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NRCan – GSC Technical Review of the Hebron project Comprehensive Study Report

Scope of Request and Review:

In response to the request from the CNLOPB, six scientists from NRCan's Geological Survey of Canada (GSC), Earth Science Sector (ESS), have reviewed the geosciences aspects of the Hebron Project Comprehensive Study Report.

Topics reviewed include: sea-bed related operations in Bull Arm, tsunamis, the scope and adequacy of the documentation of Geotechnical properties towards safe GBS placement, seabed iceberg scour probability, seismic hazard, marine hydro-carbon spills and shoreline cleanup, sea bed character and stability in the Bull Arm-Trinity bay area and disposal of bund wall, and adaptation to Sea level change and changing environmental conditions.

The technical review, conclusions, suggestions, questions and recommendations reflect the regional knowledge; professional experience and opinion of the reviewers, based on the information presented in the project EIS and the experts' relevant research and publications.

NRCan's reviewers have not undertaken any new studies or research to specifically generate new information or to independently validate data presented by the proponent.

In general, NRCan's views are that the clarifications, supplemental information requested, and recommendations are necessary in order to adequately characterize the baseline environmental conditions, predict the project's environmental effects, and safely design, build and place the GBS.

Canada

Earth Sciences Sector (ESS) Expertise provided:

GSC-Atlantic/Marine Environmental Geology scientists:

- marine geologist - Quaternary and recent processes and mapping/offshore and near-shore surficial and shallow bedrock
- coastal geologist
- geotechnical Engineering
- geophysicist/geologist - tsunami
- marine geologist - Surficial geology, geotechnical, seabed iceberg scour

GSC Canadian Hazard Information Service: seismologist

Documents Reviewed:

GSC reviewed sub-sections of the June 2010 "Hebron Project Comprehensive Study Report"

- 3.1.5
- 3.1.2.3
- 3.2.2.2
- 3.2.4
- 3.2.5
- 13.3.3
- 13.4.3
- 13.4.7
- 14.4
- 14.6.4.6
- In addition, the "Hebron_CSR_ExxonMobil Response_Document_20101126_November2010.pdf" was reviewed as it provided valuable information beyond the original documents, both in terms of raising and resolving issues.
- 14.2 Fate and Behaviour of Hebron Hydrocarbon Spills in the nearshore Study Area (Trajectory Modelling)
- Oceans&AMEC Climatology of the Hebron Project Areas May1.pdf (9MB) –Hebron Project Comprehensive Study Report (June 2010)
- November 26, 2010 Response to Consolidated Review Comments, Part 1 Page 3 of 152

Topic or Issue 1:
Seabed-related operations in Bull Arm

3.1.5 Geology of the Bull Arm (Mosquito Cove) area:

- Section references a 2005 exercise, but no background is provided. Some background on the 2005 effort would provide useful information

Dredging and spoils disposal:

Dredging and placement and removal of the bund wall are proposed for Mosquito Arm.

For the dredging, given the thin cover of loose sediment above the till, this will presumably involve considerable volumes of till. Fine components, such as silts and clays may be abundant, and will be subject to dispersal in the removal from the seabed, the raising, and the dumping.

Has water column turbidity and its transport been considered? Is there understanding of the local currents? GSC's (limited) experience is that local base of slope currents can be strong enough to remobilize muds and sands. The implication is that the "footprint" of such operations may be much larger than the immediate dump site.

The documents reviewed suggest that the dump site (for both bund wall and dredging, if we understand correctly) may be 40-45 m water depth in outer Mosquito Cove (pg 3 of review document). A bathymetric survey is proposed to further identify a dump site.

What will be the scope and purpose of this survey? Given the highly variable nature of the seabed and sediment type and thickness in this type of nearshore and fjord environment, is part of the scope of such a survey to mitigate or anticipate issues with dumping? GSC has no survey data from the arm, only the mouth, outside the "nearshore Project Area"; nearby recent survey data (2010) in nearby SW Arm suggests much thicker (10s of m) loose sediments than are reported here. This is much more mud-rich than the 50-60 % sand reported in the 1991 document. However SW Arm observations and samples are from the central portion of the fjord; Mosquito Cove may well be anomalous and the coastal boreholes indicate this. The dense dredged material (mainly till-derived) might end up being loaded onto much softer and thicker clays, for example, or being dumped in a location subject to later, natural redistribution of the sediment.

Any purely bathymetric survey plans could be modified in terms of basic survey tools to provide basic background and baseline surficial geology (multibeam, high frequency sub-bottom acoustic profiler, grab samples). Bathymetric surveys would not likely be sensitive to "redeposited fine grained sediment.... from dredge spoils", if one purpose of the survey will be to address this environmental affect as identified by the Environment Canada 2005 report. Generally individual natural or anthropogenic influences amount to dustings of sediment, not readily resolvable with sonar techniques. Is the goal to compare surficial geology findings from the NGL 1989 to 1991 surveys (referenced below) with present day (post Hibernia GBS construction)? If so, some short coring might be better suited to recognize the anthropogenic influences of the previous GBS construction.

Anchoring: Figure 3 of the CSR document shows existing mooring points in Bull Arm. Are these on land or in the marine environment? Are they bedrock based? Are there plans for further mooring points? If they are in bedrock and in very shallow water or on land, likely little impact. Has this been addressed?

Seabed beneath the GBS in mid-Bull Arm: No discussion of the impact on the seabed in mid-Bull Arm was seen in the document. Is this because none is anticipated? There are likely thick soft muds transitioning downwards to cohesive muds of glacial origin at this site (based only on assuming analogous conditions in other fjords). Is there any anchoring, risk of equipment or materials loss (dropping), including hazardous materials? Is the proponent aware of the geological conditions here? Presumably a soft or a hard seabed substrate might be impacted differently in the case of any seabed interaction at this site.

Icebergs: Is it documented that iceberg trajectories into the nearshore site are of low enough probability to eliminate a mitigation plan?

Tsunamis
3.1.2.3

- The assessment is probably correct, given the short construction period. Nevertheless, Trinity Bay and Bull arm are exposed to tsunamis, especially those originating to the NE of Newfoundland. Any tsunami from this direction would be more severe than the 1929 tsunami in Trinity Bay (since the 1929 tsunami lost its energy wrapping around Newfoundland). A further consideration is that the long bays and arms would amplify the tsunami, so a moderate/small tsunami would become much larger in amplitude.

Topic or Issue 2:

Scope and adequacy of the documentation of Geotechnical properties towards safe GBS placement.

3.2.4 (of the CSR "Geotechnical and Geological Conditions", pp. 3-80 and 3-81)

The proponent describes the regional near-surface geological conditions and then proceeds to the surficial (upper few metres) geology description.

It is unclear what the purpose and scope of this section is. It provides a general setting but does not provide the specifics that are required of a GBS placement; these requirements must be considered elsewhere for the safe placement of a large structure on strata that are not well lithified. The question arises as to the purpose of this section of the document if it only describes the strata in geologic and genetic rather than in a geotechnical framework.

Pg 3-18, uppermost paragraph: The pro-glacial outwash scenario is now considered incorrect. Still, from an environmental or geotechnical viewpoint, the character of the sediment, not its geologic genesis, is more important. The document presents rather vague descriptions of geologic units and their distribution but ignores whether the geology presents any hazards to the environment or safe installation and maintenance of a large GBS? These sections are not sufficient to demonstrate the safe placement of such a structure. Is the reader to assume that proper investigations have been or will be made? Where are the references to borehole studies? Even temporary seabed-places rigs require this. If this is beyond the scope of this CSR, then where will it appear?

On page 3-83, under the sub-heading "Comparison with Geotechnical Data", a caution is that presence of the Grand Banks Drift (diamict) is largely inferred; the stratigraphic zone is poorly imaged on all sonar, its thickness is generally not discernible and it may be patchy in its distribution. Limited groundtruth, almost all from industry engineering activities, confirms its local presence but in a very regional sense. Is the document suggesting that this level of understanding of the sub-seabed stratigraphy is sufficient for engineering assessment of foundation conditions? This is certainly not the intent nor within the scope of the material referenced by GSCA authors (eg. Sonnichsen and King, 2005). The document does not make it clear why the sub-surface stratigraphy is considered if not to characterize it for suitability for a GBS loading and if it is for this purpose, it remains wholly inadequate.

3.2.4.3

"Hebron Offshore Study Area Surficial Geology".

This section draws heavily on GSCA- authored studies of the sediment conditions within the upper few metres of the seabed.

A caution from the main GSC-A-Author, that the map presented in this document (Fig 3-42) is regional in nature, generally conforming to industry findings (from publicly available wellsite surveys) and drawing upon widely-spaced survey lines. Details of surficial texture at the Hebron site are best revealed in industry gathered investigations which no doubt exist in greater detail than presented here. Still, even these types of "wellsite survey" reports do not commonly register precise thickness and distribution of the sands and even less-so, the lag gravels and the undulating, channel-like topography below the gravels. This is technically challenging information to obtain and the reporting is commonly vague with respect to geotechnical and thickness and distribution of strata and features. All can have some impact on a GBS structure, including foundation capabilities and current-induced sediment scour or mobility.

3.2.4.4

"Geotechnical Data from the Hebron Platform Location".

This section summarizes multiple boreholes conducted primarily with the purpose of assessing foundation conditions and its variability at the GBS footprint and mooring piles.

The geotechnical section is surprisingly sparse. It very briefly summarizes results from boreholes and CPT tests conducted within the proposed Hebron Project Area and three sets of boreholes at potential mooring pile locations. The geotechnical information provided consists of a summary of the lithology and ***consistency*** of the surficial sediments. It is unclear if this summary was obtained from visual descriptions or from CPT data. This document states general semi-quantitative descriptions of the strata but fails to put them in any engineering application context.

The geotechnical characterization which is required to access the foundation conditions of the GBS site would be much more comprehensive than is provided in this section. The engineering parameters would normally be obtained from a combination of *in situ* (CPT) and laboratory tests and include index properties, grain size, static and cyclic strength parameters, compressibility, permeability and bearing capacity. In addition a geotechnical program should be in place to monitor seabed response after the emplacement of the GBS.

It is difficult to determine what is required for the CSR. The Scoping Document Table of Concordance (Section 5.3) suggests that the CSR should contain descriptions of the physical and biological environments. There is no mention of assessing foundation conditions. GSC is aware that geotechnical characterizations for the site have been completed so our presumption is that data is not required for the CSR. Is the reader to assume that full studies have been conducted? And that, yes, this is deemed a safe foundation for its intended use? If so, state this. If not, then certainly discuss the engineering design for mitigating any shortcomings. Otherwise, what is the purpose of this document section?

A table or section outlying the geotechnical tests conducted, engineering parameters, ***possible data gaps*** and future geotechnical monitoring programs may be helpful.

<u>Topic or Issue 3:</u> Seabed iceberg scour probability

3.2.5

"Ice Scour Data for the Hebron Offshore Study Area"

The CSR document describes the seabed iceberg scour phenomenon and some of the scour characteristic/metrics factors.

The term bund wall for a scour side wall is not standard and not appropriate in the ice scour context. Suggest referring to it as a side wall rather than introduce terminology not used in the field of study. This should be changed throughout the section.

Correction: Relict seabed iceberg scours have been observed to 650 m below sea level off Grand bank (Sonnichsen and King, 2005). Modern seabed scouring icebergs have been documented to 127 m (Sonnichsen et al, 2005), but based on measured iceberg keel drafts, iceberg scouring is predicted to occur to depths in excess of 200 m, possibly to 230 m.

On pg. 3-88, “sedimentation rates” is presented as one factor to assess affecting the likelihood of an iceberg affecting oil production facilities. Strictly speaking, the process is not so much “sedimentation rate” as the redistribution of nearby sandy sediment, mainly under storm conditions. There is little or no net input of sediment in the area with the possible exception of small amounts of very fine and organic-derived material which would be ephemeral. This is more a question of semantics than substance.

The study of iceberg scour has long been and remains one of ongoing research; abundant field study, documentation and sophisticated physical and numeric modeling exists, very specific to the Grand Bank hydrocarbon development area. The section appropriately references regional studies, but does not spend much time on actual risks to the project from iceberg scour. Perhaps that is appropriate for the CSR (GSCA authors fully anticipate that very specific ice scour risk assessments have been or will be done as part of eventual detailed engineering design) but presumably the purpose is to demonstrate that a new GBS will remain safe against impacts or that engineering will mitigate it effects. This is not stated.

Topic or Issue 4: **Tsunamis**

13.3.3

Although the arm is sheltered, this would not be a protection from tsunami; indeed long inlets magnify tsunami effects (e.g. Port Alberni for the 1964 tsunami). Nevertheless, the assessment that the risk is low due to the short (4 year) construction period is acceptable.

In the text, there appear to be a few discrepancies. Document cites a 13 m high wave off the Burin...in fact it was the run-up that was 13 m high. They also quote from some anecdotal evidence that Bonavista Bay "drained" and damage was done to coastal buildings. Mr. Ruffman knows only of the fact that some boats swung at anchor in Bonavista Bay - at the correct time for the arrival of the tsunami (1:30 in the morning). It is hard to imagine that the wave refracted around the entire Avalon and "drained" Bonavista Bay, without impacting St. John's harbour or anywhere in between. Neither of these issues bears any relevance, however, to the risk assessment for the Bull Arm facility.

13.4.3

The reviewer found the assessment acceptable, but in terms of operations, the owner should ensure that they will receive any tsunami alerts, so as to adjust offshore operations accordingly.

Topic or issue 5: Seismic Hazard

13.4.7 Geohazard

“A detailed geohazard assessment will have to be performed at any drilling locations selected, via a dedicated geohazard survey (or based on existing data) as per Canada-Newfoundland and

Labrador offshore Petroleum Board (C-NLOPB) guidelines." We are surprised that there is no statement of the proposed seismic design levels for the platform and its facilities in this CSR.

"The Operating and Safety Level Earthquake risk levels are usually determined by the facility owner (URS Corporation 2006)." While this section lists the proposed return periods of design events like the "Abnormal Level Earthquake: 3,000 years" where is the assurance in this CSR that the seismic hazard has been correctly assessed and that the platform and the facility will be designed to accommodate appropriate levels of earthquakes shaking?

".... there are not any focal mechanisms for earthquakes in the Jeanne d'Arc or other nearby basins." Adams and Wahlstrom (1995)[1] published a focal mechanism for the 1971 M4.8 earthquake 100 km NNW from the Hebron site. Although of rather low quality, it indicates strike-slip faulting, which is consistent with the mechanisms of the large (M7.2, M7.3) earthquakes along the Atlantic margin.

"While overall rates of seismicity are relatively low, there are zones of clustered higher rate seismicity" including one ~100 km from the Hebron site (see Adams and Wahlstrom, 1995).

Topic or Issue 6: Marine hydro-carbon spills and shoreline cleanup

14.2-14.6

For the Trinity bay -Bull Arm region the proponent has provided a good overview of spill trajectory modeling and response activities and agencies identified in the event of a marine spill. Although much of the nearshore environment is steep sloping rocky shores that do not significantly change, there are unconsolidated shores present, e.g. Belledune Beach. Physical shoreline conditions do vary over time. There is no description of the level of shoreline information available for oil spill cleanup operations. Environment Canada as part of REET has a data base of shoreline conditions taken from select temporal data.

The question is whether the shoreline in the Trinity bay -Bull Arm and approaches have been segmented into shore units and described in sufficient detail to allow rapid assessment of oiling impacts in the event of a spill and how the response agencies are updating their information so that appropriate physical and biological sensitivities are available in the event of a spill.

Topic or Issue 7: Sea bed character and stability in the Bull Arm-Trinity bay area and disposal of bund wall

There is very useful information in the consolidated response regarding the impacts of previous activities on the nearshore sea bed and anticipated changes in future plans for the bund wall. Potential disposal sites are discussed and some implications for the fisheries and fish habitat are provided.

Why were the suggested general sediment waste disposal sites selected, and what were the anticipated impacts on local sea bed sediment dynamics?

[1] Adams, J., and Wahlstrom, R. Revised seismicity of the Grand Banks and offshore Newfoundland. Geological Survey of Canada Open File 3043, 58 pp., 1995.

Topic or Issue 8: Adaptation to Sea level change and changing environmental conditions

3-91

The proponent acknowledges that facility design and operations planning have considered the potential effects of climate change. Design has considered the potential rise in sea level and more frequent and more severe storms and wave heights. New information is being published in the scientific literature all the time projecting different rates of sea level. As construction plans proceed the proponent is encouraged to incorporate the best accepted sea level projections in final designs.

There is no discussion if the present rates of projected sea level increases can be easily incorporated in design of the GBS or what levels of change substantially alter design costs or would cause delays in construction plans for the GBS.