, particularly as the parameter most sensitive to the cut-off (PGA) is larger than the GSC's value.

The error assessment in the analysis is partial, in part for practical reasons. For example, some uncertainties are ignored and the two alternatives to the magnitude-recurrence curves are middling values (leading to the close agreement of the curves in Figure 8). The impact of this partial treatment is not likely to be significant on the end result. Nevertheless, it may bias the estimate of the mean values to the low side, which makes their being lower than the GSC median even more surprising.

Although NRCan could have chosen to make other detailed comments on certain aspects of the report, it has chosen not to, because in the end the difference they would produce in the design level for the 0.0002 p.a. level would come down to relatively small (5-10 km) changes in the distance at which the magnitude ~7 is assumed to occur. This and the large variability in ground motions from individual earthquakes (considering especially the effects of rupture directivity and depth) mean that the final design should be chosen so that it is not too sensitive to small changes in the distance.

The report correctly gives seismic hazard values for a range of probability levels; the choice of the level to be used is an engineering/standards issue (see next section).

The methods used for choice of recorded time histories of earthquakes and their spectral matching to the design uniform hazard spectra seem appropriate. It is this matching that leads to the choice of ground motions from magnitude 7 earthquake at 25 km etc.

Appendix

The test is done for a test site at Trois-Rivières (middle of the zone) using a combination of two versions of a single source zone (IRM); the two versions have two different activity rates and weights ranging from 100% to 0%

2%/50 year values	mean	84%ile	50%ile	16%ile
Normal rate 100% 0.0004	368.0	546.1	316.7	153.2
10x rate 100% 0.0004	1149.7	1644.2	948.8	460.2
Normal .9 10x .1 0.0004	518.6	585.8	324.0	155.3
Normal .5 10x .5 0.0004	876.0	1166.1	501.8	250.6
Normal .1 10x .9 0.0004	1102.9	1556.9	874.8	420.2

The numbers 518.6 and 368.0 show that even after increasing the activity of the zone by 1000%, giving a weight of 10% to it only increases the seismic hazard by 40% for the mean (the mean is the parameter used in the report; the increase is much less for the median, as expected), whereas a 100% weight for the high activity version increases the hazard by 300%.

National and International Design Standards and Domestic Practice for the Choice of the "Safe-Shutdown Earthquake" (SSE)

NRCan is on record as considering the current (2001 version) of CSA Z276 inadequate as it only requires SSE design to the 0.001 p.a. (=per annum) seismic ground motions (for comparison the 1981 version used the 0.0001 p.a. values). The equivalent U.S. code NFPA 95A (2001 edition) was much more stringent, using approximately 0.0002 p.a. (although NRCan disagreed with the exception that capped the ground motions in some places and consequently did not provide a uniform level of performance across the U.S.). There is also the European Standard EN 1473, which uses 0.0001 p.a. values. [Note: a new version of NFPA 59A was issued in 2006; it uses 0.0004 p.a. for the SSE. This represents yet another increase in the probability level (it was originally 0.0001 p.a.) but the engineering justifications for the progressive change are not clear. A new edition of CSA Z276 is planned for 2007 but has not yet been issued; it might use 0.0004 p.a. NRCan is in the process of reviewing the intent of these documents.]

NRCan sees a *de facto* recognition of the code deficiencies in the design levels proposed for other contemporary LNG facilities. Among the other LNG projects whose consultants have recommended the SSE be taken as the 0.0002 p.a. probabilistic ground motions are Bear Head and Kitimat (reports in CEAA's hands). NRCan believes Rabaska is intending to design for the 0.0001 p.a. ground motions (based on EN 1473). Seismic hazard assessment reports for Bear Head and Kitimat are available to CEAA. NRCan finds convincing the arguments made in those reports that SSE design should be to the 0.0002 p.a. probabilistic ground motions.