ANNEXE B

Addendum au rapport géotechnique Terratech 2006

RABASKA LIMITED PARTNERSHIP

ADDENDUM TO GEOTECHNICAL SITE STUDY REPORT PHASE 3

SEISMICITY AND SOIL LIQUEFACTION POTENTIAL

Rabaska – LNG Receiving Terminal
Levis, Quebec

Our File :
T-1050-C (604238)

September 2006

Terratech

Rabaska – LNG Receiving Terminal
Levis, Quebec

Addendum to Geotechnical Site Study Report (Phase 3)
Seismicity and Soil Liquefaction Potential

Rabaska Limited Partnership

Our File T-1050-C (604238)
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SUBJECT: Addendum to Geotechnical Site Study Report (Phase 3)
Rabaska – LNG Receiving Terminal
Levis, Quebec
Seismicity and Soil Liquefaction Potential
Our File: T-1050-C (604238)

Dear Sir:

We are pleased to submit the enclosed Addendum Report that comprises information and comments on seismicity and soil liquefaction potential at the site of the Rabaska - LNG Receiving Terminal, in Levis, Quebec. This addendum report refers to the geotechnical data obtained at the project site and gathered in Terratech Report T-1050-C (604238) dated May 2006 "Geotechnical Site Study Report (Phase 3)".

This document is based on several seismic inputs gathered by Terratech from literature and subsurface investigation. The report also uses the seismic data supplemented in the Earthquake Hazard Analysis Preliminary Report issued in September 2006 by Mrs. Gail M. Atkinson, Ph.D., Engineering Seismologist.

We trust that the information included in this Addendum will be to your satisfaction. Please do not hesitate to contact us should you require additional information or should you have any questions.

TERRATECH
Division of SNC-Lavalin Environment Inc.

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Senior Geotechnical Engineer and Project Director
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1. INTRODUCTION

The services of Terratech**,** a Division of SNC-Lavalin Environment Inc., were retained by Rabaska Limited Partnership to carry out a Phase 3 geotechnical site study at the proposed Rabaska - LNG Receiving Terminal, located in Levis, Quebec. All of the geotechnical data obtained at the project site through on-site subsurface investigation works and laboratory testing are presented in Terratech Report T-1050-C (604238) dated May 2006 “Geotechnical Site Study Report (Phase 3)”.

Section 3.3 of the above report was specifically designated to cover and discuss the seismicity and the soil liquefaction issues of the Rabaska Site. However at the time of issue of the Geotechnical Site Study Report (Phase 3) on 23 May 2006, a specific site earthquake hazard assessment study was underway. This hazard study was since initiated and the following preliminary report was issued:

- Gail M. Atkinson 2006: “Earthquake Hazard Analysis: Rabaska LNG Facilities, Quebec, / Preliminary Report”, September 2006.

This Addendum Report addresses the issues of seismicity (earthquake history, local faults and fault activity and seismic hazard) and soil liquefaction potential.

2. SEISMICITY

2.1 Earthquake History

In the past, earthquakes strongly felt in the area of study had their epicenters located in the Charlevoix / Kamouraska and the Saguenay regions. Damaging earthquakes were recorded in 1663, 1791, 1860, 1870, and 1925. More recently, the Saguenay earthquake in 1988 was the most important. But from time to time, milder tremors with epicenters close to Quebec City have also shaken the region without causing any appreciable damage (Geoscape Quebec, 2006). In 1997, an earthquake occurred at Cap-Rouge, some 25 km southwest of the project site. Studies have demonstrated that this event was related to a reactivation of a deep fracture in the Canadian Shield.

Typically, the majority of earthquakes in eastern Canada are caused by sudden movements along ancient faults and are associated with the St. Lawrence River rift.

Additional information and comments related to earthquake historic data are provided in Atkinson, G.M. 2006 (specifically in Sections 2.2.1 and 2.3, pp. 7-10, and 13-14).

2.2 Local Faults and Fault Activity

The three following specialists were contacted by Terratech on the issue of fault activity:

- ***Dr Maurice Lamontagne***, Canadian Geological Commission, Ottawa, Ontario;
- ***Prof. Jacques Locat***, Département de géologie et de génie géologique, Université Laval, Quebec;
- ***Prof. Pierre-André Bourque***, Département de géologie et de génie géologique, Université Laval, Quebec.

From discussing with the above specialists, and in reference to Bourque web site documentation (see Section 6 - References), the following statements are provided:

- As stated in Section 3.2 of Terratech Report T-1050-C (604238) dated May 2006, the major faults of the region are overthrust type faults. They are shallow and do not penetrate the whole thickness of the lithosphere. They

were active during the Ordovician Time until the end of the raise of Appalachian Front (- 450 My to - 400 My approx.)

- The Logan Fault, which runs through the St. Lawrence River and is routed almost horizontally below the south shore area and below the Appalachian Mountains was very active during the Ordovician Era (-450 My). It was totally stabilized since at least - 400 My. It is unlikely, and almost impossible, that this major fault would be reactivated, since the fault is shallow and does not penetrate all the lithosphere. Furthermore, because it belongs to a thrust type fault, we believe that if the said fault was the locus of seismic activity, earthquakes would occur all along the St. Lawrence River, and also on the south shore regions and even in New England (eastern U.S.A.), which is not the case.

- Past records have shown that most of the local earthquakes originate from the Charlevoix region, and not from Quebec City area. Furthermore, it is impossible to correlate this seismic activity that occurs at great depth, with any of the inferred faulting that is present at rather shallow depths at the project site. This is consistent with the above stated belief that the local major faults are not active.

Findings from the boreholes support the above statements concerning the probable inactivity of the (slip) faults presumably associated with ductile phase folding. For example: the rock core recovered in Borehole BH-108-05 (see Terratech Report T-1050-C (604238) dated May 2006) presents evidence of faulting but the rock appears to be healed. This may reasonably lead us to conclude that this fault or inferred fault was cemented over time with secondary minerals such as calcite.

Nevertheless, in order to conclude formally on the faulting activity at least after the latest glacial age (- 12 ky), Trial Excavation TE-B-05 (see Terratech Report T-1050-C (604238) dated May 2006) was carried out in the glacial deposit over a known seismic refraction anomaly (possible fault or fold) to observe any evidence of movement or disturbance in the soils that could be related to a recent fault (or fold) activity. In this respect, while this excavation was being carried out, attention paid to the overburden provided no clear evidence that the soil materials were disturbed to the bedrock other than by human activity.

For additional comments on the issue of fault activity, the reader should refer to Appendix 1 of this document, specifically to Section 2.1 (pp. 4 and 5) of Earthquake Hazard Analysis Report, written by Mrs. Gail M. Atkinson, Ph.D.

2.3 Seismic Hazard

2.3.1 Site Specific Seismic Hazard Assessment

As required by Codes CSA-Z276, NFPA-59A and EN-1473, a site-specific seismic hazard assessment study was recently carried out by Mrs. Gail M. Atkinson, Ph.D., Engineering Seismologist. The earthquake hazard analysis determined the expected earthquake ground motion over a range of probability levels, for the following return periods:

- 500 years;
- 1000 years;
- 2500 years;
- 5000 years.

For the detailed results of ground motion, the reader should refer to Section 3.2 (Table 2, p. 28) of Report "Earthquake Hazard Analysis", written by Mrs. Gail M. Atkinson, Ph.D.

All critical equipment of the Rabaska LNG Terminal will be designed using the ground motion calculated by the specific seismic hazard assessment.

2.3.2 Seismic Design based on NBCC

The National Building Code of Canada (NBCC) is the reference for seismic design of structures in Canada. A new version of the NBCC came out in September 2005.

As for seismic provisions, the new 2005 version of the NBCC presents two main differences compared to the former 1995 version:

- The Geological Survey of Canada has updated its seismic hazard models (detailed description in Open File # 4459, Adams and Halchuck, 2003);
- A new design approach has been adopted. In particular, it now considers a 2500 year return period (probability of exceedance of 2% in 50 years) and has moved from using peak ground motion to spectral accelerations. Calculation methods have been adjusted consequently.

For the site for the Rabaska Site, which is located at 46,82° North and –71,06° East, peak and spectral accelerations have been evaluated by GSC seismologist Stephen Halchuck (2005). These are summarized in Table 2-1.

Table 2-1
Seismic Hazard Calculation
by Earthquake Canada (Halchuck, 2005)

	1 : 100 years		1 : 476 years		1 : 1000 years		1 : 2500 years		RGC factors
Period (s)	SA (g)		SA (g)		SA (g)		SA (g)		
	FG	HR	FG	HR	FG	HR	FG	HR	
0.1	0.100	0.072	0.241	0.173	0.338	0.243	0.522	0.376	1.39
0.2	0.107	0.055	0.266	0.137	0.381	0.196	0.577	0.297	1.94
0.5	0.049	0.021	0.136	0.057	0.206	0.087	0.320	0.134	2.38
1	0.018	0.007	0.060	0.023	0.096	0.037	0.154	0.060	2.58
2	0.006	0.002	0.020	0.007	0.031	0.011	0.052	0.018	2.86
Peak acceleration	0.067	0.048	0.152	0.109	0.226	0.163	0.344	0.247	1.39

Note:
FG: Firm Ground soil condition (Reference Class C soil condition for 2005 NBCC)
HR: Hard Rock soil condition (Class A)

As indicated, the spectral acceleration data are available for Class C (FG / Firm Ground or Soft Rock) and for Class A (HR / Hard Rock) conditions. All non-critical equipment of the Rabaska LNG Terminal will be designed using the ground motion calculated by NBCC 2005.

3. SOIL LIQUEFACTION POTENTIAL – LAND SITE

3.1 General

The resistance of foundation materials to seismic loading, mainly the liquefaction potential, was determined by Terratech for the proposed LNG Process Area, where soil deposits are generally deeper than 5 or 6 m (Boreholes BH-401-05, BH-501-05 to BH-504-05 and BH-506-05), and locally extend to depths greater than 16 m (Boreholes BH-401-05 and BH-503-05). Borehole BH-505-05 was excluded from the analyses as bedrock was encountered at a depth of 0.8 m below existing ground surface.

Based on the above borehole results, the granular soil deposits are generally compact to dense as the measured (uncorrected) N_{SPT} index mostly range from 20 to 50. Such materials are generally not expected to be potentially liquefiable. Still, the potential for liquefaction has been checked using the Seed, H.B. and Idriss, I.M. 1971 "simplified procedure" as reviewed and updated by Youd, T.L. et al. 2001. This method compares the "cyclic stress ratio" (CSR) and the "cyclic resistance ratio" (CRR) to estimate the factor of safety against liquefaction.

The assessment of soil liquefaction potential is essentially based on the deterministic approach proposed by Youd, T.L. et al. 2001. Input in terms of peak ground acceleration (PGA) and earthquake magnitude (M_w) was provided by the Report "Earthquake Hazard Analysis" (see Appendix I).

3.2 Estimation of Cyclic Stress Ratio, CSR

The CSR, the imposed cyclic stress ratio or "the seismic demand on a soil layer", is estimated based on the peak ground acceleration at the site.

$$CSR = 0.65 \frac{a_{\max}}{g} \cdot \frac{\sigma_0}{\sigma'_0} \cdot r_d$$

The following peak ground accelerations (PGA) were provided in Table 2 (p. 28) of Atkinson, G.M. 2006.

- ***Return period of 500 years:***
  PGA: a_{max} = 149 cm/s^2 (or 0.15 g)

- ***Return period of 1 000 years:***
  PGA: a_{max} = 250 cm/s^2 (or 0.25 g)

- ***Return period of 2 500 years:***
  PGA: a_{max} = 446 cm/s^2 (or 0.45 g)

- ***Return period of 5 000 years:***
  PGA: a_{max} = 630 cm/s^2 (or 0.64 g)

In compliance with the method proposed by Youd, T.L. et al. 2001, computed CSR values were by necessity adjusted and converted into CSR / Kσ values whenever the acting effective overburden vertical stress exceeds 100 kPa. This procedure was required to allow a direct comparison with the CRR reference values or curves, and the determination of factors of safety with respect to soil liquefaction.

The CSR / Kσ values are shown on Figures 1A to 4A and 1B to 4B in Appendix II. They were determined only for computed $(N_1)_{60}$ data that are less than 30, as the method precludes the use of higher corrected N values by stating that such denser soils will not be prone to liquefaction. In this perspective and in assessing the depths where liquefaction could occur, consideration was given to both the graphical and tabulated data that are presented in Appendix I.

3.3 Estimation of Cyclic Resistance Ratio, CRR

The liquefaction resistance or the “capacity of the soil to resist liquefaction”, expressed in the term CRR, is estimated based on field density measurements and the so-called Seed chart as modified by NCEER and NCEER/NSF Workshops (Youd, T.L. et al. 2001). In Figures 1A to 4A (Appendix II), reference CRR_{corr} curves are shown for soils with fine contents (particles smaller than 0.080 mm) of 5 %, 15 % and 35 %. The

CRR_{corr} values given on Figures 1B to 4B are in reference to soils with a fines content of 5 %, which constitutes a conservative CRR profile.

The CRR values were estimated for the following earthquake magnitudes, on the basis of information provided in Atkinson, G.M. 2006:

- ***Return period of 500 years*** (Ref.: Appendix II, Figures 1A and 1B):
  Magnitude, M_w : 6.00 (Richter)

- ***Return period of 1000 years*** (Ref.: Appendix II, Figures 2A and 2B):
  Magnitude, M_w : 6.25 (Richter)

- ***Return period of 2500 years*** (Ref.: Appendix II, Figures 3A and 3B):
  Magnitude, M_w : 6.50 (Richter)

- ***Return period of 5000 years*** (Ref.: Appendix II, Figures 4A and 4B):
  Magnitude, M_w : 6.75 (Richter)

3.4 Factor of Safety with respect to Soil Liquefaction

The CRR_{corr} values (curves) and the CSR / Kσ profiles (points) are compared and the factor of safety is estimated as FS = CRR_{corr} / [CSR / Kσ] (Appendix II / Figures 1B to 4B). If the factor of safety is lower than 1.0, the soil should be considered as potentially liquefiable. However soils above the water table or with a noticeable clay content (i.e. soils with some clay or clayey soils) are not prone to liquefaction.

In reference to Figures 1A to 4A and with respect only to the CRR curve (FC = 5%) applicable to soils with no more than 5 % of fine particles smaller than 0.080 mm, the following "very safe soil liquefaction predictions" are given (but will be discussed further in this report):

- ***Return period of 500 years*** (Ref.: Appendix II, Figure 1A):
  - Borehole BH-401-05: *no liquefaction*.
  - Boreholes BH-501-05 to BH-504-05 and BH-506-05: *no liquefaction.*

- ***Return period of 1000 years*** (Ref.: Appendix II, Figure 2A):
  - Borehole BH-401-05: potential liquefaction from 13.7 to 17.5 m.
  - Boreholes BH-501-05 and BH-502-05: *no liquefaction.*
  - Borehole BH-503-05: potential liquefaction from 10.5 to 11.5 m.
  - Boreholes BH-504-05 and BH-506-05: *no liquefaction* from 0 to 6.5 or 6.6 m depth.

- ***Return period of 2500 years*** (Ref.: Appendix II, Figure 3A):
  - Borehole BH-401-05: potential liquefaction from 12.2 to 17.5 m.
  - Borehole BH-501-05: potential liquefaction from 3.8 to 5.8 m.
  - Borehole BH-502-05: *no liquefaction*.
  - Borehole BH-503-05: potential liquefaction from 10.5 to 11.5, 16.6 to 17.0, and 19.7 to 20.6 m.
  - Borehole BH-504-05: *no liquefaction* from 0 to 6.5 m depth.
  - Borehole BH-506-05: potential liquefaction from 4.6 to 5.1 m, and *no liquefaction* from 0 to 4.6 m and from 5.1 to 6.6 m depth.

- ***Return period of 5000 years*** (Ref.: Appendix II, Figure 4A):
  - Borehole BH-401-05: potential liquefaction from 7.6 to 8.3 m and from 9.4 to 17.5 m.
  - Borehole BH-501-05: potential liquefaction from 3.1 to 5.8 m.
  - Borehole BH-502-05: *no liquefaction*.
  - Borehole BH-503-05: potential liquefaction from 2.3 to 2.8, 10.5 to 12.7, 16.6 to 17.0, and 19.7 to 20.6 m.
  - Borehole BH-504-05: potential liquefaction from 0.8 to 1.3 m, and *no liquefaction* from 0 to 0.8 m and from 1.3 to 6.5 m depth.
  - Borehole BH-506-05: potential liquefaction from 4.6 to 5.1 m and *no liquefaction* from 0 to 4.6 m and from 5.1 to 6.6 m depth.

In reference to Tables 4-1 and 4-3 (pages 24 and 26) of the "Geotechnical Site Study Report (Phase 3)" of 23 May 2006, granular materials encountered at the project site (mainly sand and silt or gravely sand with some silt) were found to contain variable and often large quantities of fines, ranging from 8 to 66 % and averaging 32 %, and also clay size particles (smaller than 0.002 mm) ranging from 3 to 26 % and averaging 11 %. With the above gradation results, particles smaller than 0.005 mm within the predominantly granular materials would likely range from 4 to 35 % and average 16 %, thus suggesting that a large portion of the granular soils, irrelevant of the in-situ compactness, will not be prone to liquefaction, as the "Chinese Criteria" (Youd, T.L. et al. 2001) stipulates that soils with more than 15 % of particles smaller than 0.005 mm will not liquefy. In consideration of known fine contents (based on results of grain size analyses) or inferred values thereof (from visual description of recovered soils samples), remarks were added in Figures 1B to 4B, leading to the following "realistic soil liquefaction predictions":

- ***Return period of 500 years*** (Ref.: Appendix II, Figures 1A and 1B):
  - Borehole BH-401-05: *no liquefaction*.
  - Boreholes BH-501-05 to BH-504-05 and BH-506-05: *no liquefaction*.

- ***Return period of 1000 years*** (Ref.: Appendix II, Figures 2A and 2B):
  - Borehole BH-401-05: *no liquefaction* from 13.7 to 17.5 m as the visually examined silty sand likely contains at least 20 % of fines.
  - Boreholes BH-501-05 and BH-502-05: *no liquefaction.*
  - Borehole BH-503-05: potential liquefaction from 10.5 to 11.5 m, as the sand with some silt to silty could contain a little as 10 % of fines.
  - Boreholes BH-504-05 and BH-506-05: *no liquefaction* from 0 to 6.5 or 6.6 m depth.

- ***Return period of 2500 years*** (Ref.: Appendix II, Figures 3A and 3B):
  - Borehole BH-401-05: potential liquefaction from 12.2 to 17.5 m, as the visually examined silty sand likely contains at least 20 % of fines.

- Borehole BH-501-05: *no liquefaction* as the silt and sand from 3.8 to 5.8 m was found, from grain size analyses, to contain more than 35 % of fines
- Borehole BH-502-05: *no liquefaction*.
- Borehole BH-503-05: potential liquefaction from 10.5 to 11.5, 16.6 to 17.0, and 19.7 to 20.6 m, as the visually examined sand with some silt to silty sand could contain as little as 10 % of fines.
- Borehole BH-504-05: *no liquefaction* from 0 to 6.5 m depth.
- Borehole BH-506-05: *no liquefaction* from 4.6 to 5.1 m as the silty sand probably contains more than 35 % of fines based on grain size results on adjacent soil samples, and *no liquefaction* from 0 to 4.6, and from 5.1 to 6.6 m depth.

- ***Return period of 5000 years*** (Ref.: Appendix II, Figures 4A and 4B):
  - Borehole BH-401-05: potential liquefaction from 7.6 to 8.3 m, and 9.4 to 17.5 m, as the visually examined sand with some silt or silty sand likely contain some 10 or 20 % of fines.
  - Borehole BH-501-05: *no liquefaction* as the silt and sand from 3.1 to 5.8 m was found, from grain size analyses, to contain more than 35 % of fines
  - Borehole BH-502-05: *no liquefaction*.
  - Borehole BH-503-05: *no liquefaction* from 2.3 to 2.8 m, as the gravelly silt contains more than 35 % of fines. Potential liquefaction from 10.5 to 12.7 m as the sand with some silt can contain as little as 10 % of fines. Potential liquefaction from 16.6 to 17.0, and 19.7 to 20.6 m as the visually examined sand with some silt or silty sand could contain as little as 10 % of fines.
  - Borehole BH-504-05: *no liquefaction* from 0.8 to 1.3 m, as the silty sand contains more than 20 % of fines, and *no liquefaction* from 0 to 0.8 and from 1.3 to 6.5 m depth.

- Borehole BH-506-05: *no liquefaction* from 4.6 to 5.1 m, as the silty sand probably contains more than 35 % of fines based on grain size results on adjacent soil samples, and *no liquefaction* from 0 to 4.6 and from 5.1 to 6.6 m depth.

3.5 Comments about Soil Liquefaction

From the above "realistic soil liquefaction predictions", the following comments are provided in view of facilities founded on shallow footings located in the overburden:

(1) With a return period of 500 years, no soil liquefaction will occur.

(2) With a return period of 1000 years, soil liquefaction is possible very locally, in particular between depth 10.5 to 11.5 m at the site of one borehole (BH-503-05).

(3) With a longer return period of 2500 years, soil liquefaction is possible locally at the site of two boreholes (BH-401-05 and BH-503-05) out of a total of seven boreholes put down in the proposed LNG Process Area. Furthermore, at these locations the liquefaction of soil would potentially be generated at depths greater than 10 and 12 m, and also would be confined to a sand stratum some 5 m in thickness (BH-401-05) and to three deep and compact sand layers that are no thicker than 1 m (BH-503-05). At the site of Boreholes BH-504-05 and BH-506-05, which were terminated at an approximate depth of 6.5 m below grade in dense to very dense soils and without encountering bedrock, the presence below a depth of 6.5 m of compact soils with a low content of fines, and thus prone to liquefaction, is possible as such liquefiable soils were encountered in Borehole BH-401-05. This situation needs to be further investigated during the detailed engineering phases of the project

(4) With the more stringent return period of 5000 years, and based on the available subsurface information, soil liquefaction is possible at least at the site of two boreholes (BH-401-05 and BH-503-05) out of a total of seven boreholes carried out in Process Area. The vertical extent of the probable soil liquefaction would involve a 0.7 m thick soil layer at 7.5 m depth and a 6 m thick stratum beyond 9.4 m depth (BH-401-05), and three soils strata ranging in thickness from 0.4 to

2.2 m below a depth of 10.5 m (BH-503-05). As stated in (3) and in view of a possible situation that should be further investigated during the detailed engineering phases of the project, soil liquefaction remains a possibility in the vicinity of Boreholes BH-504-05 and BH-506-05 at depths greater than 6.5 and 6.6 m.

(5) From the above consideration and statements, the risk of soil liquefaction is seen as non-existing or negligible for return periods of 1 000 years or less, as soil liquefaction is foreseen as potentially occurring only very locally and at a depth greater than 10 m.

(6) With return periods of 2500 and 5000 years, soil liquefaction may potentially occur more frequently but only at depths greater than 10 to 12 m or 7 to 10 m respectively. This assessment is specific for the sites of Boreholes BH-401-05 and BH-503-05, and also possibly (and subjected to further subsurface investigations) at a depth greater than 6.5 m in the vicinity of Boreholes BH-504-05 and BH-506-05. At these locations, soil liquefaction is seen as constituting a limited or low hazard with respect to future performance of lightly loaded isolated shallow foundations, as the rather thick generally dense soils extending to 7 or 10 m depth that are not prone to liquefaction would provide a reliable bearing backup in case of local softening of deeper soils under severe earthquake conditions. With due consideration to the residual and reduced strength of deep soils during the liquefaction process, isolated lightly loaded footings seated at shallow depths (1.8 to 2.0 m depth range) are possible, as the upper layers of dense soil will readily dissipate and eliminate most of the stress induced by the footings into the deep softened “liquefied” soils. To achieve this goal (of limiting the induced stress into the deep strata prone to liquefaction), the footings should generally not exceed 2 to 3 m in width, exert vertical pressures no larger than 230 and 150 kPa respectively, and be at least laterally spaced at 6 m. With closer footings spaced at about 4 to 5 m, the above acting pressures (at foundation level) should be limited to 130 and 100 kPa respectively. At this preliminary phase of the project, it is inferred that all contemplated facilities (except the LNG storage tanks already seated on rock) would comply in terms of surface footing loading and layout to the above limitations. During the detail engineering studies, soil liquefaction issues for the

return period of 5000 years need to be addressed more closely in terms of soils surface loading, plant layout and soil gradation.

4. SOIL LIQUEFACTION POTENTIAL – MARINE SITE

Through a direct comparison of subsurface data presently available at the marine site or Jetty (from past investigations by others) with respect to the information obtained by Terratech at the land site of the contemplated LNG facilities, and with due consideration to the gradation and the relative density of similar type of soils, it is possible to extrapolate data for the marine site from some of the soil liquefaction predictions generated from the detailed analyses at the land site.

From this preliminary exercise, which in future times should by necessity be followed by detailed investigations, testing and analyses, the potential liquefaction of marine sediments under severe earthquake conditions, was assessed along the proposed pile supported jetty and the ship docking facilities. Soil liquefaction is thus foreseen to locally involve only the first 5 to 6 m of sediments, typically sand with traces of silt or sand with gravel, constituting the bottom of the St. Lawrence River, specifically at the site of Boreholes F-1, F-2A et F-3 (carried out by Laboratoires d'Expertises de Québec Ltée). Soil liquefaction would also occur within a thin layer of the bottom sand, less than 0.9 m in thickness, at the site of Boreholes F-8 et F-9, whereas no soil liquefaction was predicted at the locus of Borehole F-7, except very locally at an approximate depth of 10 m in bottom sediments.

The above preliminary predictions support the possibility of rather local soil liquefaction phenomena and somewhat preclude a general slip failure of the riverbed sediments. In this perspective and within this preliminary phase of the project, the piles of the jetty and docking facilities should be designed with due consideration for the temporary loss of lateral support within the predicted soil liquefaction zone.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 General

In addition to the recommendations already provided in Section 6 of Terratech Report T-1050-C (604238) "Geotechnical Site Study Report (Phase 3)" issued on 23 May 2006, the following is proposed regarding soil liquefaction potential at the project site.

5.2 LNG Storage Tanks

As stated in Section 6.2 of Terratech Report T-1050-C, the LNG storage tanks will be founded on bedrock. Soil liquefaction is therefore not an issue for LNG storage tanks.

5.3 LNG Process Area

Soil liquefaction under earthquake conditions within the LNG Process Area was discussed in Section 3. Based on "realistic" predictions for 500 to 1000 year recurrence periods, the phenomenon would have no effect on shallow foundations. With the longer 2500 and 5000 year recurrence periods, negligible or no consequences are foreseen with respect to future behaviour and integrity of lightly loaded shallow foundations (see definition in Section 3.5, Item 6), as a result of or due to soil softening that could occur locally at deeply below the footings. This assessment should be addressed more closely during the detailed engineering studies

5.4 Unloading Lines

Soil liquefaction under earthquake conditions may occur locally in the shallow layers of loose sand that were encountered at less than 2 or 3 m depth in Boreholes BH-302-05 to BH-304-05. To avoid damages to the unloading lines and facilities, the shallow loose soils should be excavated and replaced by well compacted granular fill materials, or the foundations should be seated on deeper and more competent soils, or on bedrock.

5.5 Marine structures

Based on the preliminary assessments, soil liquefaction at the marine site under the most severe earthquake conditions is only possible locally within the first 5 to 6 m of sediments in the St. Lawrence riverbed. General slip failures of bottom sediments are presently not considered an issue. Additional investigations and testing together with

formal soil liquefaction analyses shall be performed at the marine site as part of the future detailed engineering studies.

6. REFERENCES

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7. PERSONNEL

Sections 1, and 3 to 7 of this Addendum Report were prepared by Mr. Raymond Bousquet, Eng., M.A.Sc. Mrs. Catherine Bédard, Eng., M.A.Sc., carried out the detailed soil liquefaction software calculations whose results are presented in Appendix I, and provided assistance to the preparation of Section 3 of this report. Sections 2.1 and 2.2 of the report were written by Mr. Jean-Jacques Hébert, Geologist, and Mr. Yves Boulianne, Eng. Section 2.3.1 of the present document refers to a specialty report on Earthquake Hazard analysis prepared by Mrs. Gail M. Atkinson, Ph.D., Engineering Seismologist. Section 2.3.2 was prepared by Dr. Denise Leahy, Eng., Dr. Eng.

This document was reviewed for ISO Conformity by Mr. Henri Madjar, Eng., M.A.Sc.

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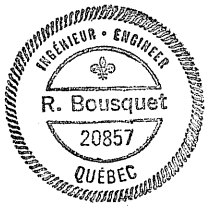

Raymond Bousquet, Eng., M.A.Sc.
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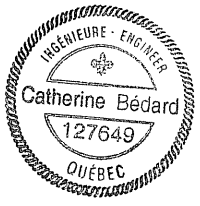

Catherine Bédard, Eng., M.A.Sc.,
Project Engineer

Reviewed for conformity
With ISO 9001 by:

Henri Madjar, Eng., M.A.Sc.
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Appendix I
Soil Liquefaction Data and Figures

Terratech

Figure 1A
Soil liquefaction - 1:500 years
Site Rabaska
a_{max} = 0.15g and magnitude 6.0 on Richter scale

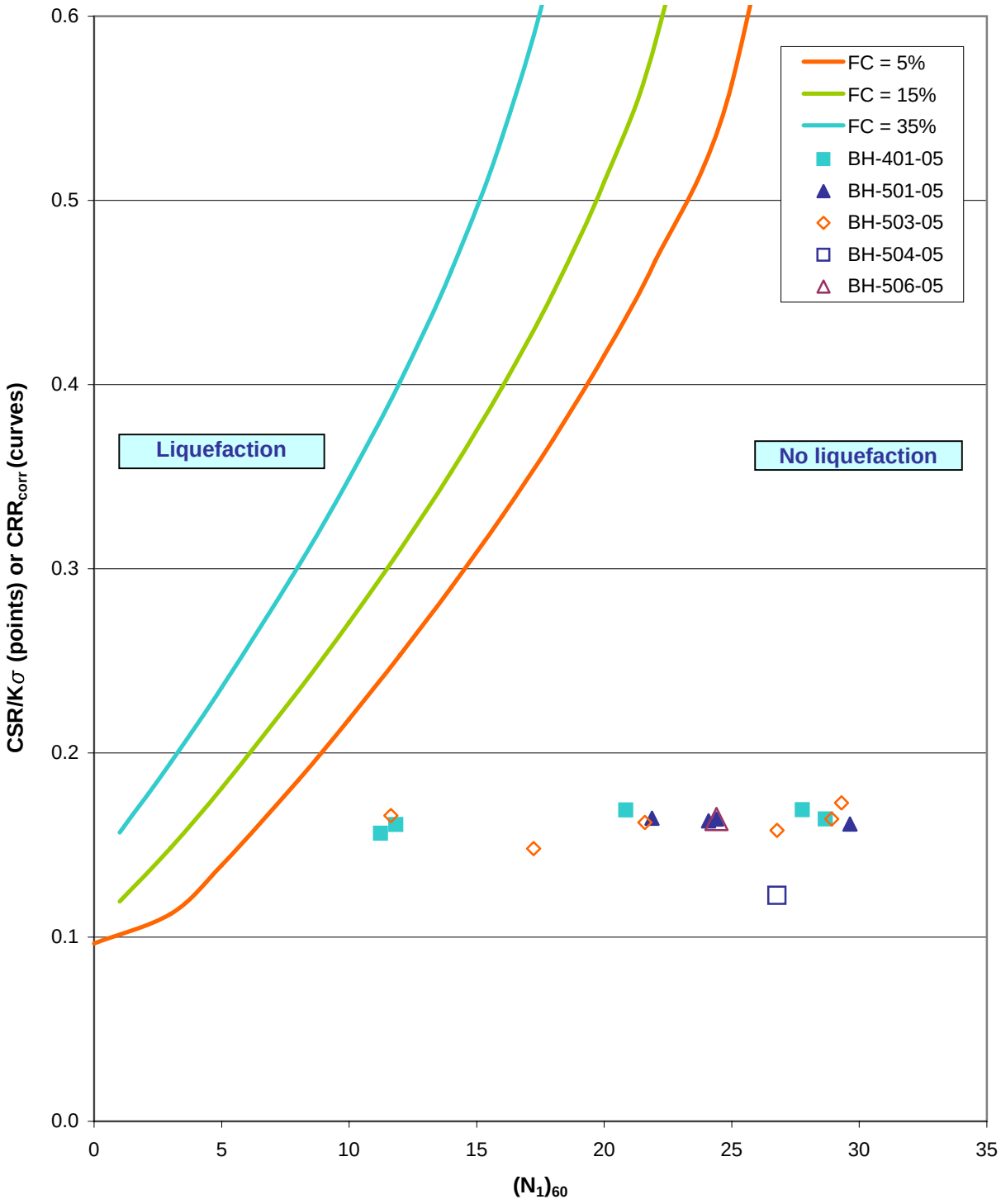

Figure 1B
Soil liquefaction for 1:500 years
Site Rabaska
a_{max} = 0.15g and magnitude of 6.0 on Richter scale

Borehole	Depth	Depth	N	σ_{vo}	σ_{vo}'	r_d	C_N	C_R	Dr	Kσ	$(N_1)_{60}$	CSR	CSR/Kσ	$CRR_{7.5}$	CRR_{corr}	Factor of Safety *	Description	Remarks
	m	m	blows / 0.3 m	kPa	kPa	-	-				blows / 0.3 m							
BH-401-05 (SS-1)	0.00	0.30	3	6	6	1.00	1.70	0.75	0.29	1.00	3.8	0.10	0.10	0.06	0.12	1.26	Sand	Above water level : no liquefaction
BH-401-05 (SS-2)	0.70	1.00	45	21	15	0.99	1.70	0.75	1.12	1.00	57.4	---	---	---	---	---	Sand	
BH-401-05 (SS-3)	1.50	1.80	37	38	24	0.99	1.70	0.75	1.01	1.00	47.2	---	---	---	---	---	Sand	
BH-401-05 (SS-4)	2.20	2.50	100	53	32	0.98	1.70	0.75	1.66	1.00	127.5	---	---	---	---	---	Sand	
BH-401-05 (SS-6)	3.00	3.30	100	69	41	0.97	1.56	0.80	1.65	1.00	125.2	---	---	---	---	---	Sand	
BH-401-05 (SS-8)	3.80	4.10	100	86	50	0.97	1.42	0.85	1.62	1.00	120.4	---	---	---	---	---	Sand	
BH-401-05 (SS-10)	4.60	4.90	54	103	59	0.96	1.30	0.85	1.14	1.00	59.9	---	---	---	---	---	Sand	
BH-401-05 (SS-11)	5.30	5.60	38	118	67	0.96	1.23	0.85	0.93	1.00	39.6	---	---	---	---	---	Sand	
BH-401-05 (SS-12)	6.10	6.40	34	134	76	0.95	1.15	0.95	0.90	1.00	37.2	---	---	---	---	---	Sand	
BH-401-05 (SS-13)	7.60	7.90	29	166	92	0.94	1.04	0.95	0.79	1.00	28.7	0.16	0.16	0.40	0.76	4.65	Sand	
BH-401-05 (SS-15)	9.00	9.30	100	195	108	0.93	0.96	0.95	1.41	0.95	91.4	---	---	---	---	---	Sand	
BH-401-05 (SS-17)	9.40	9.70	31	204	112	0.92	0.94	0.95	0.78	0.96	27.8	0.16	0.17	0.36	0.70	4.13	Sand	
BH-401-05 (SS-20)	12.20	12.50	25	263	144	0.84	0.83	1.00	0.67	0.88	20.8	0.15	0.17	0.23	0.44	2.58	Sand	
BH-401-05 (SS-21)	13.70	14.00	15	294	161	0.80	0.79	1.00	0.51	0.89	11.8	0.14	0.16	0.13	0.25	1.55	Sand	
BH-401-05 (SS-22)	15.30	15.60	15	328	178	0.76	0.75	1.00	0.49	0.87	11.2	0.14	0.16	0.12	0.24	1.53	Sand	
BH-501-05 (SS-1)	0.00	0.30	6	6	6	1.00	1.70	0.75	0.41	1.00	7.7	0.10	0.10	0.09	0.18	1.85	Sand	Above water level : no liquefaction
BH-501-05 (SS-2)	0.70	1.00	29	21	15	0.99	1.70	0.75	0.90	1.00	37.0	---	---	---	---	---	Sand	
BH-501-05 (SS-3)	1.50	1.80	17	38	24	0.99	1.70	0.75	0.69	1.00	21.7	0.15	0.15	0.24	0.46	3.04	Clayey soil	Clayey soil: no liquefaction
BH-501-05 (SS-4)	2.30	2.60	24	55	33	0.98	1.70	0.75	0.82	1.00	30.6	---	---	---	---	---	Clayey soil	Clayey soil: no liquefaction
BH-501-05 (SS-5)	3.10	3.40	24	71	42	0.97	1.54	0.80	0.80	1.00	29.6	0.16	0.16	0.44	0.86	5.31	Sand	
BH-501-05 (SS-6)	3.80	4.10	20	86	50	0.97	1.42	0.85	0.72	1.00	24.1	0.16	0.16	0.27	0.53	3.25	Sand	
BH-501-05 (SS-7)	4.60	4.90	22	103	59	0.96	1.30	0.85	0.73	1.00	24.4	0.16	0.16	0.28	0.54	3.30	Sand	
BH-501-05 (SS-8)	5.30	5.60	21	118	67	0.96	1.23	0.85	0.69	1.00	21.9	0.16	0.16	0.24	0.46	2.82	Sand	
BH-501-05 (SS-9)	6.10	6.40	47	134	76	0.95	1.15	0.95	1.06	1.00	51.4	---	---	---	---	---	Sand	
BH-501-05 (SS-10)	6.80	7.10	46	149	83	0.94	1.10	0.95	1.02	1.00	47.9	---	---	---	---	---	Sand	
BH-501-05 (SS-11)	7.60	7.90	136	166	92	0.94	1.04	0.95	1.71	1.00	134.5	---	---	---	---	---	Sand	
BH-501-05 (SS-12)	9.10	9.40	100	197	109	0.92	0.96	0.95	1.41	0.94	90.9	---	---	---	---	---	Sand	
BH-502-05 (SS-1)	0.00	0.30	7	6	6	1.00	1.70	0.75	0.44	1.00	8.9	0.10	0.10	0.10	0.20	2.06	Sand	Above water level : no liquefaction
BH-502-05 (SS-2)	0.70	1.00	64	21	19	0.99	1.70	0.75	1.33	1.00	81.6	---	---	---	---	---	Clayey soil	Clayey soil: no liquefaction
BH-502-05 (SS-3)	1.50	1.80	100	38	28	0.99	1.70	0.75	1.66	1.00	127.5	---	---	---	---	---	Sand	
BH-502-05 (SS-5)	2.20	2.50	47	53	36	0.98	1.67	0.75	1.13	1.00	58.9	---	---	---	---	---	Clayey soil	Clayey soil: no liquefaction
BH-502-05 (SS-6)	3.00	3.30	36	69	45	0.97	1.49	0.80	0.97	1.00	43.0	---	---	---	---	---	Clayey soil	Clayey soil: no liquefaction
BH-502-05 (SS-7)	3.80	4.10	25	86	54	0.97	1.36	0.85	0.79	1.00	29.0	0.15	0.15	0.41	0.79	5.23	Clayey soil	Clayey soil: no liquefaction
BH-502-05 (SS-8)	4.50	4.80	28	101	62	0.96	1.27	0.85	0.81	1.00	30.3	---	---	---	---	---	Sand	

Figure 1B
Soil liquefaction for 1:500 years
Site Rabaska
a_{max} = 0.15g and magnitude of 6.0 on Richter scale

Borehole	Depth	Depth	N	σ_{vo}	σ_{vo}'	r_d	C_N	C_R	Dr	Kσ	(N1)60	CSR	CSR/Kσ	$CRR_{7.5}$	CRR_{corr}	Factor of Safety *	Description	Remarks
	m	m	blows / 0.3 m	kPa	kPa	-	-				blows / 0.3 m							
BH-503-05 (SS-1)	0.00	0.30	13	6	6	1.00	1.70	0.75	0.60	1.00	16.6	0.10	0.10	0.18	0.34	3.50	Sand	Above water level : no liquefaction
BH-503-05 (SS-2)	0.70	1.00	30	21	15	0.99	1.70	0.75	0.91	1.00	38.3	---	---	---	---	---	Sand	
BH-503-05 (SS-3)	1.50	1.80	40	38	24	0.99	1.70	0.75	1.05	1.00	51.0	---	---	---	---	---	Sand	
BH-503-05 (SS-4)	2.30	2.60	21	55	33	0.98	1.70	0.75	0.76	1.00	26.8	0.16	0.16	0.33	0.64	4.06	Sand	
BH-503-05 (SS-5)	3.10	3.40	74	71	42	0.97	1.54	0.80	1.41	1.00	91.4	---	---	---	---	---	Sand	
BH-503-05 (SS-7)	3.80	4.10	60	86	50	0.97	1.42	0.85	1.25	1.00	72.3	---	---	---	---	---	Sand	
BH-503-05 (SS-8)	4.50	4.80	52	101	58	0.96	1.32	0.85	1.13	1.00	58.2	---	---	---	---	---	Sand	
BH-503-05 (SS-10)	5.30	5.60	54	118	67	0.96	1.23	0.85	1.11	1.00	56.2	---	---	---	---	---	Sand	
BH-503-05 (SS-11)	6.10	6.40	34	134	76	0.95	1.15	0.95	0.90	1.00	37.2	---	---	---	---	---	Sand	
BH-503-05 (SS-12)	7.60	7.90	31	166	92	0.94	1.04	0.95	0.82	1.00	30.6	---	---	---	---	---	Sand	
BH-503-05 (SS-14)	9.20	9.50	100	200	110	0.92	0.95	0.95	1.40	0.93	90.5	---	---	---	---	---	Sand	
BH-503-05 (SS-17)	9.70	10.00	67	210	116	0.91	0.93	1.00	1.16	0.92	62.3	---	---	---	---	---	Sand	
BH-503-05 (SS-19)	10.50	10.80	13	227	125	0.89	0.90	1.00	0.50	0.95	11.6	0.16	0.17	0.13	0.25	1.49	Sand	
BH-503-05 (SS-20)	12.10	12.40	35	260	143	0.84	0.84	1.00	0.80	0.87	29.3	0.15	0.17	0.43	0.82	4.75	Sand	
BH-503-05 (SS-22)	13.60	13.90	47	292	159	0.80	0.79	1.00	0.90	0.81	37.2	---	---	---	---	---	Sand	
BH-503-05 (SS-23)	15.10	15.40	73	323	176	0.76	0.75	1.00	1.09	0.73	55.0	---	---	---	---	---	Sand	
BH-503-05 (SS-24)	16.60	16.90	30	355	193	0.72	0.72	1.00	0.69	0.80	21.6	0.13	0.16	0.24	0.46	2.81	Sand	
BH-503-05 (SS-26)	18.20	18.50	42	389	211	0.68	0.69	1.00	0.79	0.74	28.9	0.12	0.16	0.41	0.78	4.78	Sand	
BH-503-05 (SS-28)	19.70	20.00	26	420	228	0.64	0.66	1.00	0.61	0.78	17.2	0.12	0.15	0.18	0.35	2.39	Sand	
BH-503-05 (SS-29)	21.20	21.50	82	452	245	0.60	0.64	1.00	1.07	0.62	52.4	---	---	---	---	---	Sand	
BH-503-05 (SS-30)	22.80	23.10	100	485	262	0.56	0.62	1.00	1.16	0.57	61.7	---	---	---	---	---	Sand	
BH-503-05 (SS-33)	24.00	24.30	100	510	276	0.53	0.60	1.00	1.14	0.56	60.2	---	---	---	---	---	Sand	
BH-504-05 (SS-1)	0.00	0.30	5	6	6	1.00	1.70	0.75	0.37	1.00	6.4	0.10	0.10	0.08	0.16	1.64	Clayey soil	Above water level and clayey soil : no liquefaction
BH-504-05 (SS-2)	0.80	1.10	21	23	18	0.99	1.70	0.75	0.76	1.00	26.8	0.12	0.12	0.33	0.64	5.23	Sand	
BH-504-05 (SS-3)	1.50	1.80	24	38	26	0.99	1.70	0.75	0.82	1.00	30.6	---	---	---	---	---	Sand	
BH-504-05 (SS-4)	2.30	2.60	34	55	35	0.98	1.69	0.75	0.97	1.00	43.1	---	---	---	---	---	Sand	
BH-504-05 (SS-5)	3.00	3.30	86	69	43	0.97	1.53	0.80	1.51	1.00	105.1	---	---	---	---	---	Sand	
BH-504-05 (SS-7)	3.80	4.10	100	86	52	0.97	1.39	0.85	1.60	1.00	118.1	---	---	---	---	---	Sand	
BH-504-05 (SS-10)	4.90	5.20	100	109	64	0.96	1.25	0.85	1.52	1.00	106.2	---	---	---	---	---	Sand	
BH-504-05 (SS-12)	5.70	6.00	68	126	73	0.95	1.17	0.95	1.28	1.00	75.6	---	---	---	---	---	Sand	
BH-504-05 (SS-13)	6.10	6.40	100	134	78	0.95	1.14	0.95	1.53	1.00	107.9	---	---	---	---	---	Sand	

Figure 1B
Soil liquefaction for 1:500 years
Site Rabaska
a_{max} = 0.15g and magnitude of 6.0 on Richter scale

Borehole	Depth	Depth	N	σ_{vo}	σ_{vo}'	r_d	C_N	C_R	Dr	Kσ	$(N1)_{60}$	CSR	CSR/Kσ	$CRR_{7.5}$	CRR_{corr}	Factor of Safety *	Description	Remarks
	m	m	blows / 0.3 m	kPa	kPa	-	-				blows / 0.3 m							
BH-506-05 (SS-1)	0.00	0.30	6	6	6	1.00	1.70	0.75	0.41	1.00	7.7	0.10	0.10	0.09	0.18	1.85	Sand	Above water level : no liquefaction
BH-506-05 (SS-2)	0.80	1.10	24	23	16	0.99	1.70	0.75	0.82	1.00	30.6	---	---	---	---	---	Sand	
BH-506-05 (SS-3)	1.50	1.80	36	38	24	0.99	1.70	0.75	1.00	1.00	45.9	---	---	---	---	---	Sand	
BH-506-05 (SS-4)	2.30	2.60	44	55	33	0.98	1.70	0.75	1.10	1.00	56.1	---	---	---	---	---	Sand	
BH-506-05 (SS-6)	3.00	3.30	100	69	41	0.97	1.56	0.80	1.65	1.00	125.2	---	---	---	---	---	Sand	
BH-506-05 (SS-8)	3.80	4.10	32	86	50	0.97	1.42	0.85	0.92	1.00	38.5	---	---	---	---	---	Sand	
BH-506-05 (SS-9)	4.60	4.90	22	103	59	0.96	1.30	0.85	0.73	1.00	24.4	0.16	0.16	0.28	0.54	3.30	Sand	
BH-506-05 (SS-10)	5.30	5.60	29	118	67	0.96	1.23	0.85	0.81	1.00	30.2	---	---	---	---	---	Sand	
BH-506-05 (SS-11)	6.10	6.40	75	134	76	0.95	1.15	0.95	1.33	1.00	82.0	---	---	---	---	---	Sand	

N: blow count/0.3 m
σ_{vo} : total overburden stress
σ_{vo} : effective overburden stress
r_d: stress reduction coefficient
C_N: correction factor foroverburden pressure
C_R: correction factor for rod lenght
Dr : relative density
Kσ: correction for high overburden stresses
$(N_1)_{60}$: correction of N
CSR: cyclic stress ratio
$CRR_{7.5}$: cyclic resistance ratio for magnitude 7.5
CRR_{corr}: cyclic resistance ratio for a different magnitude (MSF)
MSF: magnitude scaling factor

LEGEND	
Above ground water level	Depth < 9.15 m
Below ground water level	Depth > 9.15 m

Granular soil
Clayey soil

--- **$(N1)_{60}$ >= 30 : No liquefaction**

*** Factor of Safety: F.S.= ($CRR_{7.5}$/CSR)*MSF*Kσ**

* Note: factor ofs safety calculated for 5% fine content

Figure 2A
Soil liquefaction - 1:1000 years
Site Rabaska
a_{max} = 0.25g and magnitude 6.25 on Richter scale

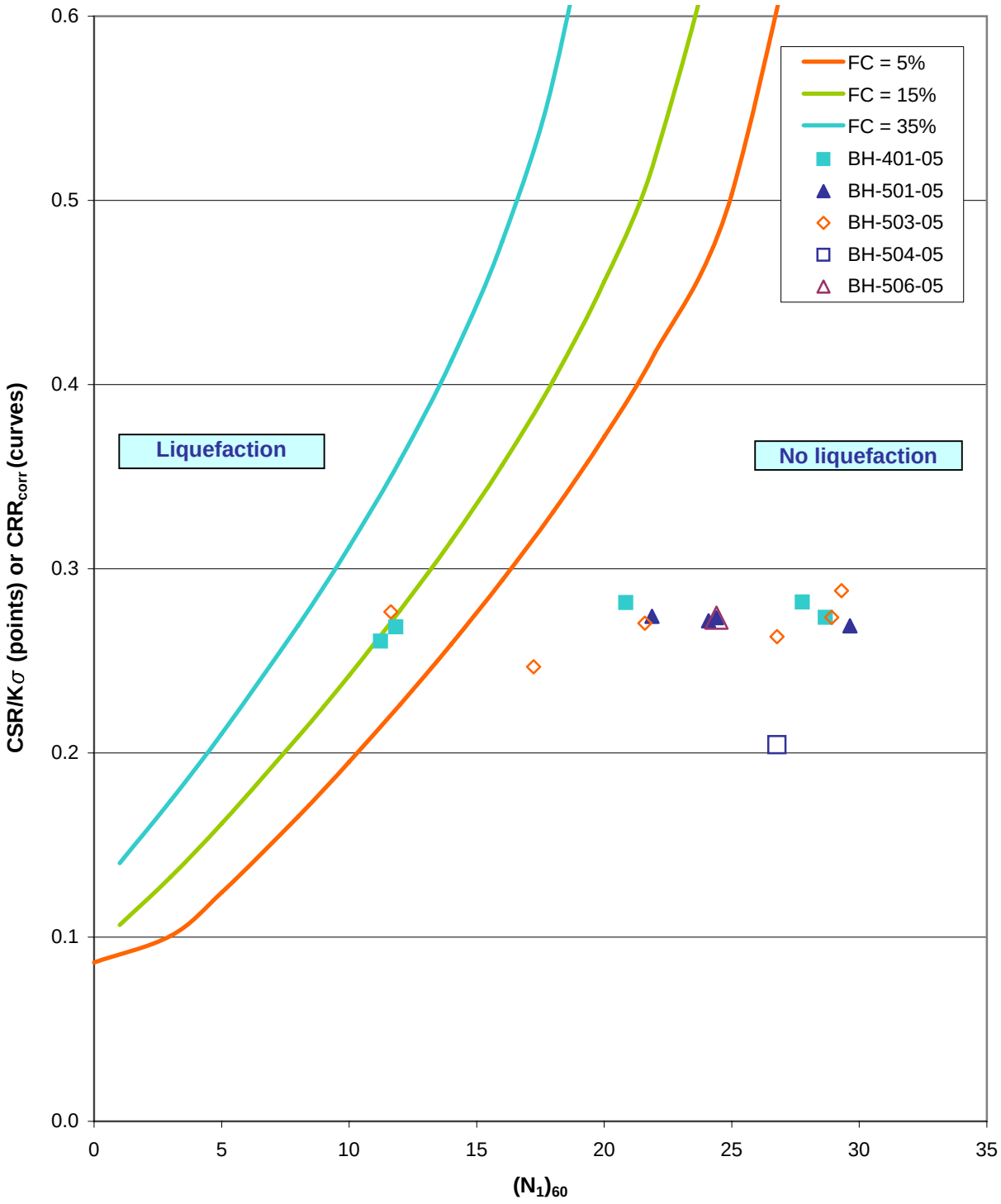

Figure 2B
Soil liquefaction for 1:1000 years
Site Rabaska
a_{max} = 0.25g and magnitude of 6.25 on Richter scale

Borehole	Depth	Depth	N	σ_{vo}	σ_{vo}'	r_d	C_N	C_R	Dr	Kσ	$(N_1)_{60}$	CSR	CSR/Kσ	$CRR_{7.5}$	CRR_{corr}	Factor of Safety *	Description	Remarks
	m	m	blows / 0.3 m	kPa	kPa	-	-				blows / 0.3 m							
BH-401-05 (SS-1)	0.00	0.30	3	6	6	1.00	1.70	0.75	0.29	1.00	3.8	0.16	0.16	0.06	0.11	0.68	Sand	Above water level : no liquefaction
BH-401-05 (SS-2)	0.70	1.00	45	21	15	0.99	1.70	0.75	1.12	1.00	57.4	---	---	---	---	---	Sand	
BH-401-05 (SS-3)	1.50	1.80	37	38	24	0.99	1.70	0.75	1.01	1.00	47.2	---	---	---	---	---	Sand	
BH-401-05 (SS-4)	2.20	2.50	100	53	32	0.98	1.70	0.75	1.66	1.00	127.5	---	---	---	---	---	Sand	
BH-401-05 (SS-6)	3.00	3.30	100	69	41	0.97	1.56	0.80	1.65	1.00	125.2	---	---	---	---	---	Sand	
BH-401-05 (SS-8)	3.80	4.10	100	86	50	0.97	1.42	0.85	1.62	1.00	120.4	---	---	---	---	---	Sand	
BH-401-05 (SS-10)	4.60	4.90	54	103	59	0.96	1.30	0.85	1.14	1.00	59.9	---	---	---	---	---	Sand	
BH-401-05 (SS-11)	5.30	5.60	38	118	67	0.96	1.23	0.85	0.93	1.00	39.6	---	---	---	---	---	Sand	
BH-401-05 (SS-12)	6.10	6.40	34	134	76	0.95	1.15	0.95	0.90	1.00	37.2	---	---	---	---	---	Sand	
BH-401-05 (SS-13)	7.60	7.90	29	166	92	0.94	1.04	0.95	0.79	1.00	28.7	0.27	0.27	0.40	0.68	2.49	Sand	
BH-401-05 (SS-15)	9.00	9.30	100	195	108	0.93	0.96	0.95	1.41	0.95	91.4	---	---	---	---	---	Sand	
BH-401-05 (SS-17)	9.40	9.70	31	204	112	0.92	0.94	0.95	0.78	0.96	27.8	0.27	0.28	0.36	0.62	2.21	Sand	
BH-401-05 (SS-20)	12.20	12.50	25	263	144	0.84	0.83	1.00	0.67	0.88	20.8	0.25	0.28	0.23	0.39	1.39	Sand	
BH-401-05 (SS-21)	13.70	14.00	15	294	161	0.80	0.79	1.00	0.51	0.89	11.8	0.24	0.27	0.13	0.22	0.83	Silty sand	No liquefaction with 20 % fines
BH-401-05 (SS-22)	15.30	15.60	15	328	178	0.76	0.75	1.00	0.49	0.87	11.2	0.23	0.26	0.12	0.21	0.82	Silty sand	No liquefaction with 20 % fines
BH-501-05 (SS-1)	0.00	0.30	6	6	6	1.00	1.70	0.75	0.41	1.00	7.7	0.16	0.16	0.09	0.16	0.99	Sand	Above water level : no liquefaction
BH-501-05 (SS-2)	0.70	1.00	29	21	15	0.99	1.70	0.75	0.90	1.00	37.0	---	---	---	---	---	Sand	
BH-501-05 (SS-3)	1.50	1.80	17	38	24	0.99	1.70	0.75	0.69	1.00	21.7	0.25	0.25	0.24	0.41	1.63	Clayey soil	Clayey soil: no liquefaction
BH-501-05 (SS-4)	2.30	2.60	24	55	33	0.98	1.70	0.75	0.82	1.00	30.6	---	---	---	---	---	Clayey soil	Clayey soil: no liquefaction
BH-501-05 (SS-5)	3.10	3.40	24	71	42	0.97	1.54	0.80	0.80	1.00	29.6	0.27	0.27	0.44	0.77	2.85	Sand	
BH-501-05 (SS-6)	3.80	4.10	20	86	50	0.97	1.42	0.85	0.72	1.00	24.1	0.27	0.27	0.27	0.47	1.75	Sand	
BH-501-05 (SS-7)	4.60	4.90	22	103	59	0.96	1.30	0.85	0.73	1.00	24.4	0.27	0.27	0.28	0.48	1.77	Sand	
BH-501-05 (SS-8)	5.30	5.60	21	118	67	0.96	1.23	0.85	0.69	1.00	21.9	0.27	0.27	0.24	0.41	1.51	Sand	
BH-501-05 (SS-9)	6.10	6.40	47	134	76	0.95	1.15	0.95	1.06	1.00	51.4	---	---	---	---	---	Sand	
BH-501-05 (SS-10)	6.80	7.10	46	149	83	0.94	1.10	0.95	1.02	1.00	47.9	---	---	---	---	---	Sand	
BH-501-05 (SS-11)	7.60	7.90	136	166	92	0.94	1.04	0.95	1.71	1.00	134.5	---	---	---	---	---	Sand	
BH-501-05 (SS-12)	9.10	9.40	100	197	109	0.92	0.96	0.95	1.41	0.94	90.9	---	---	---	---	---	Sand	
BH-502-05 (SS-1)	0.00	0.30	7	6	6	1.00	1.70	0.75	0.44	1.00	8.9	0.16	0.16	0.10	0.18	1.10	Sand	Above water level : no liquefaction
BH-502-05 (SS-2)	0.70	1.00	64	21	19	0.99	1.70	0.75	1.33	1.00	81.6	---	---	---	---	---	Clayey soil	Clayey soil: no liquefaction
BH-502-05 (SS-3)	1.50	1.80	100	38	28	0.99	1.70	0.75	1.66	1.00	127.5	---	---	---	---	---	Sand	
BH-502-05 (SS-5)	2.20	2.50	47	53	36	0.98	1.67	0.75	1.13	1.00	58.9	---	---	---	---	---	Clayey soil	Clayey soil: no liquefaction
BH-502-05 (SS-6)	3.00	3.30	36	69	45	0.97	1.49	0.80	0.97	1.00	43.0	---	---	---	---	---	Clayey soil	Clayey soil: no liquefaction
BH-502-05 (SS-7)	3.80	4.10	25	86	54	0.97	1.36	0.85	0.79	1.00	29.0	0.25	0.25	0.41	0.71	2.81	Clayey soil	Clayey soil: no liquefaction
BH-502-05 (SS-8)	4.50	4.80	28	101	62	0.96	1.27	0.85	0.81	1.00	30.3	---	---	---	---	---	Sand	

Figure 2B
Soil liquefaction for 1:1000 years
Site Rabaska
a_{max} = 0.25g and magnitude of 6.25 on Richter scale

Borehole	Depth	Depth	N	σ_{vo}	σ_{vo}'	r_d	C_N	C_R	Dr	Kσ	$(N_1)_{60}$	CSR	CSR/Kσ	$CRR_{7.5}$	CRR_{corr}	Factor of Safety *	Description	Remarks
	m	m	blows / 0.3 m	kPa	kPa	-	-				blows / 0.3 m							
BH-503-05 (SS-1)	0.00	0.30	13	6	6	1.00	1.70	0.75	0.60	1.00	16.6	0.16	0.16	0.18	0.30	1.88	Sand	Above water level : no liquefaction
BH-503-05 (SS-2)	0.70	1.00	30	21	15	0.99	1.70	0.75	0.91	1.00	38.3	---	---	---	---	---	Sand	
BH-503-05 (SS-3)	1.50	1.80	40	38	24	0.99	1.70	0.75	1.05	1.00	51.0	---	---	---	---	---	Sand	
BH-503-05 (SS-4)	2.30	2.60	21	55	33	0.98	1.70	0.75	0.76	1.00	26.8	0.26	0.26	0.33	0.57	2.18	Sand	
BH-503-05 (SS-5)	3.10	3.40	74	71	42	0.97	1.54	0.80	1.41	1.00	91.4	---	---	---	---	---	Sand	
BH-503-05 (SS-7)	3.80	4.10	60	86	50	0.97	1.42	0.85	1.25	1.00	72.3	---	---	---	---	---	Sand	
BH-503-05 (SS-8)	4.50	4.80	52	101	58	0.96	1.32	0.85	1.13	1.00	58.2	---	---	---	---	---	Sand	
BH-503-05 (SS-10)	5.30	5.60	54	118	67	0.96	1.23	0.85	1.11	1.00	56.2	---	---	---	---	---	Sand	
BH-503-05 (SS-11)	6.10	6.40	34	134	76	0.95	1.15	0.95	0.90	1.00	37.2	---	---	---	---	---	Sand	
BH-503-05 (SS-12)	7.60	7.90	31	166	92	0.94	1.04	0.95	0.82	1.00	30.6	---	---	---	---	---	Sand	
BH-503-05 (SS-14)	9.20	9.50	100	200	110	0.92	0.95	0.95	1.40	0.93	90.5	---	---	---	---	---	Sand	
BH-503-05 (SS-17)	9.70	10.00	67	210	116	0.91	0.93	1.00	1.16	0.92	62.3	---	---	---	---	---	Sand	
BH-503-05 (SS-19)	10.50	10.80	13	227	125	0.89	0.90	1.00	0.50	0.95	11.6	0.26	0.28	0.13	0.22	0.80	Sand, some silt	**Liquefaction is possible with 10 % fines**
BH-503-05 (SS-20)	12.10	12.40	35	260	143	0.84	0.84	1.00	0.80	0.87	29.3	0.25	0.29	0.43	0.73	2.55	Sand	
BH-503-05 (SS-22)	13.60	13.90	47	292	159	0.80	0.79	1.00	0.90	0.81	37.2	---	---	---	---	---	Sand	
BH-503-05 (SS-23)	15.10	15.40	73	323	176	0.76	0.75	1.00	1.09	0.73	55.0	---	---	---	---	---	Sand	
BH-503-05 (SS-24)	16.60	16.90	30	355	193	0.72	0.72	1.00	0.69	0.80	21.6	0.22	0.27	0.24	0.41	1.51	Sand	
BH-503-05 (SS-26)	18.20	18.50	42	389	211	0.68	0.69	1.00	0.79	0.74	28.9	0.20	0.27	0.41	0.70	2.56	Sand	
BH-503-05 (SS-28)	19.70	20.00	26	420	228	0.64	0.66	1.00	0.61	0.78	17.2	0.19	0.25	0.18	0.32	1.28	Sand	
BH-503-05 (SS-29)	21.20	21.50	82	452	245	0.60	0.64	1.00	1.07	0.62	52.4	---	---	---	---	---	Sand	
BH-503-05 (SS-30)	22.80	23.10	100	485	262	0.56	0.62	1.00	1.16	0.57	61.7	---	---	---	---	---	Sand	
BH-503-05 (SS-33)	24.00	24.30	100	510	276	0.53	0.60	1.00	1.14	0.56	60.2	---	---	---	---	---	Sand	
BH-504-05 (SS-1)	0.00	0.30	5	6	6	1.00	1.70	0.75	0.37	1.00	6.4	0.16	0.16	0.08	0.14	0.88	Clayey soil	Above water level and clayey soil : no liquefaction
BH-504-05 (SS-2)	0.80	1.10	21	23	18	0.99	1.70	0.75	0.76	1.00	26.8	0.20	0.20	0.33	0.57	2.80	Sand	
BH-504-05 (SS-3)	1.50	1.80	24	38	26	0.99	1.70	0.75	0.82	1.00	30.6	---	---	---	---	---	Sand	
BH-504-05 (SS-4)	2.30	2.60	34	55	35	0.98	1.69	0.75	0.97	1.00	43.1	---	---	---	---	---	Sand	
BH-504-05 (SS-5)	3.00	3.30	86	69	43	0.97	1.53	0.80	1.51	1.00	105.1	---	---	---	---	---	Sand	
BH-504-05 (SS-7)	3.80	4.10	100	86	52	0.97	1.39	0.85	1.60	1.00	118.1	---	---	---	---	---	Sand	
BH-504-05 (SS-10)	4.90	5.20	100	109	64	0.96	1.25	0.85	1.52	1.00	106.2	---	---	---	---	---	Sand	
BH-504-05 (SS-12)	5.70	6.00	68	126	73	0.95	1.17	0.95	1.28	1.00	75.6	---	---	---	---	---	Sand	
BH-504-05 (SS-13)	6.10	6.40	100	134	78	0.95	1.14	0.95	1.53	1.00	107.9	---	---	---	---	---	Sand	

Figure 2B
Soil liquefaction for 1:1000 years
Site Rabaska
a_{max} = 0.25g and magnitude of 6.25 on Richter scale

Borehole	Depth	Depth	N	σ_{vo}	σ_{vo}'	r_d	C_N	C_R	Dr	Kσ	$(N1)_{60}$	CSR	CSR/Kσ	$CRR_{7.5}$	CRR_{corr}	Factor of Safety *	Description	Remarks
	m	m	blows / 0.3 m	kPa	kPa	-	-				blows / 0.3 m							
BH-506-05 (SS-1)	0.00	0.30	6	6	6	1.00	1.70	0.75	0.41	1.00	7.7	0.16	0.16	0.09	0.16	0.99	Sand	Above water level : no liquefaction
BH-506-05 (SS-2)	0.80	1.10	24	23	16	0.99	1.70	0.75	0.82	1.00	30.6	---	---	---	---	---	Sand	
BH-506-05 (SS-3)	1.50	1.80	36	38	24	0.99	1.70	0.75	1.00	1.00	45.9	---	---	---	---	---	Sand	
BH-506-05 (SS-4)	2.30	2.60	44	55	33	0.98	1.70	0.75	1.10	1.00	56.1	---	---	---	---	---	Sand	
BH-506-05 (SS-6)	3.00	3.30	100	69	41	0.97	1.56	0.80	1.65	1.00	125.2	---	---	---	---	---	Sand	
BH-506-05 (SS-8)	3.80	4.10	32	86	50	0.97	1.42	0.85	0.92	1.00	38.5	---	---	---	---	---	Sand	
BH-506-05 (SS-9)	4.60	4.90	22	103	59	0.96	1.30	0.85	0.73	1.00	24.4	0.27	0.27	0.28	0.48	1.77	Sand	
BH-506-05 (SS-10)	5.30	5.60	29	118	67	0.96	1.23	0.85	0.81	1.00	30.2	---	---	---	---	---	Sand	
BH-506-05 (SS-11)	6.10	6.40	75	134	76	0.95	1.15	0.95	1.33	1.00	82.0	---	---	---	---	---	Sand	

N: blow count/0.3 m
σ_{vo} : total overburden stress
σ_{vo} : effective overburden stress
r_d: stress reduction coefficient
C_N: correction factor foroverburden pressure
C_R: correction factor for rod lenght
Dr : relative density
Kσ: correction for high overburden stresses
$(N_1)_{60}$: correction of N
CSR: cyclic stress ratio
$CRR_{7.5}$: cyclic resistance ratio for magnitude 7.5
CRR_{corr}: cyclic resistance ratio for a different magnitude (MSF)
MSF: magnitude scaling factor

LEGEND	
Above ground water level	Depth < 9.15 m
Below ground water level	Depth > 9.15 m

Granular soil
Clayey soil

--- **$(N1)_{60}$ >= 30 : No liquefaction**

*** Factor of Safety: F.S.= ($CRR_{7.5}$/CSR)*MSF*Kσ**

* Note: factor ofs safety calculated for 5% fine content

Figure 3A
Soil liquefaction - 1:2500 years
Site Rabaska
a_{max} = 0.45g and magnitude 6.5 on Richter scale

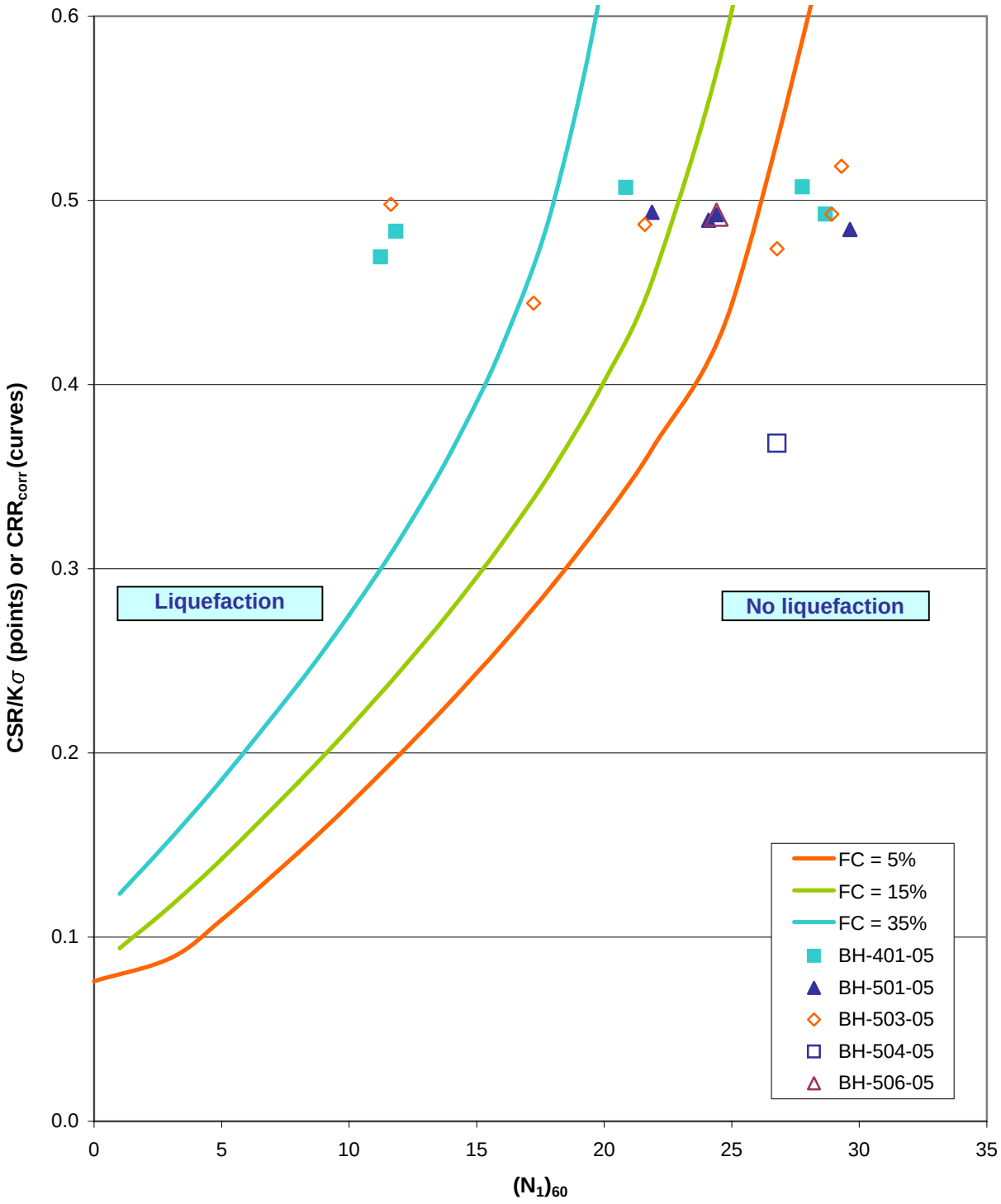

Figure 3B
Soil liquefaction for 1:2500 years
Site Rabaska
a_{max} = 0.45g and magnitude of 6.5 on Richter scale

Borehole	Depth	Depth	N	σ_{vo}	σ_{vo}'	rd	C_N	C_R	Dr	Kσ	$(N_1)_{60}$	CSR	CSR/Kσ	$CRR_{7.5}$	CRR_{corr}	Factor of Safety *	Description	Remarks
	m	m	blows / 0.3 m	kPa	kPa	-	-				blows / 0.3 m							
BH-401-05 (SS-1)	0.00	0.30	3	6	6	1.00	1.70	0.75	0.29	1.00	3.8	0.29	0.29	0.06	0.10	0.33	Sand	Above water level : no liquefaction
BH-401-05 (SS-2)	0.70	1.00	45	21	15	0.99	1.70	0.75	1.12	1.00	57.4	---	---	---	---	---	Sand	
BH-401-05 (SS-3)	1.50	1.80	37	38	24	0.99	1.70	0.75	1.01	1.00	47.2	---	---	---	---	---	Sand	
BH-401-05 (SS-4)	2.20	2.50	100	53	32	0.98	1.70	0.75	1.66	1.00	127.5	---	---	---	---	---	Sand	
BH-401-05 (SS-6)	3.00	3.30	100	69	41	0.97	1.56	0.80	1.65	1.00	125.2	---	---	---	---	---	Sand	
BH-401-05 (SS-8)	3.80	4.10	100	86	50	0.97	1.42	0.85	1.62	1.00	120.4	---	---	---	---	---	Sand	
BH-401-05 (SS-10)	4.60	4.90	54	103	59	0.96	1.30	0.85	1.14	1.00	59.9	---	---	---	---	---	Sand	
BH-401-05 (SS-11)	5.30	5.60	38	118	67	0.96	1.23	0.85	0.93	1.00	39.6	---	---	---	---	---	Sand	
BH-401-05 (SS-12)	6.10	6.40	34	134	76	0.95	1.15	0.95	0.90	1.00	37.2	---	---	---	---	---	Sand	
BH-401-05 (SS-13)	7.60	7.90	29	166	92	0.94	1.04	0.95	0.79	1.00	28.7	0.49	0.49	0.40	0.60	1.22	Sand	
BH-401-05 (SS-15)	9.00	9.30	100	195	108	0.93	0.96	0.95	1.41	0.95	91.4	---	---	---	---	---	Sand	
BH-401-05 (SS-17)	9.40	9.70	31	204	112	0.92	0.94	0.95	0.78	0.96	27.8	0.48	0.51	0.36	0.55	1.08	Sand	
BH-401-05 (SS-20)	12.20	12.50	25	263	144	0.84	0.83	1.00	0.67	0.88	20.8	0.45	0.51	0.23	0.34	0.68	Silty sand	**Liquefaction is possible with 20% fines**
BH-401-05 (SS-21)	13.70	14.00	15	294	161	0.80	0.79	1.00	0.51	0.89	11.8	0.43	0.48	0.13	0.20	0.41	Silty sand	**Liquefaction is possible with 20% fines**
BH-401-05 (SS-22)	15.30	15.60	15	328	178	0.76	0.75	1.00	0.49	0.87	11.2	0.41	0.47	0.12	0.19	0.40	Silty sand	**Liquefaction is possible with 20% fines**
BH-501-05 (SS-1)	0.00	0.30	6	6	6	1.00	1.70	0.75	0.41	1.00	7.7	0.29	0.29	0.09	0.14	0.48	Sand	Above water level : no liquefaction
BH-501-05 (SS-2)	0.70	1.00	29	21	15	0.99	1.70	0.75	0.90	1.00	37.0	---	---	---	---	---	Sand	
BH-501-05 (SS-3)	1.50	1.80	17	38	24	0.99	1.70	0.75	0.69	1.00	21.7	0.45	0.45	0.24	0.36	0.80	Clayey soil	Clayey soil: no liquefaction
BH-501-05 (SS-4)	2.30	2.60	24	55	33	0.98	1.70	0.75	0.82	1.00	30.6	---	---	---	---	---	Clayey soil	Clayey soil: no liquefaction
BH-501-05 (SS-5)	3.10	3.40	24	71	42	0.97	1.54	0.80	0.80	1.00	29.6	0.48	0.48	0.44	0.68	1.39	Sand	
BH-501-05 (SS-6)	3.80	4.10	20	86	50	0.97	1.42	0.85	0.72	1.00	24.1	0.49	0.49	0.27	0.42	0.85	Silt and sand	No liquefaction with > 35% fines
BH-501-05 (SS-7)	4.60	4.90	22	103	59	0.96	1.30	0.85	0.73	1.00	24.4	0.49	0.49	0.28	0.43	0.87	Silt and sand	No liquefaction with > 35% fines
BH-501-05 (SS-8)	5.30	5.60	21	118	67	0.96	1.23	0.85	0.69	1.00	21.9	0.49	0.49	0.24	0.37	0.74	Silt and sand	No liquefaction with > 35% fines
BH-501-05 (SS-9)	6.10	6.40	47	134	76	0.95	1.15	0.95	1.06	1.00	51.4	---	---	---	---	---	Sand	
BH-501-05 (SS-10)	6.80	7.10	46	149	83	0.94	1.10	0.95	1.02	1.00	47.9	---	---	---	---	---	Sand	
BH-501-05 (SS-11)	7.60	7.90	136	166	92	0.94	1.04	0.95	1.71	1.00	134.5	---	---	---	---	---	Sand	
BH-501-05 (SS-12)	9.10	9.40	100	197	109	0.92	0.96	0.95	1.41	0.94	90.9	---	---	---	---	---	Sand	
BH-502-05 (SS-1)	0.00	0.30	7	6	6	1.00	1.70	0.75	0.44	1.00	8.9	0.29	0.29	0.10	0.16	0.54	Sand	Above water level : no liquefaction
BH-502-05 (SS-2)	0.70	1.00	64	21	19	0.99	1.70	0.75	1.33	1.00	81.6	---	---	---	---	---	Clayey soil	Clayey soil: no liquefaction
BH-502-05 (SS-3)	1.50	1.80	100	38	28	0.99	1.70	0.75	1.66	1.00	127.5	---	---	---	---	---	Sand	
BH-502-05 (SS-5)	2.20	2.50	47	53	36	0.98	1.67	0.75	1.13	1.00	58.9	---	---	---	---	---	Clayey soil	Clayey soil: no liquefaction
BH-502-05 (SS-6)	3.00	3.30	36	69	45	0.97	1.49	0.80	0.97	1.00	43.0	---	---	---	---	---	Clayey soil	Clayey soil: no liquefaction
BH-502-05 (SS-7)	3.80	4.10	25	86	54	0.97	1.36	0.85	0.79	1.00	29.0	0.45	0.45	0.41	0.62	1.37	Clayey soil	Clayey soil: no liquefaction
BH-502-05 (SS-8)	4.50	4.80	28	101	62	0.96	1.27	0.85	0.81	1.00	30.3	---	---	---	---	---	Sand	

Figure 3B
Soil liquefaction for 1:2500 years
Site Rabaska
a_{max} = 0.45g and magnitude of 6.5 on Richter scale

Borehole	Depth	Depth	N	σ_{vo}	σ_{vo}'	r_d	C_N	C_R	Dr	Kσ	$(N_1)_{60}$	CSR	CSR/Kσ	$CRR_{7.5}$	CRR_{corr}	Factor of Safety *	Description	Remarks
	m	m	blows / 0.3 m	kPa	kPa	-	-				blows / 0.3 m							
BH-503-05 (SS-1)	0.00	0.30	13	6	6	1.00	1.70	0.75	0.60	1.00	16.6	0.29	0.29	0.18	0.27	0.92	Sand	Above water level : no liquefaction
BH-503-05 (SS-2)	0.70	1.00	30	21	15	0.99	1.70	0.75	0.91	1.00	38.3	---	---	---	---	---	Sand	
BH-503-05 (SS-3)	1.50	1.80	40	38	24	0.99	1.70	0.75	1.05	1.00	51.0	---	---	---	---	---	Sand	
BH-503-05 (SS-4)	2.30	2.60	21	55	33	0.98	1.70	0.75	0.76	1.00	26.8	0.47	0.47	0.33	0.51	1.07	Sand	
BH-503-05 (SS-5)	3.10	3.40	74	71	42	0.97	1.54	0.80	1.41	1.00	91.4	---	---	---	---	---	Sand	
BH-503-05 (SS-7)	3.80	4.10	60	86	50	0.97	1.42	0.85	1.25	1.00	72.3	---	---	---	---	---	Sand	
BH-503-05 (SS-8)	4.50	4.80	52	101	58	0.96	1.32	0.85	1.13	1.00	58.2	---	---	---	---	---	Sand	
BH-503-05 (SS-10)	5.30	5.60	54	118	67	0.96	1.23	0.85	1.11	1.00	56.2	---	---	---	---	---	Sand	
BH-503-05 (SS-11)	6.10	6.40	34	134	76	0.95	1.15	0.95	0.90	1.00	37.2	---	---	---	---	---	Sand	
BH-503-05 (SS-12)	7.60	7.90	31	166	92	0.94	1.04	0.95	0.82	1.00	30.6	---	---	---	---	---	Sand	
BH-503-05 (SS-14)	9.20	9.50	100	200	110	0.92	0.95	0.95	1.40	0.93	90.5	---	---	---	---	---	Sand	
BH-503-05 (SS-17)	9.70	10.00	67	210	116	0.91	0.93	1.00	1.16	0.92	62.3	---	---	---	---	---	Sand	
BH-503-05 (SS-19)	10.50	10.80	13	227	125	0.89	0.90	1.00	0.50	0.95	11.6	0.47	0.50	0.13	0.19	0.39	Sand, some silt	**Liquefaction is possible with 10% fines**
BH-503-05 (SS-20)	12.10	12.40	35	260	143	0.84	0.84	1.00	0.80	0.87	29.3	0.45	0.52	0.43	0.65	1.25	Sand	
BH-503-05 (SS-22)	13.60	13.90	47	292	159	0.80	0.79	1.00	0.90	0.81	37.2	---	---	---	---	---	Sand	
BH-503-05 (SS-23)	15.10	15.40	73	323	176	0.76	0.75	1.00	1.09	0.73	55.0	---	---	---	---	---	Sand	
BH-503-05 (SS-24)	16.60	16.90	30	355	193	0.72	0.72	1.00	0.69	0.80	21.6	0.39	0.49	0.24	0.36	0.74	Sand, some silt	**Liquefaction is possible with 10% fines**
BH-503-05 (SS-26)	18.20	18.50	42	389	211	0.68	0.69	1.00	0.79	0.74	28.9	0.37	0.49	0.41	0.62	1.25	Sand	
BH-503-05 (SS-28)	19.70	20.00	26	420	228	0.64	0.66	1.00	0.61	0.78	17.2	0.35	0.44	0.18	0.28	0.63	Sand, some silt	**Liquefaction is possible with 10% fines**
BH-503-05 (SS-29)	21.20	21.50	82	452	245	0.60	0.64	1.00	1.07	0.62	52.4	---	---	---	---	---	Sand	
BH-503-05 (SS-30)	22.80	23.10	100	485	262	0.56	0.62	1.00	1.16	0.57	61.7	---	---	---	---	---	Sand	
BH-503-05 (SS-33)	24.00	24.30	100	510	276	0.53	0.60	1.00	1.14	0.56	60.2	---	---	---	---	---	Sand	
BH-504-05 (SS-1)	0.00	0.30	5	6	6	1.00	1.70	0.75	0.37	1.00	6.4	0.29	0.29	0.08	0.13	0.43	Clayey soil	Above water level and clayey soil : no liquefaction
BH-504-05 (SS-2)	0.80	1.10	21	23	18	0.99	1.70	0.75	0.76	1.00	26.8	0.37	0.37	0.33	0.51	1.37	Sand	
BH-504-05 (SS-3)	1.50	1.80	24	38	26	0.99	1.70	0.75	0.82	1.00	30.6	---	---	---	---	---	Sand	
BH-504-05 (SS-4)	2.30	2.60	34	55	35	0.98	1.69	0.75	0.97	1.00	43.1	---	---	---	---	---	Sand	
BH-504-05 (SS-5)	3.00	3.30	86	69	43	0.97	1.53	0.80	1.51	1.00	105.1	---	---	---	---	---	Sand	
BH-504-05 (SS-7)	3.80	4.10	100	86	52	0.97	1.39	0.85	1.60	1.00	118.1	---	---	---	---	---	Sand	
BH-504-05 (SS-10)	4.90	5.20	100	109	64	0.96	1.25	0.85	1.52	1.00	106.2	---	---	---	---	---	Sand	
BH-504-05 (SS-12)	5.70	6.00	68	126	73	0.95	1.17	0.95	1.28	1.00	75.6	---	---	---	---	---	Sand	
BH-504-05 (SS-13)	6.10	6.40	100	134	78	0.95	1.14	0.95	1.53	1.00	107.9	---	---	---	---	---	Sand	

Figure 3B
Soil liquefaction for 1:2500 years
Site Rabaska
a_{max} = 0.45g and magnitude of 6.5 on Richter scale

Borehole	Depth	Depth	N	σ_{vo}	σ_{vo}'	r_d	C_N	C_R	Dr	Kσ	$(N_1)_{60}$	CSR	CSR/Kσ	$CRR_{7.5}$	CRR_{corr}	Factor of Safety *	Description	Remarks
	m	m	blows / 0.3 m	kPa	kPa	-	-				blows / 0.3 m							
BH-506-05 (SS-1)	0.00	0.30	6	6	6	1.00	1.70	0.75	0.41	1.00	7.7	0.29	0.29	0.09	0.14	0.48	Sand	Above water level : no liquefaction
BH-506-05 (SS-2)	0.80	1.10	24	23	16	0.99	1.70	0.75	0.82	1.00	30.6	---	---	---	---	---	Sand	
BH-506-05 (SS-3)	1.50	1.80	36	38	24	0.99	1.70	0.75	1.00	1.00	45.9	---	---	---	---	---	Sand	
BH-506-05 (SS-4)	2.30	2.60	44	55	33	0.98	1.70	0.75	1.10	1.00	56.1	---	---	---	---	---	Sand	
BH-506-05 (SS-6)	3.00	3.30	100	69	41	0.97	1.56	0.80	1.65	1.00	125.2	---	---	---	---	---	Sand	
BH-506-05 (SS-8)	3.80	4.10	32	86	50	0.97	1.42	0.85	0.92	1.00	38.5	---	---	---	---	---	Sand	
BH-506-05 (SS-9)	4.60	4.90	22	103	59	0.96	1.30	0.85	0.73	1.00	24.4	0.49	0.49	0.28	0.43	0.87	Silty Sand	No liquefaction with > 35% fines
BH-506-05 (SS-10)	5.30	5.60	29	118	67	0.96	1.23	0.85	0.81	1.00	30.2	---	---	---	---	---	Sand	
BH-506-05 (SS-11)	6.10	6.40	75	134	76	0.95	1.15	0.95	1.33	1.00	82.0	---	---	---	---	---	Sand	

N: blow count/0.3 m
σ_{vo} : total overburden stress
σ_{vo} : effective overburden stress
r_d: stress reduction coefficient
C_N: correction factor foroverburden pressure
C_R: correction factor for rod lenght
Dr : relative density
Kσ: correction for high overburden stresses
$(N_1)_{60}$: correction of N
CSR: cyclic stress ratio
$CRR_{7.5}$: cyclic resistance ratio for magnitude 7.5
CRR_{corr}: cyclic resistance ratio for a different magnitude (MSF)
MSF: magnitude scaling factor

LEGEND	
Above ground water level	Depth < 9.15 m
Below ground water level	Depth > 9.15 m

Granular soil
Clayey soil

--- $(N_1)_{60}$ >= 30 : No liquefaction

*** Factor of Safety F.S.= ($CRR_{7.5}$/CSR)*MSF*Kσ**

Note: factor of safety calculated for 5% fine content

Figure 4A
Soil liquefaction - 1:5000 years
Site Rabaska
a_{max} = 0.64g and magnitude 6.75 on Richter scale

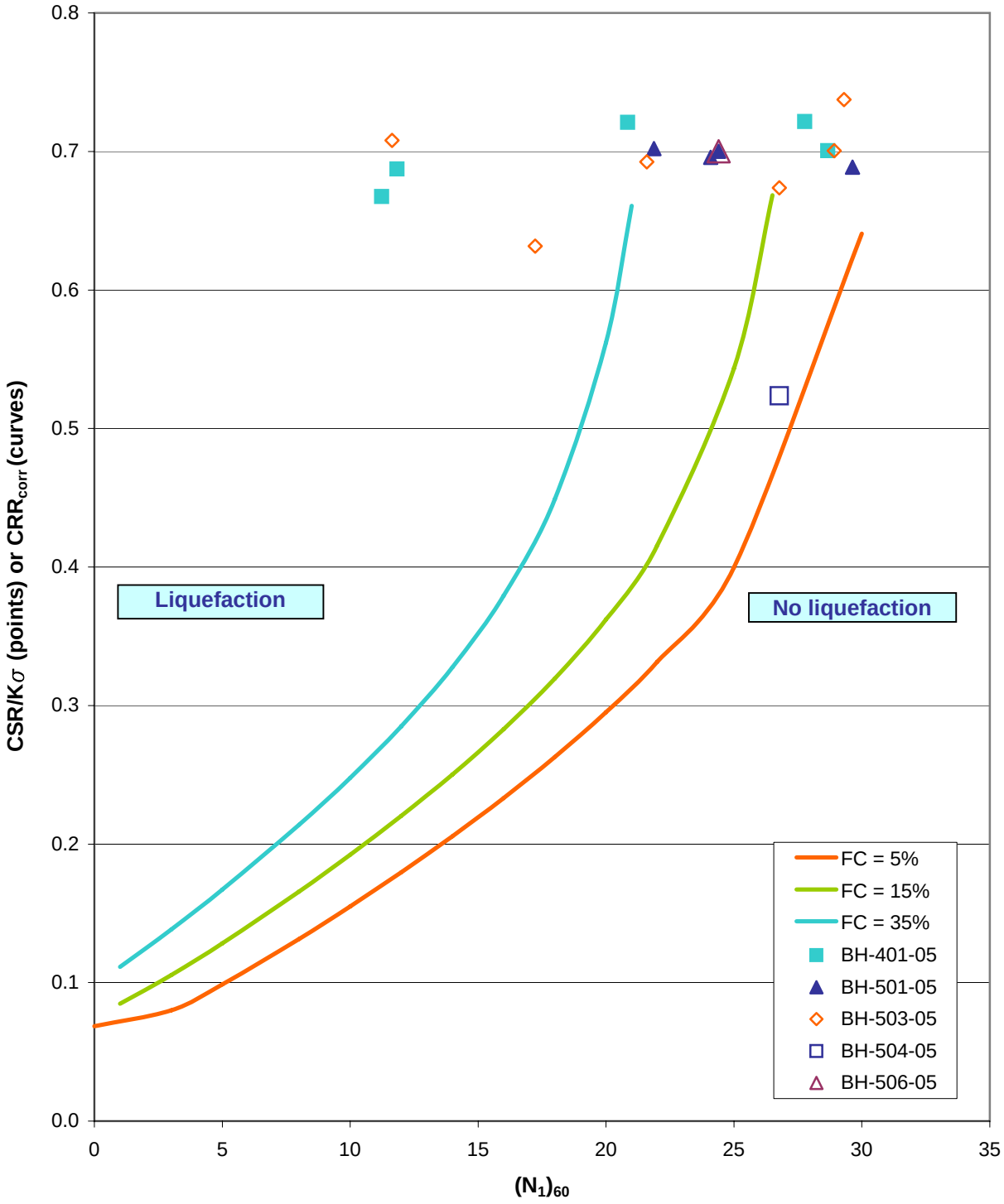

Figure 4B
Soil liquefaction for 1:5000 years
Site Rabaska
a_{max} = 0.64g and magnitude of 6.75 on Richter scale

Borehole	Depth	Depth	N	σ_{vo}	σ_{vo}'	r_d	C_N	C_R	Dr	Kσ	$(N_1)_{60}$	CSR	CSR/Kσ	$CRR_{7.5}$	CRR_{corr}	Factor of Safety *	Description	Remarks
	m	m	blows / 0.3 m	kPa	kPa	-	-				blows / 0.3 m							
BH-401-05 (SS-1)	0.00	0.30	3	6	6	1.00	1.70	0.75	0.29	1.00	3.8	0.42	0.42	0.06	0.09	0.21	Sand	Above water level : no liquefaction
BH-401-05 (SS-2)	0.70	1.00	45	21	15	0.99	1.70	0.75	1.12	1.00	57.4	---	---	---	---	---	Sand	
BH-401-05 (SS-3)	1.50	1.80	37	38	24	0.99	1.70	0.75	1.01	1.00	47.2	---	---	---	---	---	Sand	
BH-401-05 (SS-4)	2.20	2.50	100	53	32	0.98	1.70	0.75	1.66	1.00	127.5	---	---	---	---	---	Sand	
BH-401-05 (SS-6)	3.00	3.30	100	69	41	0.97	1.56	0.80	1.65	1.00	125.2	---	---	---	---	---	Sand	
BH-401-05 (SS-8)	3.80	4.10	100	86	50	0.97	1.42	0.85	1.62	1.00	120.4	---	---	---	---	---	Sand	
BH-401-05 (SS-10)	4.60	4.90	54	103	59	0.96	1.30	0.85	1.14	1.00	59.9	---	---	---	---	---	Sand	
BH-401-05 (SS-11)	5.30	5.60	38	118	67	0.96	1.23	0.85	0.93	1.00	39.6	---	---	---	---	---	Sand	
BH-401-05 (SS-12)	6.10	6.40	34	134	76	0.95	1.15	0.95	0.90	1.00	37.2	---	---	---	---	---	Sand	
BH-401-05 (SS-13)	7.60	7.90	29	166	92	0.94	1.04	0.95	0.79	1.00	28.7	0.70	0.70	0.40	0.54	0.77	Sand, some silt	**Liquefaction is possible with 10 % fines**
BH-401-05 (SS-15)	9.00	9.30	100	195	108	0.93	0.96	0.95	1.41	0.95	91.4	---	---	---	---	---	Sand	
BH-401-05 (SS-17)	9.40	9.70	31	204	112	0.92	0.94	0.95	0.78	0.96	27.8	0.69	0.72	0.36	0.50	0.69	Sand, some silt	**Liquefaction is possible with 10 % fines**
BH-401-05 (SS-20)	12.20	12.50	25	263	144	0.84	0.83	1.00	0.67	0.88	20.8	0.64	0.72	0.23	0.31	0.43	Silty sand	**Liquefaction is possible with 20% fines**
BH-401-05 (SS-21)	13.70	14.00	15	294	161	0.80	0.79	1.00	0.51	0.89	11.8	0.61	0.69	0.13	0.18	0.26	Siltty sand	**Liquefaction is possible with 20% fines**
BH-401-05 (SS-22)	15.30	15.60	15	328	178	0.76	0.75	1.00	0.49	0.87	11.2	0.58	0.67	0.12	0.17	0.25	Silty sand	**Liquefaction is possible with 20% fines**
BH-501-05 (SS-1)	0.00	0.30	6	6	6	1.00	1.70	0.75	0.41	1.00	7.7	0.42	0.42	0.09	0.13	0.31	Sand	Above water level : no liquefaction
BH-501-05 (SS-2)	0.70	1.00	29	21	15	0.99	1.70	0.75	0.90	1.00	37.0	---	---	---	---	---	Sand	
BH-501-05 (SS-3)	1.50	1.80	17	38	24	0.99	1.70	0.75	0.69	1.00	21.7	0.64	0.64	0.24	0.33	0.51	Clayey soil	Clayey soil: no liquefaction
BH-501-05 (SS-4)	2.30	2.60	24	55	33	0.98	1.70	0.75	0.82	1.00	30.6	---	---	---	---	---	Clayey soil	Clayey soil: no liquefaction
BH-501-05 (SS-5)	3.10	3.40	24	71	42	0.97	1.54	0.80	0.80	1.00	29.6	0.69	0.69	0.44	0.61	0.88	Silt and sand	No liquefaction with > 35% fines
BH-501-05 (SS-6)	3.80	4.10	20	86	50	0.97	1.42	0.85	0.72	1.00	24.1	0.70	0.70	0.27	0.38	0.54	Silt and sand	No liquefaction with > 35% fines
BH-501-05 (SS-7)	4.60	4.90	22	103	59	0.96	1.30	0.85	0.73	1.00	24.4	0.70	0.70	0.28	0.38	0.55	Silt and sand	No liquefaction with > 35% fines
BH-501-05 (SS-8)	5.30	5.60	21	118	67	0.96	1.23	0.85	0.69	1.00	21.9	0.70	0.70	0.24	0.33	0.47	Silt and sand	No liquefaction with > 35% fines
BH-501-05 (SS-9)	6.10	6.40	47	134	76	0.95	1.15	0.95	1.06	1.00	51.4	---	---	---	---	---	Sand	
BH-501-05 (SS-10)	6.80	7.10	46	149	83	0.94	1.10	0.95	1.02	1.00	47.9	---	---	---	---	---	Sand	
BH-501-05 (SS-11)	7.60	7.90	136	166	92	0.94	1.04	0.95	1.71	1.00	134.5	---	---	---	---	---	Sand	
BH-501-05 (SS-12)	9.10	9.40	100	197	109	0.92	0.96	0.95	1.41	0.94	90.9	---	---	---	---	---	Sand	
BH-502-05 (SS-1)	0.00	0.30	7	6	6	1.00	1.70	0.75	0.44	1.00	8.9	0.42	0.42	0.10	0.14	0.34	Sand	Above water level : no liquefaction
BH-502-05 (SS-2)	0.70	1.00	64	21	19	0.99	1.70	0.75	1.33	1.00	81.6	---	---	---	---	---	Clayey soil	Clayey soil: no liquefaction
BH-502-05 (SS-3)	1.50	1.80	100	38	28	0.99	1.70	0.75	1.66	1.00	127.5	---	---	---	---	---	Sand	
BH-502-05 (SS-5)	2.20	2.50	47	53	36	0.98	1.67	0.75	1.13	1.00	58.9	---	---	---	---	---	Clayey soil	Clayey soil: no liquefaction
BH-502-05 (SS-6)	3.00	3.30	36	69	45	0.97	1.49	0.80	0.97	1.00	43.0	---	---	---	---	---	Clayey soil	Clayey soil: no liquefaction
BH-502-05 (SS-7)	3.80	4.10	25	86	54	0.97	1.36	0.85	0.79	1.00	29.0	0.64	0.64	0.41	0.56	0.87	Clayey soil	Clayey soil: no liquefaction
BH-502-05 (SS-8)	4.50	4.80	28	101	62	0.96	1.27	0.85	0.81	1.00	30.3	---	---	---	---	---	Sand	

Figure 4B
Soil liquefaction for 1:5000 years
Site Rabaska
a_{max} = 0.64g and magnitude of 6.75 on Richter scale

Borehole	Depth	Depth	N	σ_{vo}	σ_{vo}'	r_d	C_N	C_R	Dr	Kσ	$(N_1)_{60}$	CSR	CSR/Kσ	$CRR_{7.5}$	CRR_{corr}	Factor of Safety *	Description	Remarks
	m	m	blows / 0.3 m	kPa	kPa	-	-				blows / 0.3 m							
BH-503-05 (SS-1)	0.00	0.30	13	6	6	1.00	1.70	0.75	0.60	1.00	16.6	0.42	0.42	0.18	0.24	0.58	Sand	Above water level : no liquefaction
BH-503-05 (SS-2)	0.70	1.00	30	21	15	0.99	1.70	0.75	0.91	1.00	38.3	---	---	---	---	---	Sand	
BH-503-05 (SS-3)	1.50	1.80	40	38	24	0.99	1.70	0.75	1.05	1.00	51.0	---	---	---	---	---	Sand	
BH-503-05 (SS-4)	2.30	2.60	21	55	33	0.98	1.70	0.75	0.76	1.00	26.8	0.67	0.67	0.33	0.46	0.68	Gravelly silt	No liquefaction with > 35% fines
BH-503-05 (SS-5)	3.10	3.40	74	71	42	0.97	1.54	0.80	1.41	1.00	91.4	---	---	---	---	---	Sand	
BH-503-05 (SS-7)	3.80	4.10	60	86	50	0.97	1.42	0.85	1.25	1.00	72.3	---	---	---	---	---	Sand	
BH-503-05 (SS-8)	4.50	4.80	52	101	58	0.96	1.32	0.85	1.13	1.00	58.2	---	---	---	---	---	Sand	
BH-503-05 (SS-10)	5.30	5.60	54	118	67	0.96	1.23	0.85	1.11	1.00	56.2	---	---	---	---	---	Sand	
BH-503-05 (SS-11)	6.10	6.40	34	134	76	0.95	1.15	0.95	0.90	1.00	37.2	---	---	---	---	---	Sand	
BH-503-05 (SS-12)	7.60	7.90	31	166	92	0.94	1.04	0.95	0.82	1.00	30.6	---	---	---	---	---	Sand	
BH-503-05 (SS-14)	9.20	9.50	100	200	110	0.92	0.95	0.95	1.40	0.93	90.5	---	---	---	---	---	Sand	
BH-503-05 (SS-17)	9.70	10.00	67	210	116	0.91	0.93	1.00	1.16	0.92	62.3	---	---	---	---	---	Sand	
BH-503-05 (SS-19)	10.50	10.80	13	227	125	0.89	0.90	1.00	0.50	0.95	11.6	0.67	0.71	0.13	0.18	0.25	Sand, some silt	**Liquefaction is possible with 10% fines**
BH-503-05 (SS-20)	12.10	12.40	35	260	143	0.84	0.84	1.00	0.80	0.87	29.3	0.64	0.74	0.43	0.58	0.79	Sand, some silt	**Liquefaction is possible with 10% fines**
BH-503-05 (SS-22)	13.60	13.90	47	292	159	0.80	0.79	1.00	0.90	0.81	37.2	---	---	---	---	---	Sand	
BH-503-05 (SS-23)	15.10	15.40	73	323	176	0.76	0.75	1.00	1.09	0.73	55.0	---	---	---	---	---	Sand	
BH-503-05 (SS-24)	16.60	16.90	30	355	193	0.72	0.72	1.00	0.69	0.80	21.6	0.55	0.69	0.24	0.32	0.47	Sand, some silt	**Liquefaction is possible with 10% fines**
BH-503-05 (SS-26)	18.20	18.50	42	389	211	0.68	0.69	1.00	0.79	0.74	28.9	0.52	0.70	0.41	0.56	0.79	Sand, some silt	**Liquefaction is possible with 10% fines**
BH-503-05 (SS-28)	19.70	20.00	26	420	228	0.64	0.66	1.00	0.61	0.78	17.2	0.49	0.63	0.18	0.25	0.40	Sand, some silt	**Liquefaction is possible with 10% fines**
BH-503-05 (SS-29)	21.20	21.50	82	452	245	0.60	0.64	1.00	1.07	0.62	52.4	---	---	---	---	---	Sand	
BH-503-05 (SS-30)	22.80	23.10	100	485	262	0.56	0.62	1.00	1.16	0.57	61.7	---	---	---	---	---	Sand	
BH-503-05 (SS-33)	24.00	24.30	100	510	276	0.53	0.60	1.00	1.14	0.56	60.2	---	---	---	---	---	Sand	
BH-504-05 (SS-1)	0.00	0.30	5	6	6	1.00	1.70	0.75	0.37	1.00	6.4	0.42	0.42	0.08	0.11	0.27	Clayey soil	Above water level and clayey soil : no liquefaction
BH-504-05 (SS-2)	0.80	1.10	21	23	18	0.99	1.70	0.75	0.76	1.00	26.8	0.52	0.52	0.33	0.46	0.87	Silty sand	No liquefaction with > 20% fines
BH-504-05 (SS-3)	1.50	1.80	24	38	26	0.99	1.70	0.75	0.82	1.00	30.6	---	---	---	---	---	Sand	
BH-504-05 (SS-4)	2.30	2.60	34	55	35	0.98	1.69	0.75	0.97	1.00	43.1	---	---	---	---	---	Sand	
BH-504-05 (SS-5)	3.00	3.30	86	69	43	0.97	1.53	0.80	1.51	1.00	105.1	---	---	---	---	---	Sand	
BH-504-05 (SS-7)	3.80	4.10	100	86	52	0.97	1.39	0.85	1.60	1.00	118.1	---	---	---	---	---	Sand	
BH-504-05 (SS-10)	4.90	5.20	100	109	64	0.96	1.25	0.85	1.52	1.00	106.2	---	---	---	---	---	Sand	
BH-504-05 (SS-12)	5.70	6.00	68	126	73	0.95	1.17	0.95	1.28	1.00	75.6	---	---	---	---	---	Sand	
BH-504-05 (SS-13)	6.10	6.40	100	134	78	0.95	1.14	0.95	1.53	1.00	107.9	---	---	---	---	---	Sand	

Figure 4B
Soil liquefaction for 1:5000 years
Site Rabaska
a_{max} = 0.64g and magnitude of 6.75 on Richter scale

Borehole	Depth	Depth	N	σ_{vo}	σ_{vo}'	r_d	C_N	C_R	Dr	Kσ	$(N_1)_{60}$	CSR	CSR/Kσ	$CRR_{7.5}$	CRR_{corr}	Factor of Safety *	Description	Remarks
	m	m	blows / 0.3 m	kPa	kPa	-	-				blows / 0.3 m							
BH-506-05 (SS-1)	0.00	0.30	6	6	6	1.00	1.70	0.75	0.41	1.00	7.7	0.42	0.42	0.09	0.13	0.31	Sand	Above water level : no liquefaction
BH-506-05 (SS-2)	0.80	1.10	24	23	16	0.99	1.70	0.75	0.82	1.00	30.6	---	---	---	---	---	Sand	
BH-506-05 (SS-3)	1.50	1.80	36	38	24	0.99	1.70	0.75	1.00	1.00	45.9	---	---	---	---	---	Sand	
BH-506-05 (SS-4)	2.30	2.60	44	55	33	0.98	1.70	0.75	1.10	1.00	56.1	---	---	---	---	---	Sand	
BH-506-05 (SS-6)	3.00	3.30	100	69	41	0.97	1.56	0.80	1.65	1.00	125.2	---	---	---	---	---	Sand	
BH-506-05 (SS-8)	3.80	4.10	32	86	50	0.97	1.42	0.85	0.92	1.00	38.5	---	---	---	---	---	Sand	
BH-506-05 (SS-9)	4.60	4.90	22	103	59	0.96	1.30	0.85	0.73	1.00	24.4	0.70	0.70	0.28	0.38	0.55	Silty Sand	No liquefaction with > 35% fines
BH-506-05 (SS-10)	5.30	5.60	29	118	67	0.96	1.23	0.85	0.81	1.00	30.2	---	---	---	---	---	Sand	
BH-506-05 (SS-11)	6.10	6.40	75	134	76	0.95	1.15	0.95	1.33	1.00	82.0	---	---	---	---	---	Sand	

N: blow count/0.3 m
σ_{vo} : total overburden stress
σ_{vo} : effective overburden stress
r_d: stress reduction coefficient
C_N: correction factor foroverburden pressure
C_R: correction factor for rod lenght
Dr : relative density
Kσ: correction for high overburden stresses
$(N_1)_{60}$: correction of N
CSR: cyclic stress ratio
$CRR_{7.5}$: cyclic resistance ratio for magnitude 7.5
CRR_{corr}: cyclic resistance ratio for a different magnitude (MSF)
MSF: magnitude scaling factor

LEGEND	
Above ground water level	Depth < 9.15 m
Below ground water level	Depth > 9.15 m

Granular soil
Clayey soil

--- **$(N_1)_{60}$ >= 30 : No liquefaction**

*** Factor of Safety F.S.= ($CRR_{7.5}$/CSR)*MSF*Kσ**

Note: factor of safety calculated for 5% fine content

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